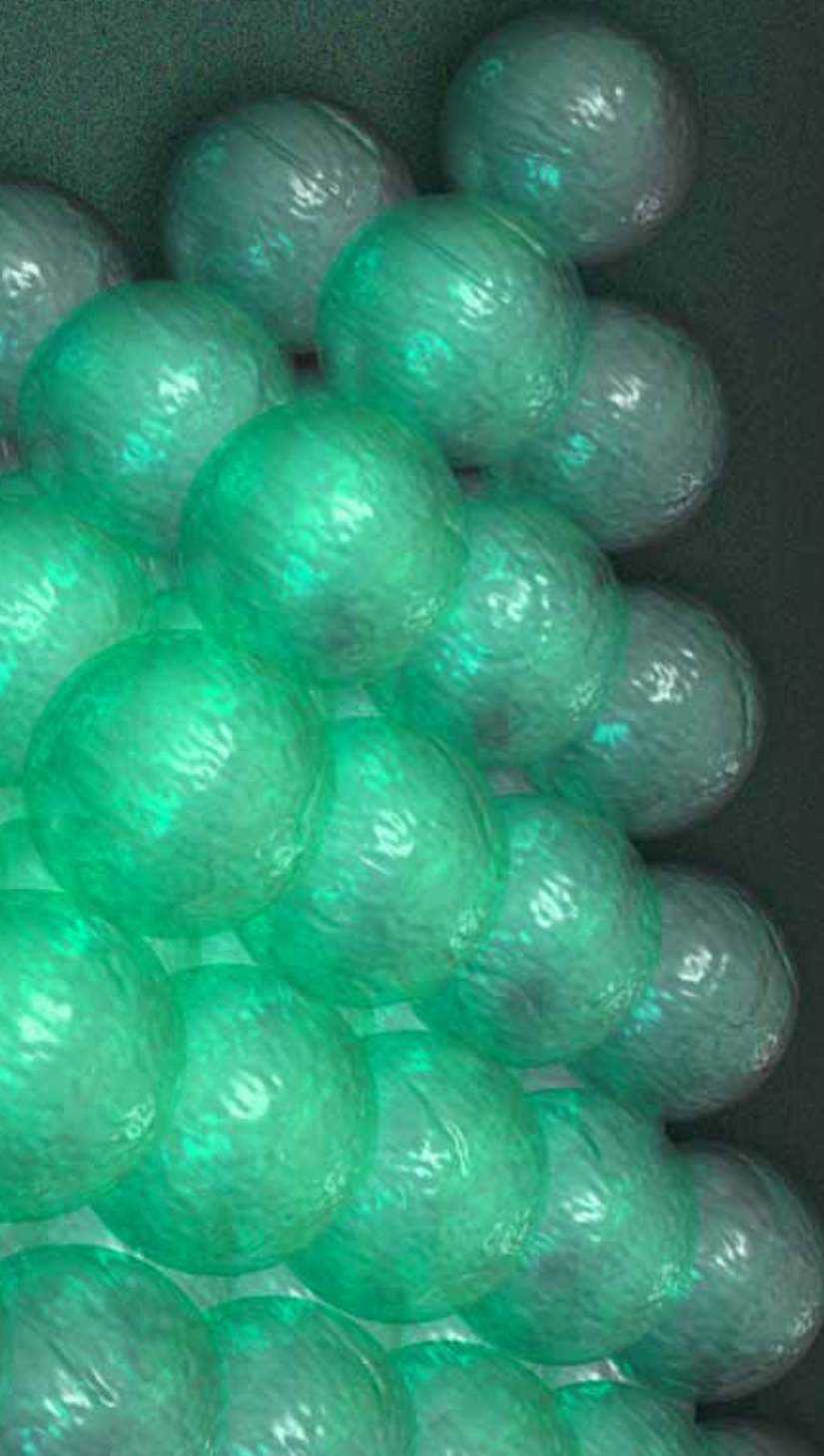


Technical Program/Final Summaries

SPIE

# Smart Materials, Nano- and Micro-Smart Systems

10-13 December 2006 University of Adelaide • Adelaide, Australia



SPIE

# Smart Materials, Nano- and Micro-Smart Systems

10-13 December 2006

University of Adelaide • Adelaide, Australia



## Welcome!

This symposium series follows the highly successful SPIE meetings around Australia over the past few years and gives you the opportunity for in-depth communication with researchers and developers in smart materials, smart structures, smart micro/nanoelectronics devices and systems, micro- and nano- technology with special emphasis on packaging and integration of MEMS and NEMS for diverse application areas. One full conference will give you access to the latest research on biomedical applications such as bio-surveillance systems. These fields are multidisciplinary and make extensive use of micro- and nanofabrication technologies. You will learn about exciting new developments in nanomaterials, sensors and actuators, as well as in the design and applications of these systems.

This program would not have been possible without first the considerable dedication and efforts of the large team of people organizing this symposium, locally and overseas. Additionally, the high quality of this meeting is a direct result of the willingness of the many researchers who have taken the time and effort to communicate the findings of their research work in this international forum. We express our sincere thanks to everyone involved.

### Symposium Chairs



**Joe Shapter**  
Flinders Univ. of South  
Australia (Australia)



**Vijay K. Varadan**  
Univ. of Arkansas  
(USA)



**Derek Abbott**  
Univ. of Adelaide  
(Australia)

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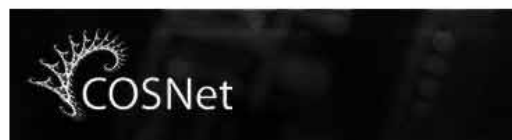
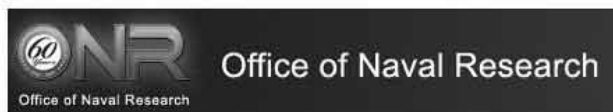
*SPIE would like to express its deepest appreciation to the program chairs, conference chairs, co-chairs, program committees, and session chairs who have so generously given of their time and advice to make this symposium possible. The symposium, like our other conferences and activities, would not be possible without the dedicated contribution of our participants and members.*

*This program is based on commitments received up to the time of publication and is subject to change without notice.*

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## Co-sponsors



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# Daily Schedule

## Special Events

| Sunday<br>10 December  | Monday<br>11 December  | Tuesday<br>12 December   | Wednesday<br>13 December  |
|--|--|--|---|
| <b>Welcome Reception and Registration</b> , 18.00 to 20.00, Foyer Area, Napier Bldg, p.6 | <b>Opening Remarks and Introduction</b> , 08.30 to 09.00, p.4  | <b>Introduction</b> , 08.50 to 09.00, p.4  | <b>Introduction</b> , 08.50 to 09.00, p.5   |
|  | <i>Plenary Presentation</i><br>09.00 to 09.45, <b>Brownian Motion Reigning Manipulation and Transport on the Nanoscale</b> , Peter Hänggi, Univ. Augsburg (Germany), p.4                     | <i>Plenary Presentation</i><br>09.00 to 09.45, <b>Microfluidic Analytical Systems for High-Throughput Multiplexed Bioassays</b> , Hywel Morgan, Univ. of Southampton (United Kingdom), p.4 | <i>Plenary Presentation</i><br>09.00 to 09.45, <b>The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders</b> , Vijay K. Varadan, Univ. of Arkansas (USA), p.5 |
|  | <i>Plenary Presentation</i><br>09.45 to 10.30, <b>Microphotonics for Signal Processing, Microfluidics, and Sensing Applications</b> , Benjamin J. Eggleton, Univ. of Sydney (Australia), p.4 | <i>Plenary Presentation</i><br>09.45 to 10.30, <b>Spontaneous Organisation of Adsorbed Molecules</b> , Peter Beton, The Univ. of Nottingham (United Kingdom), p.4                          | <i>Plenary Presentation</i><br>09.45 to 10.30, <b>All-optical Processing for Advanced Communications Systems</b> , Barry Luther-Davies, The Australian National Univ. (Australia), p.5  |
|  | <i>Poster Session</i><br>18.00 to 17.30, p.6   | <i>Symposium Dinner</i><br>19.30 to 22.00, <b>National Wine Centre of Australia</b> , p.6  |   |

## Session Schedule

| Monday 11 December    |  |             |
|-----------------------|--|-------------|
| Time                  | Event  | Room        |
| 11.00 to 12.20        | Composite Nanomaterials (Conf. 6413, Sess 1)   | Napier 208  |
| 11.00 to 12.30        | Actuators I (Conf. 6414, Sess 1)   | Napier 209  |
| 11.00 to 12.30        | Polymers/PZT (Conf. 6414, Sess 4)  | Napier 210  |
| 11.00 to 12.20        | Nanotechnology (Conf. 6451, Sess 1)  | Napier LG24 |
| 11.00 to 12.20        | Nanoscale Interactions and Devices I (Conf. 6416, Sess 1)                            | Napier LG23 |
| 13.30 to 15.00        | Radio Frequency (Conf. 6414, Sess 2)   | Napier 209  |
| 13.30 to 15.20        | Photonic/THz (Conf. 6414, Sess 5)  | Napier 210  |
| 13.30 to 15.40        | Photonics (Conf. 6415, Sess 2)   | Napier LG24 |
| 13.30 to 15.10        | Nanoscale Interactions and Devices II (Conf. 6416, Sess 2)                           | Napier LG23 |
| 14.00 to 15.40        | Nanomaterial-based Sensors (Conf. 6413, Sess 2)                                      | Napier 208  |
| 15.40 to 17.30        | Sensors Radio Frequency (Conf. 6414, Sess 3)   | Napier 209  |
| 15.50 to 18.00        | Applications (Conf. 6415, Sess 3)  | Napier LG24 |
| 16.00 to 17.00        | Piezoelectrics (Conf. 6413, Sess 3)  | Napier 208  |
| 16.00 to 18.00        | Devices (Conf. 6414, Sess 6)   | Napier 210  |
| 16.00 to 17.20        | BioMEMS (Conf. 6416, Sess 3)   | Napier LG23 |
| Tuesday 12 December   |  |             |
| 11.00 to 12.20        | Bionanotechnology I (Conf. 6413, Sess 4)   | Napier 208  |
| 11.00 to 12.30        | Actuators II (Conf. 6414, Sess 7)  | Napier 209  |
| 11.00 to 12.20        | Fabrication (Conf. 6415, Sess 4)   | Napier LG24 |
| 11.00 to 12.20        | Microfluidics I (Conf. 6416, Sess 4)   | Napier LG23 |
| 11.00 to 12.20        | Nonlinearity in Device Applications and Manufacturing Processes (Conf. 6417, Sess 1) | Napier 210  |
| 13.30 to 15.10        | Structures Monitoring (Conf. 6414, Sess 8)   | Napier 209  |
| 13.30 to 15.20        | Materials (Conf. 6415, Sess 5)   | Napier LG24 |
| 13.30 to 17.20        | Microfluidics II (Conf. 6416, Sess 5)  | Napier LG23 |
| 13.50 to 15.30        | Disorder, Imbalance, and Nonequilibrium (Conf. 6417, Sess 2)                         | Napier 210  |
| 14.00 to 15.00        | Bionanotechnology II (Conf. 6413, Sess 5)  | Napier 208  |
| 15.00 to 17.00        | Active Materials (Conf. 6413, Sess 6)  | Napier 208  |
| 15.40 to 17.50        | Analog/Digital Circuits (Conf. 6414, Sess 9)   | Napier 209  |
| 15.50 to 17.20        | Packaging and Manufacturing (Conf. 6415, Sess 6)                                     | Napier LG24 |
| 16.00 to 17.20        | Exploring and Exploiting Noise (Conf. 6417, Sess 3)                                  | Napier 210  |
| Wednesday 13 December |  |             |
| 11.00 to 11.40        | Organic Thin Films (Conf. 6413, Sess 7)  | Napier 208  |
| 11.00 to 12.20        | Fibers (Conf. 6414, Sess 10)   | Napier 209  |
| 11.00 to 12.20        | Fluidics/Bio-applications (Conf. 6415, Sess 7)                                       | Napier LG24 |
| 11.00 to 12.20        | Modelling and Computation (Conf. 6416, Sess 6)                                       | Napier LG23 |
| 11.00 to 12.00        | Bio- and Socio-System Dynamics (Conf. 6417, Sess 4)                                  | Napier 210  |
| 11.40 to 13.00        | Laser-assisted Nanofabrication (Conf. 6413, Sess 8)                                  | Napier 208  |
| 13.30 to 14.30        | Imagers and Vision (Conf. 6414, Sess 11)   | Napier 209  |
| 13.30 to 15.30        | Terahertz Technology and Devices (Conf. 6416, Sess 7)                                | Napier LG23 |
| 13.30 to 15.10        | The Complex Human Body (Conf. 6417, Sess 5)  | Napier 210  |
| 14.30 to 16.30        | Process/Technology (Conf. 6414, Sess 12)   | Napier 209  |

## Welcome Reception and Registration

Foyer Area, Napier Bldg.

Sunday 10 December ..... 18.00 to 20.00  
All registered attendees are cordially invited to relax, socialize, and enjoy light refreshments. Please remember to wear your conference registration badge. Dress is casual.

## Conference Dinner

Tuesday 12 December ..... 19.30 to 22.00

## National Wine Centre of Australia

Home to the nation's peak wine industry organisations, the National Wine Centre of Australia is also a must-see attraction for any visitor to Adelaide. The Centre is adjacent to the Botanic Gardens of Adelaide, in the north east part of the City. The pedestrian entrance is located on Botanic Road, the continuation of North Terrace. You can also walk through the Botanic Gardens to the Centre. For further information on the National Wine Centre of Australia, please visit:

<http://www.wineaustralia.com.au/location/>

All registered attendees are invited to attend. Additional Guest tickets can be purchased when you register for the meeting. Attendees must pick-up a ticket at the registration desk before noon on Monday to confirm attendance.

## Poster Session

Monday ..... 18.00 to 19.30

Poster authors can begin to post their papers at 08.00 on the scheduled day of presentation. Poster must be posted by 16.00. Each poster presenter is provided a space (1.1 m x 1.2 m) in which to display a summary of the paper. Authors must remain in the vicinity of the poster board during the poster session to answer the questions of attendees. Please remove your posters after the session; remaining posters will be discarded.

So that the poster is readable from a distance of about 6-10 feet away, please use a point size of ~36 for the title, ~25 for the authors, and at least 15 for the double-spaced text. Include explanations for graphs, pictures, and tables. The poster should include a brief introduction, goals, experimental detail, conclusions, and references. Make sure this information is presented in a logical and clear sequence. The most successful and attractive posters are graphically produced posters that highlight and summarize the main points, with the author filling in the details. The least effective poster format are photocopies of manuscripts.

## Accompanying Persons Tour Information

We have taken the liberty of compiling a short list of possible activities, along with tour company contact information, that might be of interest to you and/or your accompanying person.

### Barossa Valley Wine Tour

The Barossa Valley is the largest wine producing region in Australia. Premium award winning wines, magnificent stone architecture and boutique wineries all encapsulated in a peaceful rural setting of vineyards and rolling hills.

### Mt. Lofty Lookout and Hahndorf Tour

Visit the alluring charm of the village of Hahndorf - classified as Australia's oldest German settlement set amid the tranquil sylvan setting of the Mount Lofty Ranges. Glorious autumn colours, vibrant spring gardens, crisp winter and cool summers makes this verdant landscape very enjoyable all year round. Stroll amongst the century old cork elms lining the main street of stone cottages and curios.

### Southern Highlights Tour

Enjoy a delightful combination tour of the Fleurieu Peninsula - seaside landscapes of Victor Harbor & Encounter Bay, rolling vineyards of the South Wine Coast, southern beaches, majestic Mount Lofty Ranges and the old paddle steamer river port of Goolwa.

### Coorong Discovery Cruise

The Coorong National Park is a majestic aquatic wilderness region only 80 kms south of Adelaide and home to more than two hundred different species of waterbirds. From the Mundoo Channel on Hindmarsh Island the Spirit of the Coorong cruises along the waterways for an exciting journey of discovery and adventure.

### Murray River Highlights Cruise

The mighty Murray meanders through three States to the Great Southern Ocean in South Australia. Experience the mallee outback landscape enjoy a relaxing morning cruise.

### City Highlights Tour: Haigh's Chocolates & Glenelg Esplanade

Renowned as the 'thinking capital of Australia', Adelaide is a cosmopolitan blend of European and Modern architecture, great food and wine and a relaxed unwinding lifestyle. The city flanked by the ocean on the west and panoramic Mount Lofty Ranges on the east, offers a myriad of annual cultural experiences expressing a vibrant and festive mood.

### Cleland Wildlife Park

The Cleland Wildlife Park is located in the picturesque rolling hills of the Mount Lofty Ranges. The whole family will enjoy the freedom to explore the trails and come face to face with a host of Australian wildlife & flora.

There are several tour companies operating in Adelaide and most will be able to arrange tours of the attractions described. If you wish to book some of these tours the easiest thing to do is contact the tour companies directly via the internet. Some possible companies can be found at

<http://www.adelaidesightseeing.com.au>

<http://www.topfoodandwinetours.com.au>

<http://www.adelaideluxurytours.com.au>

<http://www.adelaidebackpackers.com.au>

<http://www.adelaidesouthaustraliatours.com.au>

For general information about Adelaide the best site is probably <http://www.adelaide.southaustralia.com/home.asp> which gives a broad outline of the city and its attractions.

Monday 11 December

Opening Remarks and Introduction 08.30 to 09.00

Napier 102

09.00 to 09.45

## Brownian Motion Reigning Manipulation and Transport on the Nanoscale



**Prof. Peter Hänggi**,  
Lehrstuhl für  
Theoretische Physik I,  
Univ. Augsburg

**Prof. Hänggi** received his Ph.D from the Univ. of Basel in 1977. He then worked in various capacities both in Europe and the United States before starting an academic position at the Polytechnic Institute of New York in 1980. In 1987, he moved to his current position of Full Professor (Ordinarius, C4), Univ. of Augsburg (Lehrstuhl für Theoretische Physik I). He is a fellow of many societies and institutes including the American Physical Society and is an elected member of the German Academy of Natural Scientists. He has many awards including a Medal of honour from the Jagellonian Univ. in Krakow in recognition for his most outstanding scientific achievements and his continued dissemination of statistical physics works, Doctor honoris causa from the National Academy of Sciences of Ukraine and the award for the "Chair of Physics Elena Aizen de Moshinsky" from the National Autonomous Univ. of Mexico (UNAM). He serves in an editorial capacity on many journals including Physical Review E and Chemical Physics. His main area of research interest is Theoretical Statistical Mechanics and Quantum mechanics.

09.45 to 10.30

## Microphotonics for Signal Processing, Microfluidics and Sensing Applications



**Prof. Benjamin J. Eggleton**, Professor of Physics, ARC Federation Fellow, Director, CUDOS – ARC Centre of Excellence - Ultrahigh-bandwidth Devices, for Optical System, School of Physics, Univ. of Sydney

Optical System, School of Physics, Univ. of Sydney

**Benjamin J. Eggleton** is currently an ARC Federation Fellow and Professor of Physics at the Univ. of Sydney and the Director of CUDOS, an ARC Centre of Excellence. In 1996, he joined Bell Laboratories, Lucent Technologies as a Postdoctoral Member of staff then transferred to the Optical Fiber Research Department. In 2000 he was promoted to Research Director within the Specialty Fiber Business Division where he was responsible for forward-looking research supporting Lucent Technologies business in optical fiber devices. Prof. Eggleton has co-authored over 14\50 journal publications and numerous conference papers and was the recipient of the 2004 Prime Ministers Malcolm McIntosh Science Prize for Physical Scientist of the year, the 2003 ICO prize from the International Commission on Optics, the 1998 Adolph Lomb Medal from the OSA the distinguished lecturer award from the IEEE/LEOS, is an OSA fellow and recipient of an R&D100 award.

Tuesday 12 December

Introduction 08.50 to 09.00

Napier 102

09.00 to 09.45

## Microfluidic Analytical Systems for High- Throughput Multiplexed Bio-assays



**Prof. Hywel Morgan**,  
School of Electronics and  
Computer Science, Univ.  
of Southampton

**Hywel Morgan** obtained both his first degree and his PhD at the Univ. of Wales, in 1981 and 1985 respectively. He was appointed to a lectureship at the Univ. of Glasgow in 1993, where he established a research programme in AC electrokinetics. He was appointed professor of Bioelectronics at Glasgow in 2001, and is now Professor of Bioelectronics at the Univ. of Southampton. In 2001 he was awarded a Royal Society-Leverhulme Senior Research Fellowship. His research interests are concerned with understanding and exploiting the applications of electric fields to biology, particularly in the context of micro and nano-systems. He has developed new particle manipulation and characterisation methods and is interested in developing methods for controlling fluids in micro-systems through the exploitation of electrohydrodynamic effects. He has published widely and recently co-authored a text-book on AC electrokinetics.

09.45 to 10.30

## Spontaneous Organisation of Adsorbed Molecules



**Prof. Peter Beton**,  
Nanoscience Group,  
School of Physics and  
Astronomy, Univ. of  
Nottingham

Wednesday 13 December  
Introduction 08.50 to 09.00

Napier 208

09.00 to 09.45

## The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders



**Prof. Vijay K. Varadan**, Twenty First Century Endowed Chair in Nano- and Bio-Technology and Medicine, Distinguished Professor of Electrical Engineering,

Distinguished Professor of Biomedical Engineering, Director- High Density Electronics Center (HiDEC), Professor of Neurosurgery, College of Medicine, Univ. of Arkansas, Professor of Neurosurgery, Pennsylvania State Univ., Hershey Medical Ctr.

Nanotechnology has been broadly defined as the one for not only the creation of functional materials and devices as well as systems through control of matter at the scale of 1-100 nm, but also the exploitation of novel properties and phenomena at the same scale. Growing needs in the point-of-care (POC) that is an increasing market for improving patient's quality of life, are driving the development of nanotechnologies for diagnosis and treatment of various life threatening diseases. This paper addresses the recent development of nanodiagnostic sensors and nanotherapeutic devices with functionalized carbon nanotube and/or nanowire on a flexible organic thin film electronics to monitor and control of the three leading diseases namely 1) neurodegenerative diseases, 2) cardiovascular diseases, and 3) diabetes and metabolic diseases. Selected movies illustrating the applications of nanodevices to patients will be shown at the talk.

**Prof. Vijay K. Varadan** is currently the Twenty-First Century Endowed Chair in Nano-and Bio-Technology and Medicine, and Distinguished Professor of Electrical Engineering and Distinguished Professor of Biomedical Engineering (College of Engineering) and Neurosurgery (College of Medicine) at Univ. of Arkansas. He is also the Director of the Institute for Nano-, Micro, and Neuro-Electronics, Sensors and Systems and the Director of the High Density Electronics Center. He has concentrated on the design and development of various electronic, acoustic and structural composites, smart materials, structures, and devices including sensors, transducers, Microelectromechanical Systems (MEMS), synthesis and large scale fabrication of carbon nanotubes, NanoElectroMechanical Systems (NEMS), microwave, acoustic and ultrasonic wave absorbers and filters. He has developed neurostimulator, wireless microsensors and systems for sensing and control of Parkinson's disease, epilepsy, glucose in the blood and Alzheimer's disease. He is also developing both silicon and organic based wireless sensor systems with RFID for human gait analysis and sleep disorders and various neurological disorders. He is an editor of the Journal of Wave-Materials Interaction and the Editor-in-Chief of the Journal of Smart Materials and Structures. He is an Associate Editor of the Journal of Microlithography, Microfabrication and Microsystem. He serves on the editorial board of International Journal of Computational Methods. He has published more than 500 journal papers and 12 books. He has 12 patents pertinent to conducting polymers, smart structures, smart antennas, phase shifters, carbon nanotubes, implantable device for Parkinson's patients, MEMS accelero-meters and gyroscopes.

09.45 to 10.30

## All-optical Processing for Advanced Communications Systems



**Prof. Barry Luther-Davies**, Ctr. for Ultrahigh Bandwidth Devices for Optical Systems, Laser Physics Ctr., Research School of Physical Sciences and

Engineering, The Australian National Univ.

A "holy grail" of photonics is the development of all-optical processors capable of duplicating in the optical domain the functions of the transistor in electronics. The promise of all-optical processing is that it will overcome the speed limitations inherent in current opto-electronic processors - the so-called electronic bottleneck. However all optical processing requires effective nonlinear optical materials and devices and the design and fabrication of such devices is very challenging. In this talk I will review some of the requirements for all-optical processing and present a summary of research undertaken within CUDOS towards aimed at realizing all-optical processing in nonlinear chalcogenide glass.

**Prof. Luther-Davies** is a Federation Fellow and head of the Laser Physics Centre at the Australian National Univ. His interests include laser physics, nonlinear optics, linear and nonlinear optical materials, laser-matter interaction physics and photonics. His current research is focused on the fabrication of micro- and nano-scale optical devices for all-optical processing as part of the programs of the ARC Centre for Excellence in Ultrahigh Bandwidth Devices for Optical Systems (CUDOS).

His research has been recognized through the award of the Pawsey Medal of the Australian Academy of Sciences as well as election as a Fellow of the Optical Society of America; the Australian Academy of Technological Sciences and Engineering and the Australian Institute of Physics.

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# Smart Materials IV

Conference Chair: **Nicolas H. Voelcker**, Flinders Univ. of South Australia (Australia)

Cochairs: **Alan R. Wilson**, Defence Science and Technology Organisation (Australia); **Hans J. Griesser**, Univ. of South Australia (Australia); **Neville V. Richardson**, Univ. of St. Andrews (United Kingdom); **Fausto Sanz**, Univ. de Barcelona (Spain)

Program Committee: **Frank Caruso**, The Univ. of Melbourne (Australia); **Giuseppe Cavallaro**, Commonwealth Scientific and Industrial Research Organisation (Australia); **Jason P. Hayes**, MiniFAB Ply Ltd. (Australia); **Sunil Kumar**, Univ. of South Australia (Australia); **Max Lu**, The Univ. of Queensland (Australia); **David Mainwaring**, Royal Melbourne Institute of Technology (Australia); **Thomas Maschmeyer**, The Univ. of Sydney (Australia); **Anton Middelberg**, The Univ. of Queensland (Australia); **Colin Raston**, The Univ. of Western Australia (Australia); **Helmut W. Thissen**, Commonwealth Scientific and Industrial Research Organisation (Australia); **Wei-Bor Tsai**, National Taiwan Univ. (Taiwan); **Terence W. Turney**, Commonwealth Scientific and Industrial Research Organisation (Australia); **Robert B. Yates**, Gillette Management Inc. (United Kingdom)

## Monday 11 December

08.30 to 09.00 **Opening Remarks and Introduction**

Plenary Presentations

09:00 to 09.45 **Brownian Motion Reigning Manipulation and Transport on the Nanoscale**, P. Hänggi, Univ Augsburg (Germany)

09:45 to 10.30 **Microphotonics for Signal Processing, Microfluidics, and Sensing**, B. J. Eggleton, The Univ. of Sydney (Australia)

10.30 to 11.00 **Morning Tea**

### SESSION 1

Room: Napier 208 ..... Mon. 11.00 to 11.40

#### Composite Nanomaterials

Chair: **Sunil Kumar**, Univ. of South Australia (Australia)

11.00: **Anisotropic surface roughness enhances the bending response of ionic polymer-metal composite (IPMC) artificial muscles**, B. L. Stojmenov, The Institute of Physical and Chemical Research (Japan); J. M. Rossiter, Univ. of Bristol (United Kingdom) and The Institute of Physical and Chemical Research (Japan); T. Mukai, The Institute of Physical and Chemical Research (Japan) ..... [6413-02]

11.20: **Plasma modified carbon surfaces for supporting sensor architectures**, A. Deslandes, A. J. Barlow, J. G. Shapter, J. S. Quinton, Flinders Univ. (Australia) ..... [6413-03]

Lunch Break ..... 11.40 to 14.00

### SESSION 2

Room: Napier 208 ..... Mon. 14.00 to 15.40

#### Nanomaterial-based Sensors

Chair: **Alan R. Wilson**, Defence Science and Technology Organisation (Australia)

14.00: **Three-dimensional network of ZnO tetrapods for use in gas sensing (Invited Paper)**, J. Delaunay, N. Kakoiyama, I. Yamada, The Univ. of Tokyo (Japan) ..... [6413-04]

14.40: **Modeling of active fiber composite for delamination sensing**, P. J. Guruprasad, Texas A&M Univ. (USA); A. Tamrakar, D. Harursampath, Indian Institute of Science (India) ..... [6413-05]

15.00: **Highly reliable advanced grid structures (HRAGS) for aircraft structures using multi-point FBG sensor**, H. Takeya, S. Kazushi, M. Kume, T. Ozaki, Mitsubishi Electric Corp. (Japan); N. Takeda, The Univ. of Tokyo (Japan); N. Tajima, R&D Institute of Metals and Composites for Future Industries (Japan) ..... [6413-06]

15.20: **The producing and properties studying of carbon fiber smart concrete**, Z. Xu, Nanjing Univ. of Science & Technology (China) ..... [6413-07]

Afternoon Tea ..... 15.40 to 16.00

### SESSION 3

Room: Napier 208 ..... Mon. 16.00 to 17.00

#### Piezoelectrics

Chair: **Neville V. Richardson**, Univ. of St. Andrews (United Kingdom)

16.00: **Low-temperature processing of lead zirconate titanate thin films by 28 GHz microwave irradiation for MEMS application**, Z. Wang, Tohoku Univ. (Japan) ..... [6413-08]

16.20: **Analysis of constrained piezoelectric thin film sensor**, R. Ali, Indian Institute of Science (India) ..... [6413-09]

16.40: **High-performance piezoelectric actuator consisting of two piezoelectric materials**, S. Jeong, M. Kim, J. Song, Korea Electrotechnology Research Institute (South Korea) ..... [6413-10]

### ✓ Posters-Monday

✓ **Dielectric and piezoelectric properties of a piezoelectric complex for micropower harvesting**, J. Song, S. Jeong, M. Kim, I. Kim, Korea Electrotechnology Research Institute (South Korea) ..... [6413-24]

✓ **Measurement of mechanically induced luminescence from microparticles**, T. Koga, K. Sakai, S. Maehara, N. Terasaki, Y. Imai, C. Xu, National Institute of Advanced Industrial Science and Technology (Japan) ..... [6413-26]

✓ **Mechanical response of low-temperature sintered body consisting of clusters of submicron gold particles**, Y. Fujisawa, Yokohama National Univ. (Japan) ..... [6413-27]

✓ **Silica nanostructure formation from R5 peptide**, I. Tajuddin, N. H. Voelcker, J. Mitchell, Flinders Univ. (Australia) ..... [6413-30]

✓ **Application of nanostructured biochips for efficient cell transfection microarrays**, Y. Akkamsetty, A. L. Hook, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); J. P. Hayes, MiniFAB (Aust) Pty Ltd. (Australia); N. H. Voelcker, Flinders Univ. (Australia) ..... [6413-31]

✓ **Morphology controlled cellular localization of inorganic nanoparticles**, K. Porazik, M. Niebert, Z. P. Xu, M. Lu, P. Gray, The Univ. of Queensland (Australia) ..... [6413-32]

✓ **Zinc Phthalocyanine(ZnPc) thin films as nanomaterials**, M. Puri, Guru Nanak Dev Univ. (India) ..... [6413-33]

✓ **Studies on parameters measurement and analysis of optic fiber**, Z. Zhao, L. Guo, Y. Chen, K. Wang, L. Wang, Nanjing Univ. of Aeronautics and Astronautics (China) ..... [6413-35]

✓ **Fabrication of embedded conductive layer in polymer by plasma immersion ion implantation and gold assisted sacrificial conductive surface layer**, P. C. T. Ha, Z. J. Han, Y. B. Xing, B. K. Tay, Nanyang Technological Univ. (Singapore) ..... [6413-36]

✓ **Synthesis and electrical properties of Chitosan-g-poly(aniline)/Fe<sub>2</sub>O<sub>3</sub> nanocomposite**, A. Tiwari, S. P. Singh, National Physical Lab. (India) ..... [6413-38]

✓ **Development of SMART fabrics for potential wound dressing applications**, V. Cornelius, N. Majcen, M. Snowden, J. C. Mitchell, Univ. of Greenwich (United Kingdom); B. Voncina, Univ. of Maribor (Slovenia) ..... [6413-39]

✓ **The use of colloidal microgels for the controlled delivery of proteins and peptides**, V. J. Cornelius, M. Snowden, J. C. Mitchell, Univ. of Greenwich (United Kingdom) ..... [6413-40]

✓ **Micro-array printing and analysis of fluorescently labeled proteins on reactive substrates**, M. D. Kurkuri, Flinders Univ. (Australia); C. Driever, H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); N. H. Voelcker, Flinders Univ. (Australia) ..... [6413-42]



**Tuesday 12 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **Microfluidic Analytical Systems for High-Throughput Multiplexed Bio-assays**, H. Morgan, Univ of Southampton (United Kingdom)09:45 to 10.30 **Spontaneous Organisation of Adsorbed Molecules**, P. Beton, The Univ. of Nottingham (United Kingdom)10.30 to 11.00 **Morning Tea****SESSION 4****Room: Napier 208 ..... Tues. 11.00 to 12.20****Bionanotechnology I***Chair: Nicolas H. Voelcker*, Flinders Univ. (Australia)11.00: **Microarrays for the evaluation of cell-biomaterial surface interactions** (*Invited Paper*), H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia) ..... [6413-11]11.40: **A platform for the advanced spatial and temporal control of biomolecules**, A. L. Hook, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); J. P. Hayes, MiniFAB (Aust) Pty Ltd. (Australia); N. H. Voelcker, Flinders Univ. (Australia) ..... [6413-12]12.00: **A radio frequency controlled microvalve for biomedical applications**, D. W. Dissanayake, S. F. Al-Sarawi, The Univ. of Adelaide (Australia) ..... [6413-13]

Lunch Break ..... 12.20 to 14.00

**SESSION 5****Room: Napier 208 ..... Tues. 14.00 to 15.00****Bionanotechnology II***Chair: Helmut W. Thissen*, Commonwealth Scientific and Industrial Research Organisation (Australia)14.00: **Nanomechanical properties of supported lipid bilayers studied by force spectroscopy** (*Invited Paper*), S. Garcia-Manyes, Columbia Univ. (USA); G. Oncins, Univ de Barcelona (Spain); F. Sanz, Univ. de Barcelona (Spain) ..... [6413-14]14.40: **Hybrid organic-inorganic nanoparticles: controlled incorporation of gold into virus-like particles**, M. Niebert, J. Riches, M. Howes, C. Ferguson, R. Parton, A. Middelberg, The Univ. of Queensland (Australia) ..... [6413-15]**SESSION 6****Room: Napier 208 ..... Tues. 15.00 to 17.00****Active Materials***Chair: David Mainwaring*, Royal Melbourne Institute of Technology (Australia)15.00: **Responsive interfaces with polyampholyte brushes** (*Invited Paper*), Y. Tran, S. Sanjuan, École Supérieure de Physique et de Chimie Industrielles (France) ..... [6413-16]

Afternoon Tea ..... 15.40 to 16.00

16.00: **Electroactive polymers activate an innovative handling system**, C. Pagano, L. Zanoni, I. Fassi, Istituto di Tecnologia Industriali e Automazione (Italy) ..... [6413-17]16.40: **Application of nanotechnologies in smart textiles**, Z. Peng, F. M. She, L. Kong, Univ. of South Australia (Australia) ..... [6413-19]**Wednesday 13 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders**, V. K. Varadan, Univ. of Arkansas (USA)09:45 to 10.30 **All-optical Processing for Advanced Communications Systems**, B. Luther-Davies, The Australian National Univ. (Australia)10.30 to 11.00 **Morning Tea****SESSION 7****Room: Napier 208 ..... Wed. 11.00 to 11.40****Organic Thin Films***Chair: Nicolas H. Voelcker*, Flinders Univ. (Australia)11.00: **Growth and structure of poly-aromatic thin films on metal and semiconductor substrates** (*Invited Paper*), N. V. Richardson, Univ. of St. Andrews (United Kingdom) ..... [6413-20]**SESSION 8****Room: Napier 208 ..... Wed. 11.40 to 12.50****Laser-assisted Nanofabrication***Chair: Jason P. Hayes*, MiniFAB (Aust) Pty Ltd. (Australia)11.40: **Three-dimensional deposition of silicon from silicate glass with dispersed metallic aluminum by a femtosecond laser** (*Invited Paper*), K. Miura, Y. Shimotsuma, S. Hamabe, K. Hirao, Kyoto Univ. (Japan) ..... [6413-21]12.10: **Laser interference deposition of silver-nanoparticles on glass**, F. Funabiki, Tokyo Institute of Technology (Japan) ..... [6413-22]12.30: **Nanosized modification of transparent materials using femtosecond laser irradiation**, S. Kanehira, K. Miura, K. Fujita, K. Hirao, Kyoto Univ. (Japan) ..... [6413-23]

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# Conference 6414 • Room: Napier 209: Concurrent Sessions/Napier 210

Monday-Wednesday 11-13 December 2006 • Proceedings of SPIE Vol. 6414

## Smart Structures, Devices, and Systems III

Conference Chair: **Said F. Al-Sarawi**, The Univ. of Adelaide (Australia)

Cochairs: **Vijay K. Varadan**, Univ. of Arkansas (USA); **Neil Weste**, NHEW R&D Pty Ltd. (Australia)

Program Committee: **Derek Abbott**, The Univ. of Adelaide (Australia); **Kamal Alameh**, Edith Cowan Univ. (Australia); **Mahmoud A. Al-Qutayri**, Etisalat Univ. College (United Arab Emirates); **Subhas Basu**, Silicon Interfaces (India); **Abdesselam S. Bouzerdoum**, Univ. of Wollongong (Australia); **Robert G. Clark**, Univ. of New South Wales (Australia); **Sorin D. Cotozana**, Technische Univ. Delft (Netherlands); **Bernard Courtois**, TIMA Lab. (France); **Paul D. Franzone**, North Carolina State Univ. (USA); **Manfred Glesner**, Technische Univ. Darmstadt (Germany); **Hedley J. Hansen**, Defence Science and Technology Organisation (Australia); **Sung-Mo Kang**, Univ. of California/Santa Cruz (USA); **Chee Yee Kwok**, Univ. of New South Wales (Australia); **Stefan W. Lachowicz**, Edith Cowan Univ. (Australia); **Kevin C. Liddiard**, Electro-optic Sensor Design (Australia); **Michael Liebelt**, The Univ. of Adelaide (Australia); **Warren Marwood**, Defence Science and Technology Organisation (Australia); **Alireza Moini**, Silverbrook Research Pty. Ltd. (Australia); **Ampalavanapillai Nirmalathas**, The Univ. of Melbourne (Australia); **Saeid Nooshabadi**, Univ. of New South Wales (Australia); **Adam Osseiran**, Edith Cowan Univ. (Australia); **Dimitris Pavlidis**, Univ. of Michigan (USA); **Richard Perks**, Cardiff Univ. (United Kingdom); **Braden J. Phillips**, The Univ. of Adelaide (Australia); **Jugdutt J. Singh**, La Trobe Univ. (Australia); **David V. Thiel**, Griffith Univ. (Australia)

### Monday 11 December

08.30 to 09.00 **Opening Remarks and Introduction**  
Plenary Presentations  
09:00 to 09.45 **Brownian Motion Reigning Manipulation and Transport on the Nanoscale**, P. Hänggi, Univ Augsburg (Germany)  
09:45 to 10.30 **Microphotonics for Signal Processing, Microfluidics, and Sensing**, B. J. Eggleton, The Univ. of Sydney (Australia)  
10.30 to 11.00 **Morning Tea**

Sessions 1-2-3 run concurrently with Sessions 4-5-6

#### SESSION 1

Room: Napier 209 ..... Mon. 11.00 to 12.10

##### Actuators I

- 11.00: **Design of a high-performance electrothermally driven vertical microactuator** (*Invited Paper*), M. Mayyas, The Univ. of Texas at Arlington (USA) ..... [6414-01]  
11.30: **State estimation of nonlinear piezoelectric stack actuator hysteresis and creep model**, J. L. Minase, T. Lu, F. Wornle, The Univ. of Adelaide (Australia) ..... [6414-02]  
11.50: **A two-level comb-driven electrostatic microrelay with low-actuation voltage**, G. Xu, Hefei Univ. of Technology (China) .... [6414-04]

Lunch Break ..... 12.10 to 13.30

#### SESSION 2

Room: Napier 209 ..... Mon. 13.30 to 15.00

##### Radio Frequency

- 13.30: **TCAM core design in 3D IC for low-matchline capacitance and low power** (*Invited Paper*), E. C. Oh, P. D. Franzone, North Carolina State Univ. (USA) ..... [6414-05]  
14.00: **A broadband 8-18GHz 4-input 4-output Butler matrix**, L. E. Milner, M. E. Parker, Defence Science and Technology Organisation (Australia) ..... [6414-06]  
14.20: **An optimized low-power voltage controlled oscillator**, K. V. Shah, H. P. Le, J. J. Singh, La Trobe Univ. (Australia) ..... [6414-08]  
14.40: **A high-frequency divider in 0.180  $\mu\text{m}$  SiGe BiCMOS technology**, N. Kamal, Y. Zhu, S. F. Al-Sarawi, The Univ. of Adelaide (Australia); N. Weste, Macquarie Univ. (Australia); D. Abbott, The Univ. of Adelaide (Australia) ..... [6414-09]

#### SESSION 4

Room: Napier 210 ..... Mon. 11.00 to 12.10

##### Polymers/PZT

- 11.00: **Modeling of a fluid-filled ionic polymer-metal composite cylindrical shell** (*Invited Paper*), L. Zhang, Y. Yang, Nanyang Technological Univ. (Singapore) ..... [6414-15]  
11.30: **Asymptotic analysis of thermal behavior of smart materials**, A. Almajid, Z. Abduljabbar, M. AlSadoon, King Saud Univ. (Saudi Arabia) ..... [6414-16]  
11.50: **Bending analysis of functionally graded piezoelectric actuator using Timoshenko beam theory**, H. Xiang, Beijing Jiaotong Univ. (China); J. Yang, S. Kitipornchai, K. Liew, City Univ. of Hong Kong (Hong Kong China) ..... [6414-17]

Lunch Break ..... 12.10 to 13.30

#### SESSION 5

Room: Napier 210 ..... Mon. 13.30 to 15.20

##### Photonic/THz

- 13.30: **Integrated microphotonic beamformer for broadband adaptive nulling in smart antennas** (*Invited Paper*), B. Juswady, K. Alameh, Edith Cowan Univ. (Australia) ..... [6414-19]  
14.00: **Microwire fibers for low-loss THz transmission**, S. Atakaramians, S. Afshar Vahid, H. Ebendorff-Heidepriem, B. M. Fischer, T. M. Monro, D. Abbott, The Univ. of Adelaide (Australia) ..... [6414-20]  
14.20: **Opto-VLSI-based reconfigurable free-space optical interconnects architecture**, M. Aljada, K. Alameh, Edith Cowan Univ. (Australia); Y. Lee, I. Chung, Gwangju Institute of Science and Technology (South Korea) ..... [6414-21]  
14.40: **Design and optimization of programmable lens arrays for adaptive optics**, Z. Wang, S. H. Eng, Edith Cowan Univ. (Australia); K. Alameh, Edith Cowan Univ. (Australia) ..... [6414-22]  
15.00: **Review of THz near-field methods**, H. Lin, B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6414-23]  
Afternoon Tea ..... 15.00 to 15.40

Concurrent Sessions (*continued*)

## SESSION 3

Room: Napier 209 ..... Mon. 15.40 to 17.30

## Sensors

- 15.40: **A novel strain sensor using organic semiconductor films on polymeric substrates** (*Invited Paper*), S. Jung, T. Ji, V. K. Varadan, Univ. of Arkansas (USA) ..... [6414-10]
- 16.10: **Physical modeling of a highly sensitive linear MOS sensor array system for 2D detection of magnetic fields**, A. Abou-Elnour, O. Abo-Elnor, Ajman Univ. of Science and Technology (United Arab Emirates) ..... [6414-11]
- 16.30: **Optimization of integrated antennas for wireless sensors**, M. Mussetta, A. Gandelli, R. E. Zich, Politecnico di Milano (Italy) ... [6414-12]
- 16.50: **Thin metal foil sensors**, A. R. Wilson, P. J. McMahon, R. F. Muscat, O. Vargas, P. S. Vincent, Defence Science and Technology Organisation (Australia) ..... [6414-13]
- 17.10: **Potential system efficiencies for MEMS vibration energy harvesting**, S. Behrens, Commonwealth Scientific and Industrial Research Organisation (Australia) ..... [6414-14]

## SESSION 6

Room: Napier 210 ..... Mon. 15.40 to 17.20

## Devices

- 15.40: **Thin films of zinc phthalocyanine (ZnPc) for optoelectronic devices**, M. Puri, Guru Nanak Dev Univ. (India) ..... [6414-24]
- 16.00: **Template synthesis of nano-/microresonant tunneling diodes**, S. K. Chakarvarti, National Institute of Technology/Kurukshetra (India) ..... [6414-25]
- 16.20: **Fuzzy control of shear-mode MR damper under impact force**, J. Joh, J. Cho, Changwon National Univ. (South Korea) ..... [6414-26]
- 16.40: **Development of a mechanical mover device by compositing hydrogen storage alloy thin films with a perfluorosulfonic acid layer**, T. Ogasawara, H. Uchida, Y. Nishi, Tokai Univ. (Japan) ..... [6414-27]
- 17.00: **Electro-acoustic and acousto-optic communications for robotic agents in smart structures**, G. Wild, S. Hinckley, Edith Cowan Univ. (Australia) ..... [6414-28]

## ✓ Posters-Monday

- ✓ **Prototype ROIC with differential pixel readout for uncooled IR detector arrays**, S. J. Hwang, Y. Kim, M. Sung, Korea Univ. (South Korea) ..... [6414-50]
- ✓ **Sanitizing solid state USB drives: how much destruction is enough?**, B. J. Phillips, The Univ. of Adelaide (Australia); C. Schmidt, The University of Adelaide (Australia) ..... [6414-58]
- ✓ **A reconfigurable photonic bandpass RF filter employing a semiconductor optical amplifier and an opto-VLSI processor**, R. Zheng, K. Alameh, Edith Cowan Univ. (Australia); Y. T. Lee, Dept of Information and Communications (South Korea) and Gwangju Institute of Science and Technology (South Korea); Z. Wang, Edith Cowan Univ. (Australia) ..... [6414-61]
- ✓ **Thin silicon shadow masks for organic light-emitting diodes deposition processes**, G. J. Su, National Taiwan Univ. (Taiwan) ..... [6414-62]
- ✓ **Fabrication of high-aspect-ratio coil for electromagnetic actuators using LIGA process**, D. Noda, Y. Matsumoto, S. Yamashita, M. Setomoto, T. Hattori, Univ. of Hyogo (Japan) ..... [6414-63]
- ✓ **A novel photoelectric system for optical intelligent structure health monitoring**, Z. Zhao, L. Guo, Y. Hou, J. Ma, K. Wang, Nanjing Univ. of Aeronautics and Astronautics (China) ..... [6414-64]
- ✓ **The effect of structure perturbation on PBG of one-dimensional photonic crystals**, L. Xia, J. Yurong, X. Wei, Y. Zhinong, L. Weiqiang, Beijing Institute of Technology (China) ..... [6414-65]
- ✓ **Multiwavelength oscillation DFB solid state dye laser with cascade arranged grating**, N. Nakai, M. Fukuda, Chitose Institute of Science and Technology (Japan) ..... [6414-66]
- ✓ **Fabrication of grating with Moire fringes and its application to solid state dye laser**, K. Miura, M. Fukuda, Chitose Institute of Science and Technology (Japan) ..... [6414-67]
- ✓ **Study of holographic grating in porous silicon optical waveguides**, Z. Jia, Xinjiang Univ. (China) ..... [6414-69]
- ✓ **Tunable properties of dielectrics thick film added MgO/Li<sub>2</sub>CO<sub>3</sub> to BST**, I. Kim, B. Min, J. Song, Korea Electrotechnology Research Institute (South Korea); S. Jeon, Kyungnam Univ. (South Korea) ..... [6414-70]
- ✓ **Temperature-insensitive strain sensing based on measurement of the reflected bandwidth from a tapered fiber grating**, X. Yang, Harbin Institute of Technology (China) ..... [6414-71]
- ✓ **Sensitivity calibration of a fiber Bragg grating strain sensor**, H. Ji, B. A. Wedding, L. Kong, H. Hsu, G. C. Lin, Univ. of South Australia (Australia); K. Fan, National Taiwan Univ. (Taiwan) ..... [6414-72]
- ✓ **Camphor sulfonic acid-doped polyaniline nanofiber-based 64° YX LiNbO<sub>3</sub> SAW hydrogen gas sensor**, W. B. Wlodarski, Royal Melbourne Institute of Technology (Australia) ..... [6414-73]
- ✓ **The modeling of coplanar waveguide transmission lines in multiple metal layer processes**, E. Heading, Flinders Univ. of South Australia (Australia); M. E. Parker, H. J. Hansen, Defence Science and Technology Organisation (Australia) ..... [6414-74]
- ✓ **Motion detection with a view toward VLSI implementation**, X. J. Tan, D. Kuan-Guan, T. J. Rainsford, S. F. Al-Sarawi, The Univ. of Adelaide (Australia) ..... [6414-75]
- ✓ **The effect on crosstalk and maximum quantum efficiency of inter-pixel ridges incorporated in a stacked gradient homojunction vertical single-junction photodiode architecture**, P. V. Jansz, S. Hinckley, Edith Cowan Univ. (Australia) ..... [6414-76]
- ✓ **Terahertz detection of substances for security related purposes**, B. S. Y. Ung, J. Balakrishnan, B. M. Fischer, B. W. H. Ng, D. Abbott, The Univ. of Adelaide (Australia) ..... [6414-77]
- ✓ **Grooved infrared polarizers with a reduced reflectance**, I. Yamada, Ryukoku Univ. (Japan); J. Nishii, National Institute of Advanced Industrial Science and Technology (Japan); M. Saito, Ryukoku Univ. (Japan) ..... [6414-81]
- ✓ **Optimized MEMS based reconfigurable VCO for a mobile receiver**, H. P. Le, J. J. Singh, La Trobe Univ. (Australia) ..... [6414-80]
- ✓ **Design and fabrication of metal oxide based gas sensor system for environmental monitoring**, G. Wiranto, R. Manurung, P. Hermida, M. R. T. Siregar, Indonesian Institute of Sciences (Indonesia) ..... [6414-81]
- ✓ **Development of a tendon driven system using a pneumatic balloon**, R. Sato, N. Saga, S. Chonan, Akita Prefectural Univ. (Japan) ..... [6414-82]
- ✓ **A compact optical fiber scanner for medical imaging**, N. Dhaubanjari, H. P. Hu, D. P. Dave, P. Phuyal, J. Sin, H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA) ..... [6414-83]
- ✓ **Investigation of vertical displacement thermal actuators**, N. Dhaubanjari, S. M. N. Rao, H. Lun-Chen, M. Luquire, D. Popa, The Univ. of Texas/Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada); H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA) ..... [6414-84]
- ✓ **A cantilever-type electrostatic zipping actuator**, N. Dhaubanjari, S. M. N. Rao, Y. Cai, D. Popa, The Univ. of Texas/Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada); J. Chiao, The Univ. of Texas/Arlington (USA) ..... [6414-85]
- ✓ **An RNS public key cryptography accelerator**, T. Coleman, J. Kitchener, D. Pudney, K. Wauchope, B. J. Phillips, The Univ. of Adelaide (Australia) ..... [6414-86]
- ✓ **Control performance of pneumatic artificial muscle**, N. Saga, Akita Prefectural Univ. (Japan) ..... [6414-87]
- ✓ **Implementation of saturation for modeling pattern noise using naturalistic stimuli**, S. Rajesh, T. J. Rainsford, R. S. A. Brinkworth, D. Abbott, D. C. O'Carroll, The Univ. of Adelaide (Australia) ..... [6414-88]
- ✓ **An active locking mechanism for assembling 3D microstructures**, P. Zhang, M. Mayyas, W. H. Lee, D. Popa, P. S. Shiakolas, H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA) ..... [6414-89]
- ✓ **Characteristic comparison between McKibben type artificial muscles and straight fibers type artificial muscles**, T. Nakamura, Chuo University (Japan) ..... [6414-90]

## Tuesday 12 December

|  |
|--|
| 08.50 to 09.00 <b>Introduction</b>   |
| Plenary Presentations  |
| 09:00 to 09.45 <b>Microfluidic Analytical Systems for High-Throughput Multiplexed Bio-assays</b> , H. Morgan, Univ of Southampton (United Kingdom) |
| 09:45 to 10.30 <b>Spontaneous Organisation of Adsorbed Molecules</b> , P. Beton, The Univ. of Nottingham (United Kingdom)                          |
| 10.30 to 11.00 <b>Morning Tea</b>  |

### SESSION 7

Room: Napier 209 ..... Tues. 11.00 to 12.30

#### Actuators II

- 11.00: **A hybrid magnetic and piezoelectric polymer microactuator** (*Invited Paper*), Y. Fu, Silverbrook Research Pty Ltd. (Australia); M. K. Ghantasala, Western Michigan Univ. (USA); E. C. Harvey, Swinburne Univ. of Technology (Australia) ..... [6414-30]
- 11.30: **Gold electrode fabrication to a cellulose surface for operating microwave-driven paper actuator**, K. S. Kang, Inha Univ. (South Korea) ..... [6414-31]
- 11.50: **Magnetic actuation for microfluidics based on ferrofluid droplets**, N. Nguyen, X. Huang, Nanyang Technological Univ. (Singapore) ..... [6414-32]
- 12.10: **Improving the security and actuation of wireless controlled microvalve**, A. C. Tikka, S. F. Al-Sarawi, D. Abbott, The Univ. of Adelaide (Australia) ..... [6414-33]
- Lunch Break ..... 12.30 to 13.30

### SESSION 8

Room: Napier 209 ..... Tues. 13.30 to 14.50

#### Structures Monitoring

- 13.30: **Design of a multiple input sensor for strain threshold testing**, D. S. Macnamara, D. V. Thiel, P. Lisner, Griffith Univ. (Australia) ..... [6414-35]
- 13.50: **Health assessment of bonded composite repairs with frequency response techniques**, C. M. White, Royal Melbourne Institute of Technology (Australia); B. Wittingham, Monash Univ. (Australia); H. C. H. Li, Royal Melbourne Institute of Technology (Australia); I. Herszberg, Cooperative Research Ctr. for Advanced Composite Structures Ltd. (Australia); A. P. Mouritz, Royal Melbourne Institute of Technology (Australia) ..... [6414-42]
- 14.10: **Influence of loading on structures actuated with piezoceramic transducers (PZT) for use in structural health monitoring**, V. G. Annamdas, Y. Yang, C. K. Soh, Nanyang Technological Univ. (Singapore) ..... [6414-37]
- 14.30: **Multi-zone HVAC control systems from existing single-zone systems using wireless sensor networks**, A. Redfern, M. Koplow, P. Wright, Univ. of California/Berkeley (USA) ..... [6414-38]
- Afternoon Tea ..... 14.50 to 15.40

### SESSION 9

Room: Napier 209 ..... Tues. 15.40 to 17.10

#### Analog/Digital Circuits

- 15.40: **A small low-power networked and versatile sensor interface** (*Invited Paper*), P. S. Vincent, P. J. McMahon, R. F. Muscat, L. Zeve, A. R. Wilson, Defence Science and Technology Organisation (Australia) ..... [6414-39]
- 16.10: **Fourth-order discrete-time variable center frequency bandpass Sigma-Delta modulator**, Y. Zhu, Univ. of Adelaide (Australia) ..... [6414-40]
- 16.30: **An open source synthesisable VHDL model of a 64-bit MIPS-based processor**, D. R. Kelly, B. J. Phillips, S. F. Al-Sarawi, The Univ. of Adelaide (Australia) ..... [6414-41]
- 16.50: **A data transport layer for parallel matrix computation**, A. Burdeniuk, C. Lim, M. Liebelt, The Univ. of Adelaide (Australia) ..... [6414-43]

## Wednesday 13 December

|   |
|---|
| 08.50 to 09.00 <b>Introduction</b>  |
| Plenary Presentations   |
| 09:00 to 09.45 <b>The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders</b> , V. K. Varadan, Univ. of Arkansas (USA) |
| 09:45 to 10.30 <b>All-optical Processing for Advanced Communications Systems</b> , B. Luther-Davies, The Australian National Univ. (Australia)  |
| 10.30 to 11.00 <b>Morning Tea</b>   |

### SESSION 10

Room: Napier 209 ..... Wed. 11.00 to 12.00

#### Fibers

- 11.00: **Optimal configurations of active fiber composites based on asymptotic torsional analysis**, D. Harursampath, A. K. Tamrakar, Indian Institute of Science (India) ..... [6414-45]
- 11.20: **Macro-fiber composite (MFC) as a delamination sensor in antisymmetric laminates**, S. Hari Krishna, Indian Space Research Organisation (India); H. Dineshkumar, Indian Institute of Science (India) ..... [6414-46]
- 11.40: **Study on micro-bend light transmission performance of novel liquid-core optical fiber in smart structures**, J. Ma, Qingdao Univ. (China) and Nanjing Univ. of Aeronautics and Astronautics (China); Z. Zhimin, W. Kaisheng, G. Linfeng, Nanjing Univ. of Aeronautics and Astronautics (China) ..... [6414-48]
- Lunch Break ..... 12.00 to 13.30

### SESSION 11

Room: Napier 209 ..... Wed. 13.30 to 14.30

#### Imagers and Vision

- 13.30: **Pixel-wise adaptive imaging**, R. S. A. Brinkworth, E. Mah, D. C. O'Carroll, The Univ. of Adelaide (Australia) ..... [6414-49]
- 13.50: **MOEMS development of infrared security sensors**, K. C. Liddiard, Electro-optic Sensor Design (Australia) ..... [6414-51]
- 14.10: **Bio-inspired optical rotation sensor**, D. C. O'Carroll, The Univ. of Adelaide (Australia); P. A. Shoemaker, Tanner Research, Inc. (USA); R. S. A. Brinkworth, The Univ. of Adelaide (Australia) ..... [6414-52]

### SESSION 12

Room: Napier 209 ..... Wed. 14.30 to 16.30

#### Process/Technology

- 14.30: **An integrated MEMS design synthesis architecture using case-based reasoning and multi-objective genetic algorithms** (*Invited Paper*), C. L. Cobb, Y. Zhang, A. M. Agogino, Univ. of California/Berkeley (USA) ..... [6414-53]
- Afternoon Tea ..... 15.00 to 15.30
- 15.30: **Response improvement of a mover device using hydrogen storage alloy powder by addition of a catalyst**, A. Sato, K. Akazawa, T. Ogasawara, H. Uchida, Y. Nishi, Tokai Univ. (Japan) ..... [6414-54]
- 15.50: **Nickel and titanium silicide formation from sputtered and evaporated metals: a comparison**, M. Bhaskaran, S. Sriram, A. S. Holland, Royal Melbourne Institute of Technology (Australia) ..... [6414-55]
- 16.10: **Structural, optical, and electrical characterization of cadmium oxide thin films**, G. M. Choudhury, Univ. of Rajshahi (Bangladesh) ..... [6414-56]

# Micro- and Nanotechnology: Materials, Processes, Packaging, and Systems III

Conference Chair: **Jung-Chih Chiao**, The Univ. of Texas at Arlington (USA)

Cochairs: **Andrew S. Dzurak**, Univ. of New South Wales (Australia); **Chennupati Jagadish**, The Australian National Univ. (Australia); **David V. Thiel**, Griffith Univ. (Australia)

Program Committee: **Derek Abbott**, The Univ. of Adelaide (Australia); **Richard J. Blaikie**, Univ. of Canterbury (New Zealand); **Simon A. Brown**, Univ. of Canterbury (New Zealand); **Carles Cané**, Ctr. Nacional de Microelectrónica (Spain); **Mu Chiao**, The Univ. of British Columbia (Canada); **Franck A. Chollet**, Nanyang Technological Univ. (Singapore); **Nicolaas F. de Rooij**, Univ. de Neuchâtel (Switzerland); **John M. Dell**, The Univ. of Western Australia (Australia); **Robert G. Elliman**, The Australian National Univ. (Australia); **Masayoshi Esashi**, Tohoku Univ. (Japan); **Lorenzo Faraone**, The Univ. of Western Australia (Australia); **Paul D. Franzon**, North Carolina State Univ. (USA); **Thomas George**, ViaLogy Corp. (USA); **Katia M. Grenier**, LAAS-CNRS (France); **Alex R. Hamilton**, Univ. of New South Wales (Australia); **Kazuhiro Hane**, Tohoku Univ. (Japan); **Alex J. Hariz**, Univ. of South Australia (Australia); **Erol C. Harvey**, Swinburne Univ. of Technology (Australia); **Huey Hoon Hng**, Nanyang Technological Univ. (Singapore); **Ciprian I. Iliescu**, Institute of Bioengineering and Nanotechnology (Singapore); **Chantal G. Khan-Malek**, Ctr. National de la Recherche Scientifique (France); **Yong-Hyup Kim**, Seoul National Univ. (South Korea); **Youngwoo Kwon**, Seoul National Univ. (South Korea); **Ronald A. Lawes**, Imperial College London (United Kingdom); **Woo Ho Lee**, The Univ. of Texas at Arlington (USA); **Mary J. Li**, NASA Goddard Space Flight Ctr. (USA); **Lih-Yuan Lin**, Univ. of Washington (USA); **Liwei Lin**, Univ. of California/Berkeley (USA); **Victor M. Lubecke**, Univ. of Hawai'i at Manoa (USA); **Barry Luther-Davies**, The Australian National Univ. (Australia); **Robert M. Mehalso**, Microtec Associates (USA); **Meyya Meyyappan**, NASA Ames Research Ctr. (USA); **Giacinta Parish**, The Univ. of Western Australia (Australia); **Steven D. Prawer**, The Univ. of Melbourne (Australia); **Olaf Reinhold**, Defence Science and Technology Organisation (Australia); **Olivia M. Samardzic**, Defence Science and Technology Organisation (Australia); **Kazuo Sato**, Nagoya Univ. (Japan); **Michael S. Shur**, Rensselaer Polytechnic Institute (USA); **Yu-Chuan Su**, National Tsing Hua Univ. (Taiwan); **Hitoshi Tabata**, Osaka Univ. (Japan); **Hark Hoe Tan**, The Australian National Univ. (Australia); **Ooi-Kiang Tan**, Nanyang Technological Univ. (Singapore); **Kazuyoshi Tsuchiya**, Tokai Univ. (Japan); **Sai Peng Wong**, The Chinese Univ. of Hong Kong (Hong Kong China)

## Monday 11 December

08.30 to 09.00 **Opening Remarks and Introduction**

Plenary Presentations

09:00 to 09.45 **Brownian Motion Reigning Manipulation and Transport on the Nanoscale**, P. Hänggi, Univ Augsburg (Germany)

09:45 to 10.30 **Microphotronics for Signal Processing, Microfluidics, and Sensing**, B. J. Eggleton, The Univ. of Sydney (Australia)

10.30 to 11.00 **Morning Tea**

### SESSION 1

Room: Napier LG24 ..... Mon. 11.00 to 12.20

#### Nanotechnology

Chair: **Jung-Chih Chiao**, The Univ. of Texas at Arlington (USA)

11.00: **Effect of annealing temperature on the formation of silicon nanocrystals in a nitride matrix**, G. Scardera, T. Puzzer, E. Pink, T. Fangsuwannarak, G. Conibeer, M. A. Green, Univ. of New South Wales (Australia) ..... [6415-02]

11.20: **Effect of sonication on the mechanical properties of poly (vinyl alcohol)/carbon nanotube composites**, V. Truong, K. Tsang, S. Keough, N. St John, Defence Science and Technology Organisation (Australia) ..... [6415-03]

11.40: **Optical properties of covalently anchored single-walled carbon nanotube arrays on silicon (100) surfaces**, J. Yu, J. G. Shapter, J. S. Quinton, M. Johnston, Flinders Univ. (Australia); D. Beattie, Univ. of South Australia (Australia) ..... [6415-04]

12.00: **Optical and micro-structural investigations in nanostructured doped PT and PZT piezoceramics**, E. E. Dimitriu, REGO COM SRL (Romania); M. Sima, V. Ghiordanescu, National Institute for Materials Physics (Romania); R. Ramer, Univ. of New South Wales (Australia); G. V. Aldica, National Institute of Materials Physics (Romania) ..... [6415-66]

Lunch Break ..... 12.20 to 13.30

### SESSION 2

Room: Napier LG24 ..... Mon. 13.30 to 15.20

#### Photonics

Chair: **Mary J, Li**, NASA Goddard Space Flight Ctr. (USA)

Keynote Presentation

13.30: **In(Ga)As/GaAs quantum dots for optoelectronic devices (Invited Paper)**, K. Sears, S. Mokkaapati, M. Buda, J. Wong-Leung, H. H. Tan, C. Jagadish, The Australian National Univ. (Australia) ..... [6415-05]

14.00: **Study of size dispersion and trapped states with aging for CdSxSe1-x quantum dots in glass matrix**, S. Nagpal, Univ. of Delhi (India) ..... [6415-06]

14.20: **Effects of silicon nanocrystallite density on the Raman-scattering spectra of silicon quantum dot superlattices**, T. Fangsuwannarak, E. Pink, Y. Huang, G. Scardera, G. Conibeer, M. A. Green, Univ. of New South Wales (Australia) ..... [6415-07]

14.40: **GaN membrane MSM ultraviolet photodetectors**, A. Muller, IMT Bucharest (Romania); G. Konstantinidis, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Neculoiu, National Institute for Research and Development in Microtechnologies (Romania); A. Kostopoulos, Institute of Electronic Structure and Laser of the Foundation for Research and Development in Microtechnologies (Romania); M. Androulidaki, M. Kayambaki, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Vasilache, C. Buiculescu, I. Petrini, D. C. Dascalescu, National Institute for Research and Development in Microtechnologies (Romania) .... [6415-08]

15.00: **Analysis of AlN/GaN quantum dots: coupled effects**, R. V. N. Melnik, D. R. Mahapatra, Wilfrid Laurier Univ. (Canada) ..... [6415-67]

Afternoon Tea ..... 15.20 to 16.00

## SESSION 3

Room: Napier LG24 ..... Mon. 16.00 to 18.10

## Applications

Chair: Kallistra K. Sears, The Australian National Univ.  
(Australia)

## Keynote Presentation

16.00: **MEMS microshutter arrays for James Webb Space Telescope** (*Invited Paper*), M. J. Li, M. A. Beamesderfer, R. S. Babu, S. Bajikar, A. J. Ewin, D. E. Franz, L. A. Hess, R. Hu, M. D. Jhabvala, D. P. Kelly, T. T. King, G. Kletetschka, A. S. Kuttyrev, B. A. Lynch, S. H. Moseley, Jr., D. B. Mott, L. Oh, D. A. Rapchun, C. Ray, C. Sappington, R. F. Silverberg, W. Smith, S. J. Snodgrass, R. Steptoe-Jackson, V. Valeriano, L. L. Wang, C. A. Zincke, NASA Goddard Space Flight Ctr. (USA) ..... [6415-11]

16.30: **Millimeter-wave monolithic integrated receivers based on GaAs micromachining**, G. Konstantinidis, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Neculoiu, National Institute for Research and Development in Microtechnologies (Romania); A. Stavrinidis, Z. Chatzopoulos, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); A. Muller, National Institute for Research and Development in Microtechnologies (Romania); K. Tsagaraki, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Vasilache, I. Petrini, C. Buiculescu, National Institute for Research and Development in Microtechnologies (Romania); L. Bary, R. Plana, LAAS-CNRS (France) ..... [6415-12]

16.50: **Theoretical and experimental investigation of thermocapillary actuation for microplugs**, N. Nguyen, Z. Jiao, X. Huang, Nanyang Technological Univ. (Singapore) ..... [6415-13]

17.10: **Silicon-on-insulator microdosimeter for radiobiology**, W. H. Lim, Univ. of New South Wales (Australia) and Univ. of Wollongong (Australia) and Australian Nuclear Science and Technology Organisation (Australia); A. S. Dzurak, Univ. of New South Wales (Australia); I. Cornelius, A. Rosenfeld, Univ. of Wollongong (Australia); M. Reinhard, Australian Nuclear Science and Technology Organisation (Australia) ..... [6415-14]

17.30: **A hydraulic micro-actuator with an integrated inductive position sensor**, M. De Volder, F. S. G. Ceysens, J. Coosemans, A. J. M. Moers, Katholieke Univ. Leuven (Belgium); O. Smal, Katholieke de Louvain (Belgium); J. Peirs, R. Puers, Katholieke Univ. Leuven (Belgium); B. Raucant, Univ. Catholique de Louvain (Belgium); D. F. Reynaerts, Katholieke Univ. Leuven (Belgium) ..... [6415-15]

17.50: **Characterisation of a CMP nanoscale planarisation-based process for RF MEMS micromechanical resonators**, S. Enderling, H. Lin, A. C. H. Broek, J. T. M. Stevenson, A. J. Walton, Univ. of Edinburgh (United Kingdom) ..... [6415-16]

## ✓ Posters-Monday

- ✓ **Amphiphilic block copolymer nanotubes stabilized by photopolymerization**, R. B. Kishore, A. Jofre, J. B. Hutchison, L. E. Locascio, K. Helmerston, National Institute of Standards and Technology (USA) ..... [6415-01]
- ✓ **Managing design for manufacture and assembly in the development of MEMS-based products**, H. Hsu, N. Narasimhan, A. J. Hariz, Univ. of South Australia (Australia) ..... [6415-29]
- ✓ **Low-temperature synthesis and thermal study of Manganese-Zinc ferrite nanoparticles by a ferriolate precursor method**, M. L. Gera, M. Singh, Himachal Pradesh Univ. (India) ..... [6415-36]
- ✓ **Self-operated blood plasma separation using micropump in polymer-based microfluidic device**, W. I. Jang, K. H. Chung, H. B. Pyo, S. H. Park, Electronics and Telecommunications Research Institute (South Korea) ..... [6415-38]
- ✓ **Structural studies of SnS films prepared by thermal evaporation**, S. Cheng, Fuzhou Univ. (China) ..... [6415-39]
- ✓ **Accuracy and limitation of improved Rayleigh-Sommerfeld Method 1 for analyzing the focusing characteristics of cylindrical microlenses with small f-number**, J. Liu, Beijing Jiaotong Univ. (China) ..... [6415-40]
- ✓ **Development of nanostructured titanium-oxide thin films using a gas carving technique**, D. Dhawan, Y. M. Sabri, S. K. Bhargava, K. K. Zadeh, D. K. Sood, Royal Melbourne Institute of Technology (Australia) ..... [6415-42]
- ✓ **Fabrication processes of MEMS phase shifters on polymer-based substrates**, J. Wang, Y. Cai, T. Ativanichayaphong, W. Huang, L. Hsu, J. Chiao, The Univ. of Texas at Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada) ..... [6415-43]

- ✓ **Multiclass T-ray signal classification via support vector machines**, X. Yin, B. W. H. Ng, The Univ. of Adelaide (Australia); B. S. Ferguson, Tenix Corp. (Australia); S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6415-44]
- ✓ **Computational thermal analysis of a continuous-flow micropolymerase chain reaction (PCR) chip**, S. Dharmalingam, M. A. Ashraf, L. Kong, Univ. of South Australia (Australia) ... [6415-45]
- ✓ **Fabrication of flexible field emitter using electrostatic layer-by-layer assembled carbon nanotube multilayer film**, X. Yan, Z. J. Han, P. C. T. Ha, B. K. Tay, Nanyang Technological Univ. (Singapore) ..... [6415-46]
- ✓ **Textural properties of Fe-SBA-15 nanostructured materials by controlling aging time of hydrothermal synthesis**, P. T. Dang, P. H. Nguyen, Vietnamese Academy of Science and Technology (Vietnam); K. Q. Dinh, S. T. Le, Hue Univ. (Vietnam) ..... [6415-48]
- ✓ **Synthesis, characterization, and catalytic properties of Ti-containing SBA-15 nanostructured materials**, P. T. Dang, H. G. Le, T. C. Dinh, D. V. Hoang, Y. Hoang, T. A. Vu, L. H. Bui, H. T. K. Tran, Vietnamese Academy of Science and Technology (Vietnam) ..... [6415-50]
- ✓ **Photocatalytic oxidation and reduction over some nanosized TiO<sub>2</sub> catalysts**, Y. Hoang, L. H. Bui, T. C. Dinh, P. T. Dang, T. A. Vu, Vietnamese Academy of Science and Technology (Vietnam) ..... [6415-51]
- ✓ **Study on photocatalytic performance of nano- and microstructured materials**, T. C. Dinh, Y. Hoang, L. H. Bui, L. K. Le, P. T. Dang, T. A. Vu, H. M. Do, V. Q. Tran, Vietnamese Academy of Science and Technology (Vietnam) ..... [6415-52]
- ✓ **Methane detection with semiconductor oxide SnO<sub>2</sub> obtained by sol-gel method**, G. G. Telipan, Jr., M. M. Ignat, Institutul National de Cercetare (Romania); V. Parvulescu, S. Somacescu, Institute of Physical Chemistry (Romania) ..... [6415-55]
- ✓ **Control of cohesive-force ordering in organic-inorganic hybrid pillar arrays**, H. Segawa, S. Yamaguchi, T. Yano, S. Shibata, Tokyo Institute of Technology (Japan) ..... [6415-56]
- ✓ **Fabrication of inexpensive metallic mould for nanoimprinting using colloidal monolayers as a nanomask**, M. Ashraf, A. Sreenath, F. A. Chollet, Nanyang Technological Univ. (Singapore) ..... [6415-57]
- ✓ **Pattern transfer over extreme topographies using a SU-8 leveling process**, F. S. G. Ceysens, R. Puers, Katholieke Univ. Leuven (Belgium) ..... [6415-58]
- ✓ **A new technique for preparing PSG film using rf magnetron sputtering**, S. Chandra, V. Bhatt, Indian Institute of Technology Delhi (India) ..... [6415-59]
- ✓ **Adhesive wafer-to-wafer bonding using contact imprinting**, L. Yu, National Univ. of Singapore (Singapore) and Institute of Bioengineering and Nanotechnology (Singapore); A. J. Pang, B. Chen, Institute of Bioengineering and Nanotechnology (Singapore) and National Univ. of Singapore (Singapore); C. I. Iliescu, Institute of Bioengineering and Nanotechnology (Singapore) ..... [6415-60]
- ✓ **Nanosphere lithography using thermal evaporation of gold**, B. S. Flavel, J. G. Shapter, Flinders Univ. (Australia); J. S. Quinton, Flinders Univ. of South Australia (Australia) ..... [6415-61]
- ✓ **Analysis of the sharp increase in the specific heat of single-wall carbon nanotube ropes due to the absorption of helium atoms in the temperature range 2-20 K**, S. Tewari, P. Silotia, S. Dabas, A. Saxena, Univ. of Delhi (India) ..... [6415-62]
- ✓ **A new disposable MEMS-based manometric catheter for in-vivo medical tests**, M. Teng, A. J. Hariz, H. Hsu, Univ. of South Australia (Australia) ..... [6415-63]
- ✓ **Optimization of wireless and batteryless power transmission for micro implants in-vivo environments**, V. J. Baxi, A. J. Hariz, Univ. of South Australia (Australia) ..... [6415-64]
- ✓ **Deformable grating modulator array for use as wavelength-selective switch**, A. Pothisorn, A. J. Hariz, Univ. of South Australia (Australia) ..... [6415-65]

**Tuesday 12 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **Microfluidic Analytical Systems for High-Throughput Multiplexed Bio-assays**, H. Morgan, Univ of Southampton (United Kingdom)09:45 to 10.30 **Spontaneous Organisation of Adsorbed Molecules**, P. Beton, The Univ. of Nottingham (United Kingdom)10.30 to 11.00 **Morning Tea****SESSION 4****Room: Napier LG24 ..... Tues. 11.00 to 12.20****Fabrication***Chair: David V. Thiel, Griffith Univ. (Australia)*11.00: **Microfabrication of PLLA polymer by X-ray lithography**, Y. Li, S. Sigiya, Ritsumeikan Univ. (Japan) ..... [6415-17]11.20: **High-productivity DRIE solutions for 3D-SiP and MEMS volume manufacturing**, M. Puech, J. Thevenoud, N. Launay, P. Godinat, N. Arnal, Alcatel Vacuum Technology (France) ..... [6415-18]11.40: **Surface morphology and stress analysis of piezoelectric strontium-doped lead zirconate titanate thin films**, S. Sriram, M. Bhaskaran, A. S. Holland, Royal Melbourne Institute of Technology (Australia) ..... [6415-19]12.00: **Fabrication of forward type DC-DC converter using nanocrystalline Mn-Zn ferrites**, S. R. Murthy, Osmania Univ. (India) ..... [6415-20]

Lunch Break ..... 12.20 to 13.30

**SESSION 5****Room: Napier LG24 ..... Tues. 13.30 to 15.20****Materials***Chair: Robert M. Mehals, Microtec Associates (USA)***Keynote Presentation**13.30: **Low-stress silicon nitride layers for MEMS applications (Invited Paper)**, C. I. Iliescu, J. Wei, B. Chen, P. L. Ong, Institute of Bioengineering and Nanotechnology (Singapore); F. E. H. Tay, Institute of Bioengineering and Nanotechnology (Singapore) and National Univ. of Singapore (Singapore) ..... [6415-21]14.00: **Structural and magnetic properties of cobalt implanted TiO<sub>2</sub> thin films**, W. Y. Luk, S. P. Wong, N. Ke, Q. Li, The Chinese Univ. of Hong Kong (Hong Kong China) ..... [6415-23]14.20: **T-ray antireflection coating**, W. Withayachumnankul, B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6415-24]14.40: **Formation of silicon nanoislands on c-Si substrate by thermal annealing of silicon rich oxide deposited by LPCVD**, Z. Yu, Nankai Univ. (China); M. Aceves, A. Luna-López, Instituto Nacional de Astrofísica, Óptica y Electrónica (Mexico); J. Du, D. Bian, Tianjin Polytechnic Univ. (China) ..... [6415-25]15.00: **Development of MgSiO<sub>3</sub> biocompatible piezoelectric film for bio-MEMS actuator**, K. Maeda, Osaka Institute of Technology (Japan); K. Tsuchiya, Tokai Univ. (Japan); T. Uenoya, Advanced Software Technology & Mechatronics Research Institute of Kyoto (Japan); Y. Uetsuji, E. Nakamachi, Osaka Institute of Technology (Japan) .. [6415-26]

Afternoon Tea ..... 15.20 to 16.00

**SESSION 6****Room: Napier LG24 ..... Tues. 15.50 to 17.20****Packaging and Manufacturing***Chair: Jung-Chih Chiao, The Univ. of Texas at Arlington (USA)***Keynote Presentation**15.50: **Packaging challenges and opportunities for micro- and nanosystems-based products (Invited Paper)**, R. M. Mehals, Microtec Associates (USA) ..... [6415-27]16.20: **Optimization of MEMS fabrication process design by virtual experiments**, K. Hahn, T. Schmidt, Univ. Siegen (Germany); T. Binder, Silvaco Data Systems (United Kingdom); A. Wagener, J. Popp, R. Brueck, Univ. Siegen (Germany) ..... [6415-28]16.40: **Aspects of laser micromachining for sensor prototyping**, P. J. McMahon, P. S. Vincent, A. R. Wilson, R. F. Muscat, Defence Science and Technology Organisation (Australia) ..... [6415-30]17.00: **Maskless lithography using off-the-shelf inkjet printer**, C. Leo, F. A. Chollet, Nanyang Technological Univ. (Singapore) ..... [6415-31]**Wednesday 13 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders**, V. K. Varadan, Univ. of Arkansas (USA)09:45 to 10.30 **All-optical Processing for Advanced Communications Systems**, B. Luther-Davies, The Australian National Univ. (Australia)10.30 to 11.00 **Morning Tea****SESSION 7****Room: Napier LG24 ..... Wed. 11.00 to 12.20****Fluidics/Bio-applications***Chair: Cipriani I. Iliescu, Institute of Bioengineering and Nanotechnology (Singapore)*11.00: **Microfluidic device with asymmetric electrodes for the delivery of cells and reagents**, G. Xu, D. Y. S. Lee, Institute of Bioengineering and Nanotechnology (Singapore); H. K. Tay, C. Yang, Nanyang Technological Univ. (Singapore); J. Y. Ying, Massachusetts Institute of Technology (USA) ..... [6415-32]11.20: **BioMEMS for the determination of rheological properties of biological fluids**, A. M. Avram, M. Avram, IMT-Bucharest (Romania); C. Iliescu, Institute of Bioengineering and Nanotechnology (Singapore); M. Volmer, Transilvania Univ. (Romania) ..... [6415-33]11.40: **A novel technique for immobilizing nanoparticles on a substrate through the epoxy-amino cross-linking**, O. Shogo, O. Kazufumi, Kagawa Univ. (Japan) ..... [6415-34]12.00: **A ferrofluid seal technology for hydraulic microactuators**, M. De Volder, D. F. Reynaerts, Katholieke Univ. Leuven (Belgium) ..... [6415-35]

# Biomedical Applications of Micro- and Nanoengineering III

Conference Chair: **Dan V. Nicolau**, The Univ. of Liverpool (United Kingdom)

Cochairs: **Joe G. Shapter**, Flinders Univ. (Australia); **Derek Abbott**, The Univ. of Adelaide (Australia)

Program Committee: **Maan M. Alkaisi**, Univ. of Canterbury (New Zealand); **John M. Bell**, Queensland Univ. of Technology (Australia); **Shin-Ho Chung**, The Australian National Univ. (Australia); **Paul Dan A. Cristea**, Univ. Politehnica Bucharest (Romania); **Piotr Grodzinski**, National Institutes of Health (USA); **Min Gu**, Swinburne Univ. of Technology (Australia); **Abraham P. Lee**, Univ. of California/Irvine (USA); **Torsten Lehmann**, Univ. of New South Wales (Australia); **Nigel H. Lovell**, Univ. of New South Wales (Australia); **Don McNaughton**, Monash Univ. (Australia); **Gottfried Otting**, The Australian National Univ. (Australia); **Tamath J. Rainsford**, The Univ. of Adelaide (Australia); **Takahisa Taguchi**, National Institute of Advanced Industrial Science and Technology (Japan)

## Monday 11 December

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| 08.30 to 09.00 <b>Opening Remarks and Introduction</b>   |
| Plenary Presentations  |
| 09:00 to 09.45 <b>Brownian Motion Reigning Manipulation and Transport on the Nanoscale</b> , P. Hänggi, Univ Augsburg (Germany)          |
| 09:45 to 10.30 <b>Microphotonics for Signal Processing, Microfluidics, and Sensing</b> , B. J. Eggleton, The Univ. of Sydney (Australia) |
| 10.30 to 11.00 <b>Morning Tea</b>  |

### SESSION 1

Room: Napier LG23 ..... Mon. 11.00 to 12.20

#### Nanoscale Interactions and Devices I

Chair: **Dan V. Nicolau**, The Univ. of Liverpool (United Kingdom)

11.00: **DNA-sensors based on functionalized conducting polymers and quantum dots (Invited Paper)**, C. Soeller, H. Peng, T. Kjällman, J. Travas-Sejdic, Univ. of Auckland (New Zealand) ..... [6416-01]

11.40: **EB induced wetting of polypropylene surface**, H. Sato, T. Shimmi, K. Iwata, M. Kanda, A. Tonegawa, Y. Nishi, Tokai Univ. (Japan) ..... [6416-02]

12.00: **Diffusion of polymeric chains in nano-confined spaces**, P. J. Livingston, R. Boysen, D. V. Nicolau, Monash Univ. (Australia) .. [6416-03]

Lunch Break ..... 12.20 to 13.30

### SESSION 2

Room: Napier LG23 ..... Mon. 13.30 to 15.10

#### Nanoscale Interactions and Devices II

Chair: **Dan V. Nicolau**, The Univ. of Liverpool (United Kingdom)

13.30: **Fluorescent intensity-based differential counting of FITC-doped silica nanoparticles: applications of CD4+ T-cell detection in microchip-type flowcytometers**, H. Yun, H. Bang, W. G. Lee, Seoul National Univ. (South Korea); J. Park, Digital Bio Technology, Inc. (South Korea); J. Lee, Seoul National Univ. (South Korea); A. Riaz, Univ. of California/Berkeley (USA); K. Cho, C. Chung, Digital Bio Technology, Inc. (South Korea); D. Han, Seoul National Univ. (South Korea); J. K. Chang, Digital Bio Technology, Inc. (South Korea) ..... [6416-04]

13.50: **Switchable surface coatings for control over protein adsorption**, M. A. Cole, Univ. of South Australia (Australia); N. H. Voelcker, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); R. G. Horn, H. J. Griesser, Univ. of South Australia (Australia) ..... [6416-05]

14.10: **Low-frequency vibrational modes of biologically important isomers**, I. Jones, T. J. Rainsford, B. M. Fischer, D. Abbott, The Univ. of Adelaide (Australia) ..... [6416-06]

14.30: **Enzyme electrodes immobilized on hetero-structured metallic nanowire array for glucose sensing**, H. Yoon, D. Deshpande, R. R. Chintakuntla, V. K. Varadan, Univ. of Arkansas (USA) ..... [6416-08]

14.50: **Binding of mouse immunoglobulin G to polylysine-coated glass substrate for immundiagnosis**, S. K. Vashist, Univ. of Genoa (Italy) ..... [6416-09]

Afternoon Tea ..... 15.10 to 16.00

### SESSION 3

Room: Napier LG23 ..... Mon. 16.00 to 17.20

#### BioMEMS

Chair: **Ciprian I. Iliescu**, Institute of Bioengineering and Nanotechnology (Singapore)

16.00: **Development of blood extraction pump by shape-memory alloy actuator for bio-MEMS**, K. Tsuchiya, Y. Shimazu, Tokai Univ. (Japan); Y. Uetsuji, E. Nakamachi, Osaka Institute of Technology (Japan) ..... [6416-10]

16.20: **Compensation of nonlinearities in a piezoelectric Stack actuator with application in intra-cytoplasmic sperm injection**, A. S. Putra, K. K. Tan, T. H. Lee, S. K. Panda, S. Huang, S. Zhao, National Univ. of Singapore (Singapore) ..... [6416-11]

16.40: **Development of the new shape PZT ceramics sounder suitable for a sound source of artificial larynx**, K. Ooe, R. Kanetake, A. Tanaka, Y. Sugio, Ritsumeikan Univ. (Japan) ..... [6416-12]

17.00: **Development of a blood vessel searching system for HMS device**, T. Kuroda, Osaka Institute of Technology (Japan); T. Uenoya, Advanced Software Technology & Mechatronics Research Institute of Kyoto (Japan); Y. Uetshji, E. Nakamachi, Osaka Institute of Technology (Japan) ..... [6416-14]

### ✓ Posters-Monday

✓ **Single-cell impedance spectroscopy: maximum length sequence analysis**, T. Sun, N. G. Green, S. Gawad, H. Morgan, Univ. of Southampton (United Kingdom) ..... [6416-18]

✓ **A wireless sensor for detecting gastroesophageal reflux**, T. Ativanichayaphong, W. Huang, J. Wang, S. M. N. Rao, The Univ. of Texas at Arlington (USA); H. Tibbals, S. Tang, S. Spechler, The Univ. of Texas Southwestern Medical Ctr. at Dallas (USA); H. E. Stephanou, J. Chiao, The Univ. of Texas at Arlington (USA) ..... [6416-38]

✓ **Self-assembled magnosilicate nanocapturer for the in-situ separation of human DNA and proteins**, J. H. Chang, K. J. Kim, Korea Institute of Ceramic Engineering and Technology (South Korea) ..... [6416-39]

✓ **Functional bone-mimetic scaffolds of bicontinuous, thermo-responsive L3-phase silica/hydroxyapatite nanocomposites**, J. H. Chang, K. J. Kim, Korea Institute of Ceramic Engineering and Technology (South Korea) ..... [6416-40]

✓ **Electrical detection of biomolecules in a PDMS microfluidic channel using a MOSFET-type biosensor**, J. Shin, D. Kim, Kyungpook National Univ. (South Korea); G. Lim, Pohang Univ. of Science and Technology (South Korea); S. Shoji, Waseda Univ. (Japan) ..... [6416-41]

✓ **Encapsulation of cell into monodispersed hydrogels on microfluidic device**, C. Choi, J. Lee, H. Shim, N. Lee, J. Jung, T. Yoon, D. Kim, C. Lee, Chungnam National Univ. (South Korea) ..... [6416-42]

✓ **Rapid bio-patterning method based on the fabrication of PEG microstructures and layer-by-layer polymeric thin film**, H. Shim, J. Lee, C. Choi, B. Kim, N. Lee, J. Jung, D. Kim, C. Lee, Chungnam National Univ. (South Korea) ..... [6416-43]



**Tuesday 12 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **Microfluidic Analytical Systems for High-Throughput Multiplexed Bio-assays**, H. Morgan, Univ of Southampton (United Kingdom)09:45 to 10.30 **Spontaneous Organisation of Adsorbed Molecules**, P. Beton, The Univ. of Nottingham (United Kingdom)10.30 to 11.00 **Morning Tea****SESSION 4****Room: Napier LG23 ..... Tues. 11.00 to 12.20****Microfluidics I***Chair: Hywel Morgan*, Univ. of Southampton (United Kingdom)11.00: **Active control for droplet-based microfluidics** (*Invited Paper*), N. Nguyen, T. Teck-Hui, Y. F. Yap, W. Teck Neng, C. Chee Kiong John, Nanyang Technological Univ. (Singapore) ..... [6416-15]11.40: **Novel microfluidic device for cell characterization by impedance spectroscopy**, C. I. Ilescu, Institute of Bioengineering and Nanotechnology (Singapore); D. P. Poenar, Nanyang Technological Univ. (Singapore); K. J. Leck, Institute of Bioengineering and Nanotechnology (Singapore); M. Carp, Nanyang Technological Univ. (Singapore); A. J. Pang, F. C. Loe, Institute of Bioengineering and Nanotechnology (Singapore) ..... [6416-16]12.00: **An electromechanical filter for bioparticles trapping**, C. I. Ilescu, G. Xu, Institute of Bioengineering and Nanotechnology (Singapore); F. E. H. Tay, Institute of Bioengineering and Nanotechnology (Singapore) and National Univ. of Singapore (Singapore); P. L. Ong, Institute of Bioengineering and Nanotechnology (Singapore) .... [6416-17]

Lunch Break ..... 12.20 to 13.30

**SESSION 5****Room: Napier LG23 ..... Tues. 13.30 to 17.00****Microfluidics II***Chair: Dan V. Nicolau*, The Univ. of Liverpool (United Kingdom)**Keynote Presentation**13.30: **Integrated microsystems technology for lab-on-a-chip applications** (*Invited Paper*), H. Stapert, Philips Research Labs. (Netherlands) ..... [6416-44]14.00: **Nature-inspired polymeric actuating materials for microfluidic manipulation using external stimuli** (*Presentation Only*), H. T. A. Wilderbeek, T. N. Mol, J. de Goede, W. Talen, M. Gillies, Philips Research Labs. (Netherlands); D. J. Broer, Technische Univ. Eindhoven (Netherlands); J. M. den Toonder, Philips Research Labs. (Netherlands) ..... [6416-45]14.20: **Detection of inorganic ions on a capillary electrophoresis microchip using a conductivity technique**, Y. Zhu, K. Petkovic-Duran, Commonwealth Scientific and Industrial Research Organisation (Australia) ..... [6416-20]14.40: **Capillary flow in polymer microfluidic chips**, Y. Zhu, K. Petkovic-Duran, Commonwealth Scientific and Industrial Research Organisation (Australia) ..... [6416-21]15.00: **Blood flow assessment during heart valve testing based on MRI procedure using optical flow analysis**, K. K. L. Wong, J. Mazumdar, D. Abbott, The Univ. of Adelaide (Australia); P. Sanders, S. Worthley, Royal Adelaide Hospital (Australia); P. Kuklik, Politechnika Warszawska (Poland) ..... [6416-22]

Afternoon Tea ..... 15.20 to 15.40

15.40: **Microfluidic with optical sensor for rapid detection of nerve-agent sarin in water samples**, H. Y. Tan, DSO National Labs. (Singapore); N. Nguyen, Nanyang Technological Univ. (Singapore); W. K. Loke, Y. T. Tan, DSO National Labs. (Singapore) ..... [6416-23]16.00: **The culture of human embryonic stem cells in microchannel perfusion bioreactors**, N. Korin, A. Bransky, S. Levenberg, U. Dinnar, Technion - Israel Institute of Technology (Israel) ..... [6416-24]16.40: **An electrically controlled micromachined drug delivery device employing two silicon wafers**, R. Rajan, S. M. Aziz, T. C. Vaithianathan, Univ. of South Australia (Australia) ..... [6416-27]**Wednesday 13 December**08.50 to 09.00 **Introduction****Plenary Presentations**09:00 to 09.45 **The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders**, V. K. Varadan, Univ. of Arkansas (USA)09:45 to 10.30 **All-optical Processing for Advanced Communications Systems**, B. Luther-Davies, The Australian National Univ. (Australia)10.30 to 11.00 **Morning Tea****SESSION 6****Room: Napier LG23 ..... Wed. 11.00 to 12.20****Modelling and Computation***Chair: Dan V. Nicolau*, The Univ. of Liverpool (United Kingdom)11.00: **A biologically inspired model for signal compression**, M. D. McDonnell, D. Abbott, The Univ. of Adelaide (Australia) ..... [6416-28]11.20: **Toward 'smart' DNA microarrays: algorithms for improving data quality and statistical inference**, D. J. Bakewell, The Univ. of Liverpool (United Kingdom); E. Wit, Lancaster Univ. (United Kingdom) ..... [6416-29]11.40: **Prediction of protein adsorption from molecular surface properties**, D. V. Nicolau, Jr., Univ. of Oxford (United Kingdom); G. Solana, D. V. Nicolau, F. Fulga, The Univ. of Liverpool (United Kingdom) ..... [6416-30]12.00: **Advanced monitoring systems for biological applications**, A. Gandelli, F. Grimaccia, R. E. Zich, Politecnico di Milano (Italy); R. W. Johnstone, T. Chiffings, The Univ. of Queensland (Australia); U. Cella, Politecnico di Milano (Italy) ..... [6416-31]

Lunch Break ..... 12.20 to 13.30

**SESSION 7****Room: Napier LG23 ..... Wed. 13.30 to 15.10****Terahertz Technology and Devices***Chair: Tamath J. Rainsford*, The Univ. of Adelaide (Australia)13.30: **T-ray biosensing** (*Invited Paper*), B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6416-32]14.10: **Investigation of terahertz liquid-spectroscopy for contaminant detection**, J. Balakrishnan, B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6416-33]14.30: **Enhancing coupling between THz and skin**, G. M. Png, B. W. H. Ng, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia) ..... [6416-34]14.50: **Terahertz as a diagnostic tool for skin cancer**, T. J. Rainsford, M. J. Berryman, The Univ. of Adelaide (Australia); D. Abarno, Univ. of South Australia (Australia) ..... [6416-35]**SPIE Digital Library**

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# Complexity and Nonlinear Dynamics

Conference Chair: **Axel Bender**, Defence Science and Technology Organisation (Australia)

Cochairs: **Hussein A. Abbass**, Univ. of New South Wales (Australia); **Derek Abbott**, The Univ. of Adelaide (Australia); **Adi R. Bulsara**, Space and Naval Warfare Systems Command, San Diego (USA)

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## Tuesday 12 December

08.50 to 09.00 **Introduction**  
Plenary Presentations  
09:00 to 09.45 **Microfluidic Analytical Systems for High-Throughput Multiplexed Bio-assays**, H. Morgan, Univ of Southampton (United Kingdom)  
09:45 to 10.30 **Spontaneous Organisation of Adsorbed Molecules**, P. Beton, The Univ. of Nottingham (United Kingdom)  
10.30 to 11.00 **Morning Tea**

### SESSION 1

Room: Napier 210 ..... Tues. 11.00 to 12.20

#### Nonlinearity in Device Applications and Manufacturing Processes

Chair: **Adi R. Bulsara**, Space and Naval Warfare Systems Command, San Diego (USA)

11.00: **Electric field detectors in a coupled ring configuration: preliminary results** (*Invited Paper*), S. Baglio, B. Ando, Univ. degli Studi di Catania (Italy); A. R. Bulsara, V. In, Space and Naval Warfare Systems Command, San Diego (USA); N. Savalli, Univ. degli Studi di Catania (Italy) ..... [6417-01]  
11.40: **Wearing process simulation between 2 polymer materials**, H. Lin, H. Lin, L. Kong, Univ. of South Australia (Australia) ..... [6417-03]  
12.00: **Nonlinear dynamics that appears in the dynamical model of drying process of a polymer solution coated on a flat substrate**, H. Kagami, Nagoya College (Japan) ..... [6417-04]  
Lunch Break ..... 12.20 to 13.50

### SESSION 2

Room: Napier 210 ..... Tues. 13.50 to 15.30

#### Disorder, Imbalance, and Nonequilibrium

Chair: **Axel Bender**, Defence Science and Technology Organisation (Australia)

13.50: **Optical tweezers demonstrations of new concepts in nonequilibrium statistical mechanics** (*Invited Paper*), E. M. Sevick, D. J. Evans, G. Wang, The Australian National Univ. (Australia) ..... [6417-06]  
14.30: **High-resolution optimal quantization for stochastic pooling networks** (*Invited Paper*), M. D. McDonnell, The Univ. of Adelaide (Australia); P. Amblard, Ctr. National de la Recherche Scientifique (France); N. G. Stocks, The Univ. of Warwick (United Kingdom); S. Zozor, École Nationale Supérieure d'Ingénieurs Electriciens de Grenoble (France); D. Abbott, The Univ. of Adelaide (Australia) ..... [6417-08]  
15.10: **Relaxation in complex systems and fractional calculus**, V. E. Arkhincheev, Buryat Institute of Natural Sciences (Russia) and Federal Urdu Univ. (Pakistan); A. B. Bainova, Buryat State Univ. (Russia) ..... [6417-09]  
Afternoon Tea ..... 15.30 to 16.00

### SESSION 3

Room: Napier 210 ..... Tues. 16.00 to 17.20

#### Exploring and Exploiting Noise

Chair: **Michael F. Barnsley**, The Australian National Univ. (Australia)

16.00: **Brownian motion in titled periodic potential driven by green impule noise**, M. V. Sviridov, S. A. Guz, M. G. Nikulin, Moscow Institute of Physics and Technology (Russia) ..... [6417-10]  
16.20: **Brownian ratchets in the simulated annealing algorithm**, A. G. Allison, D. Abbott, The Univ. of Adelaide (Australia) ..... [6417-11]  
16.40: **On the fractal properties of Parrondo's games**, A. G. Allison, D. Abbott, The Univ. of Adelaide (Australia) ..... [6417-12]  
17.00: **Simulation and measurement of a two-stage complex network model**, H. H. L. Luo, K. Horadam, Royal Melbourne Institute of Technology (Australia) ..... [6417-16]

## Wednesday 13 December

08.50 to 09.00 **Introduction**  
Plenary Presentations  
09:00 to 09.45 **The Role of Nanotechnology and Engineering in Monitoring and Control of Cardiovascular Diseases and Neurological Disorders**, V. K. Varadan, Univ. of Arkansas (USA)  
09:45 to 10.30 **All-optical Processing for Advanced Communications Systems**, B. Luther-Davies, The Australian National Univ. (Australia)  
10.30 to 11.00 **Morning Tea**

### SESSION 4

Room: Napier 210 ..... Wed. 11.00 to 12.00

#### Bio- and Socio-System Dynamics

Chair: **Derek Abbott**, The Univ. of Adelaide (Australia)

11.00: **Transformations between fractals** (*Invited Paper*), M. F. Barnsley, The Australian National Univ. (Australia) ..... [6417-13]  
11.40: **Marital infidelity and its effect on pathogen diversity**, M. J. Berryman, The Univ. of Adelaide (Australia) ..... [6417-14]  
Lunch Break ..... 12.00 to 13.30

### SESSION 5

Room: Napier 210 ..... Wed. 13.30 to 15.10

#### The Complex Human Body

Chair: **Matthew J. Berryman**, The Univ. of Adelaide (Australia)  
13.30: **Quantitative modeling of multiscale neural activity** (*Invited Paper*), P. A. Robinson, The Univ. of Sydney (Australia) ..... [6417-19]  
14.10: **Rate coding by noise-induced attractor selection in multistable neuronal networks**, L. A. Safonov, Y. Yamamoto, The Univ. of Tokyo (Japan) ..... [6417-20]  
14.30: **Analyses of heart-rate dynamics before the onset of ventricular tachycardia using scaling characteristics and compression entropy**, M. Baumert, The Univ. of Adelaide (Australia) ..... [6417-21]  
14.50: **Is the fractal geometry of nature a coincidence?**, J. D. Halley, Commonwealth Scientific and Industrial Research Organisation (Australia) ..... [6417-22]

SPIE

# Smart Materials, Nano- and Micro-Smart Systems

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## 6413-02, Session 1

### Anisotropic surface roughness enhances the bending response of ionic polymer-metal composite (IPMC) artificial muscles

B. L. Stoimenov, The Institute of Physical and Chemical Research (Japan); J. M. Rossiter, Univ. of Bristol (United Kingdom) and The Institute of Physical and Chemical Research (Japan); T. Mukai, The Institute of Physical and Chemical Research (Japan)

Ionic polymer-metal composites (IPMC) are new materials, which hold promise as soft bio-mimetic actuators, such as artificial muscles, for a new generation of soft robots inspired by nature. When electrical potential is applied to an IPMC, it responds by bending. Some of the advantages of IPMC actuators are their softness and insensitivity to damage, lack of moving parts and low actuation voltage. At present, however, a serious limitation of these new actuators is their low mechanical power output. Past works have shown that power output can be increased by increasing polymer thickness, but this leads to a significant reduction in the amount of bending, which can be achieved. We propose to introduce anisotropy as a way to achieve improved bending response in the desired direction. We have investigated two methods to make an anisotropic actuator - the first one by mechanical working of the IPMC in the direction of bending as a part of the manufacturing process; the second one - by directional roughening of the polymer surface prior to metal electrode coating.

Rectangular IPMC actuators, whose surfaces were roughened with microgrooves perpendicular to the length showed double the amount of bending of actuators with isotropic surfaces.

## 6413-03, Session 1

### Plasma modified carbon surfaces for supporting sensor architectures

A. Deslandes, A. J. Barlow, J. G. Shapter, J. S. Quinton, Flinders Univ. (Australia)

Carbon has a number of properties that make it ideal for use in sensor and electrical applications. Using radio frequency plasma with different precursor gases and plasma conditions it is possible to surface pre-treat a variety of carbon surfaces in preparation for further molecular attachment, or for surface functionalisation. Research in our laboratory involves studies on highly ordered pyrolytic graphite (HOPG) as a model carbon substrate, pyrolysed photoresist films (PPF) and single-walled carbon nanotubes (SWCNTs). Treated surfaces have been characterised using a variety of investigatory surface techniques. In this paper we report on results obtained using X-ray photoelectron spectroscopy probe the chemical nature of the treated surfaces, and hence the extent of treatment. Time of flight secondary-ion mass spectrometry (ToFSIMS) has been utilised to determine the extent of hydrogenation after plasma treatment. Scanning tunnelling microscopy (STM) measurements provide information on the morphology of treated surfaces, in particular the damage and change in surface structures caused by various plasma treatments. Etching and/or nucleation and growth features are observed, with the type of features and their distribution strongly dependent on the precursor gas that is used to support the plasma.

## 6413-04, Session 2

### Three-dimensional network of ZnO tetrapods for use in gas sensing

J. Delaunay, N. Kakoiyama, I. Yamada, The Univ. of Tokyo (Japan)

A three-dimensional network of ZnO tetrapods was fabricated on

a quartz substrate. The interconnected tetrapods, having legs with length of several  $\mu\text{m}$  and diameter in the 0.1-1  $\mu\text{m}$  range, were synthesized via a simple thermal oxidation reaction. Zn powder was heated in a furnace at a temperature of 900C and was made to react with air and water vapor. The content of water vapor in air was found to control the adherence onto the substrate and the morphology of the deposited layers. The layers developed a grain structure or a porous structure made of interconnected tetrapods, depending on the content of water vapor in air. The network of tetrapods which was obtained for a small content of water vapor formed a highly porous layer with a high surface to volume ratio. The tetrapod network was tested as a gas sensing element by measuring changes in its electrical resistance upon exposure to ethanol. The responses to ethanol were investigated as a function of the layer temperature and the ethanol concentration. The optimum temperature of the tetrapod network layer was found to be 400 C, at which ethanol concentration as low as 0.5 ppm was easily detected. The tetrapod network exhibited a ten fold increase in sensitivity when compared with a ZnO polycrystalline thick film.

## 6413-05, Session 2

### Modeling of active fiber composite for delamination sensing

P. J. Guruprasad, Texas A&M Univ. (USA); A. Tamrakar, D. Harursampath, Indian Institute of Science (India)

In order to demonstrate the feasibility of Active Fiber Composites (AFC) as sensors for detecting damage, a pretwisted strip made of AFC with symmetric free-edge delamination is considered in this paper. The strain developed on the top/bottom of the strip is measured to detect and assess delamination. Variational Asymptotic Method (VAM) is used in the development of a non-classical non-linear cross sectional model of the strip. The original three dimensional (3D) problem is simplified by the decomposition into two simpler problems: a two-dimensional (2D) problem, which provides in a compact form the cross-sectional properties using VAM, and a non-linear one-dimensional (1D) problem along the length of the beam. This procedure gives the non-linear stiffnesses, which are very sensitive to damage, at any given cross-section of the strip. The developed model is used to study a special case of cantilevered laminated strip with antisymmetric layup, loaded only by an axial force at the tip. The charge generated in the AFC lamina is derived in closed form in terms of the 1D strain measures. It is observed that delamination length and location have a definite influence on the charge developed in the AFC lamina. Also, sensor voltage output distribution along the length of the beam is obtained using evenly distributed electrode strip. The voltage data obtained is used to detect the presence of damage in the pretwisted strip.

## 6413-06, Session 2

### Highly reliable advanced grid structures (HRAGS) for aircraft structures using multi-point FBG sensor

H. Takeya, S. Kazushi, M. Kume, T. Ozaki, Mitsubishi Electric Corp. (Japan); N. Takeda, The Univ. of Tokyo (Japan); N. Tajima, R&D Institute of Metals and Composites for Future Industries (Japan)

Composite materials such as graphite fiber reinforced plastics are promising candidates to meet cost and weight saving demand in aircraft structures. However, since extremely high reliability is required for aircraft systems, composite materials have not been fully applied especially in commercial aircraft. A structural health monitoring system is the most effective technology to meet this requirement. The authors have been developing a new lightweight composite grid structure equipped with a health monitoring system utilizing FBG (Fiber Bragg Grating) sensors for aircraft applications. A grid structure, comprising multiple interconnected ribs in a truss-like arrangement, has a very simple

path of stress, which is easily detected with FBG sensors embedded in the ribs.

In this report, fabrication and test results of HRAGS proto-system were described first. The proto-system was composed of HRAGS panel and FBG monitoring system. The size of the HRAGS panel was 525×550 mm. The number of embedded FBG sensor was 29. The skin panel was attached to the grid structure. The strain distribution of the panel was measured under compressive load conditions. The artificial damage in the skin panel of the specimen was successfully detected by comparing the strain distribution before and after the introduction of the damage. Next, the application of HRAGS to the wing tip was examined.

## 6413-07, Session 2

### The producing and properties studying of carbon fiber smart concrete

Z. Xu, Nanjing Univ. of Science & Technology (China)

Smart carbon fiber concrete(SCFC) is a kind of multifunctional cement based composite material by uniformly admixing short carbon fibers to concrete and it not only has good mechanical characters but also possesses the sensing ability. This sensing capability can be used in health monitoring, forecast of damage accumulation and residual life to the concrete structure on service or subject to natural disaster and reduces the loss of personnel and properties.

The following conclusions have been obtained in this paper:

(1) The principle, producing technique and the main factors which influence the conductive properties of the smart concrete are discussed. It is found that the dispersion of carbon fiber is the key problem of manufacturing SCFC. The content and the degree of dispersion of carbon fiber, the water/cement ratio, the sand/cement ratio and the curing age have an obvious effects on the resistance of SCFC.

(2) The piezoresistivity of SCFC under monotonic compressive loading, cyclic loading with increasing amplitudes, cyclic loading with same amplitude and the dead loading are investigated. The experiment results reveal that the resistance changing of SCFC can reflect quantitatively the loading on it, so the SCFC can be used as compress strain sensor.

(3) The change of resistance in SCFC under fatigue compress loading is studied. The resistance value increases gradually with the number of the loading cycles. This phenomenon indicates the damage occurred under the fatigue load and the damage is accumulated during the fatigue process.

## 6413-08, Session 3

### Low-temperature processing of lead zirconate titanate thin films by 28 GHz microwave irradiation for MEMS application

Z. Wang, Tohoku Univ. (Japan)

Lead zirconate titanate (Pb(Zr, Ti)O<sub>3</sub>: PZT) has been extensively studied in thin film form, mainly for potential applications in non-volatile ferroelectric random access memories (FeRAMs) and micro-electromechanical systems (MEMS), such as membrane-type micropumps, atomic force microscopy (AFM) cantilevers and micro-scanning mirror devices. Many thin-film fabrication techniques, such as sputtering, laser ablation, metalorganic chemical vapor deposition and the sol-gel method, have been used to fabricate ferroelectric PZT thin films on Pt/Ti/SiO<sub>2</sub>/Si substrates. However, to obtain well-crystallized PZT films on Pt/Ti/SiO<sub>2</sub>/Si substrates, substrate temperatures (in the case of in situ deposition) or postdeposition annealing temperatures (in the case of films deposited at lower substrate temperatures or room temperature) in the range of 600-750°C are required. This thermal treatment at high temperatures seriously damages the stack, leading to interdiffusion between the elements of the films and substrate, and the evaporation of lead and lead oxide from the surface of films, and can cause loss of the films' stoichiometry. Therefore, it is imperative to decrease processing temperature and thermal treatment time for PZT films to be used in FeRAMs and MEMS

applications. In this paper, we report the low-temperature growth of PZT thin films deposited on Pt/Ti/SiO<sub>2</sub>/Si substrates by the sol-gel method and then crystallized by 28 GHz microwave irradiation. The crystalline phases and microstructures as well as the electrical properties of the microwave-irradiated PZT films were investigated. The elevated temperature generated by microwave irradiation to obtain the perovskite phase is only 480°C, which is significantly lower than that of conventional thermal processing (600-750°C). X-ray diffraction analysis indicated that the PZT films crystallized well in the perovskite phase. The average values of the remanent polarization, coercive field, dielectric constant and loss of the PZT films are 24 μC/cm<sup>2</sup>, 48 kV/cm, 1050 and 0.04, respectively. It is clear that microwave irradiation is effective for obtaining well-crystallized PZT films with good properties at low temperatures.

## 6413-09, Session 3

### Analysis of constrained piezoelectric thin film sensor

R. Ali, Indian Institute of Science (India)

A three dimensional electro-mechanical continuum field model is developed to analyze the constrained boundary effects on the transduction performance of thin Piezoelectric films. The model proposed in this paper for Piezoelectric thin film is based on 3D continuum mechanics under plane-stress condition. The plane-stress condition is justifiable for the fact that the thickness of the piezoelectric film is of the order of microns(in z direction); and hence, very small in comparison to the other two dimensions(in x and y directions) of the film. The film, and its proposed model, are intended to be used for Structural Health Monitoring of any structural component, such as, wing of an aircraft. The thin film is surface-mounted on this structural component, and this component will be termed as Host structure, henceforth. When the host structure is strained under the action of loads, the displacement vector field that is generated acts as an input to the thin film in this model. The performance of the thin film in terms of its voltage response, capacitance, and effect of residual stresses on capacitance and output voltage are studied here. The results show significant variation of the same as compared to conventional design and analysis based on electro-statics.

The voltage distribution and its variation over the film when a crack is initiated in the host structure under mode-I and mode-II loadings are also presented. It has been observed that in micro-electronic devices, various process-induced stresses such as intrinsic stress, epitaxial stress, thermal stress etc., play crucial role in the device performance. The model presented here is capable of handling such stresses while designing the sensor itself.

## 6413-10, Session 3

### High-performance piezoelectric actuator consisting of two piezoelectric materials

S. Jeong, M. Kim, J. Song, Korea Electrotechnology Research Institute (South Korea)

Actuators are devices transferring electric energy into mechanical energy. The piezoelectric actuators have outstanding properties in higher stiffness and faster response than those of solenoid actuators. Especially piezoelectric bender actuators exhibit large millimeter scale stroke. In order to obtain better electro-mechanical performance, four-layered bender actuator were designed under a consideration that the piezoelectric constant and thickness ratio of each layer are the important factors. The best actuation behavior could be observed with a relationship between the piezoelectric d<sub>31</sub> constant and geometry of each layer.

## 6413-11, Session 4

### Microarrays for the evaluation of cell-biomaterial surface interactions

H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia)

The evaluation of cell-material surface interactions is important

for the design of novel biomaterials which are used in a variety of biomedical applications. While traditional *in vitro* test methods have routinely used samples of relatively large size, microarrays representing different biomaterials offer many advantages, including high throughput and reduced sample handling. Here, we describe the simultaneous cell-based testing of matrices of polymeric biomaterials, arrayed on glass slides with a low cell-attachment background coating. Arrays were constructed using a microarray robot at 6 fold redundancy with solid pins having a diameter of 375  $\mu\text{m}$ . Printed solutions contained at least one monomer, an initiator and a bifunctional crosslinker. After subsequent UV polymerisation, the arrays were washed and characterised by X-ray photoelectron spectroscopy. Cell culture experiments were carried out over 24 hours using HeLa cells. The cells were labelled with CellTracker(r) Green for the final hour of incubation. After fixation the arrays were scanned. Individual spots were also viewed by fluorescence microscopy. The evaluation of cell attachment allowed the identification of a novel non cell-supportive substrate material. The evaluation of cell-surface interactions in high-throughput assays as demonstrated here is a key enabling technology for the effective development of future biomaterials.

### 6413-12, Session 4

#### A platform for the advanced spatial and temporal control of biomolecules

A. L. Hook, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); J. P. Hayes, MiniFAB (Aust) Pty Ltd. (Australia); N. H. Voelcker, Flinders Univ. (Australia)

Manipulating biomolecules at solid/liquid interfaces is important for the development of various bio-devices including microarrays. Smart materials that enable both spatial and temporal control of biomolecules by combining switchability with patterned surface chemistry offer unprecedented levels of control of biomolecule manipulation. Such a system has been developed for the microscale spatial control over both DNA and cell growth on highly doped p-type silicon. Surface modification, involving plasma polymerisation of allylamine and poly(ethylene glycol) grafting with subsequent laser ablation, led to the production of a patterned surface with dual biomolecule adsorption and desorption properties. On patterned surfaces, preferential electro-stimulated adsorption of DNA to the allylamine plasma polymer surface and subsequent desorption by the application of a negative bias was observed. The ability of this surface to control both DNA and cell attachment in four dimensions has been demonstrated, exemplifying its capacity to be used for complex biological studies such as gene function analysis. This system has been successfully applied to living microarray applications and remains an exciting platform for any system incorporating biomolecules.

### 6413-13, Session 4

#### A radio frequency controlled microvalve for biomedical applications

D. W. Dissanayake, S. F. Al-Sarawi, The Univ. of Adelaide (Australia)

In this research we propose the use of a RF controlled microvalve that can be implemented on a PZT substrate for use in biomedical applications. Such device have a huge range of applications such as Parallel mixing of photo-lithographically defined nanoliter volumes, flow control in pneumatically driven, microfluidic systems and lab-on-chip applications. The valve makes use of direct actuation mechanisms at the microscale level to allow its use in vivo application. A number of acoustic propagation modes will be investigated and their suitability for biomedical application, in terms of surrounding environment and fluidic properties, will be evaluated. A finite element analysis (FEA) model of the SAW device will be presented and its use in the micro-valve will be evaluated using ANSYS tools. Furthermore, the wireless aspect of the device will be considered through the RF antenna and also will be included in the microvalve simulation by assuming a high carrier frequency with a small peak-to-peak signal. Then, further optimisation of the device will be carried out to achieve a

better coupling between electrical signal and mechanical actuation of the SAW device.

### 6413-14, Session 5

#### Nanomechanical properties of supported lipid bilayers studied by force spectroscopy

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The physicochemical properties of biological membranes are crucial to understand membrane function, since their main role is to provide a barrier that divides electrolytic solutions into different compartments guaranteeing at the same time membrane mechanical stability. It is well-known that the chemical composition of the phospholipid molecules that compose the membrane greatly determine the architecture of such biological systems.

Force Spectroscopy with AFM is a powerful tool able to study the nanomechanical properties of supported planar lipid bilayers (SPBs). Force plots on lipid bilayers show a discontinuity in the approaching curve that is interpreted as the penetration of the AFM tip through the lipid bilayer. The force at which this discontinuity occurs is the maximum force the bilayer is able to withstand before breaking and it can be regarded as a 'fingerprint' of the bilayer stability, just like force is the fingerprint for a protein to unfold or for a hard material surface to be indented.

We report on an experimental quantitative Force Spectroscopy study on how both lipid bilayer stability and compactness depend (i) on the solution ionic composition, (ii) on the chemical composition of the phospholipids composing the membrane and (iii) on the temperature. Regarding (i), a small variation in ionic strength give rise to a huge change in bilayer (nano)mechanical resistance due to an ion-binding effect [1, 2]. Concerning (ii), we have performed detailed quantitative measurements that aim to individually study the role that the hydrophilic phospholipid headgroup and the hydrophobic tail play upon membrane stability [3]. Last but not least, we have studied the topographic evolution of such SPBs as a function of temperature (iii), and we are able to precisely determine the temperatures at which phase transition took place. These topographic changes are closely related to an important variation in membrane mechanical stability [4].

Finally, Chemical Force Microscopy enables us to titrate a complex surface with more than one acidic group such as a phosphatidylcholine head forming lipid bilayers with a -COOH group attached to the tip [5]. The local pKa of the acidic groups of the surface has been measured, and results have been related to those obtained through zeta potential measurements.

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### 6413-15, Session 5

#### Hybrid organic-inorganic nanoparticles: controlled incorporation of gold into virus-like particles

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A capsid is the protein coat surrounding a virus' genome, that ensures its protection and transport. The capsid of murine polyomavirus (muPy) consists of one major (VP1) and two minor (VP2/3) proteins, from which just VP1 is sufficient to form the capsid when expressed recombinantly. From a material engineering point of view, viral capsids are of interest because they present

a paradigm for complex self-assembly on the nanometer scale. Understanding and controlling these assembly dynamics will allow the construction of nanoscale structures using a self-assembly process. The first step in this direction was the discovery that capsids of several viruses can be reversibly disassembled into their building blocks and reassembled using the same building blocks by simply changing the buffer conditions. Such capsids already find applications as targeted *in vivo* delivery vectors for genes, proteins or small molecular drugs, as optical probes for biomedical imaging and sensing purposes with unprecedented resolution and sensitivity and can potentially be used as templates for nanoelectronics.

Here we show the controlled incorporation of inorganic gold nanoparticles into the capsid shell of muPy. This incorporation is mediated by covalent sulfide bonds between the capsid proteins cysteine residues and the molecular gold. The number of incorporated gold particles can be controlled during the assembly process and the capsids retain their ability to transduce cells. These particles provide new tools for tracking of viral particles in cells, and simultaneously allow the delivery of genes packages in the hollow capsid.

### 6413-16, Session 6

#### Responsive interfaces with polyampholyte brushes

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Polyampholyte brushes have some interesting responsive properties because they can withstand great and rapid deformation. With an excess of overall charges they behave as polyelectrolytes, while in stoichiometric proportions of positive and negative charges, they adopt the so-called anti-polyelectrolyte behavior. This conformation transition of stretched and collapsed chains can be tuned by chemical stimulus such as pH.

We synthesize polyampholyte brushes in a controlled way using a surface-initiated ATRP (Atom Transfer Radical Polymerization). The three-step synthesis includes the covalent grafting of small initiator molecules onto the substrate, the growing of neutral polymer chains from the surface (grafting from method) by ATRP and the conversion of chains into polyampholytes by *in situ* hydrolysis and quaternization reactions.

The interfacial structure is characterized by ellipsometry and neutron reflectometry. In high basic or acidic pH range, the polyampholyte brushes behave as polyelectrolyte brushes. The collapse conformation is observed in the pH range of zero net charge. From scaling laws of polyelectrolyte brushes, the ionization ratio of the brush as a function of pH is deduced. Surface acid/base titration is also determined by electrochemical and electro-osmotic measurements. Scanning Electro Chemical Microscopy (SECM) is used to follow the exchange and release of protons from the polymer brush. We also develop an application of polyampholyte brushes in microfluidic devices. We build microchannels with one-wall covered by the brush. We study the electro-osmotic properties by determining the velocity and the direction of the flow under an electric field while varying the ionization of the polyampholyte with pH.

### 6413-17, Session 6

#### Electroactive polymers activate an innovative handling system

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Although semiconductor-based manufacturing techniques excel at producing high-volume integrated circuits, at the state of the art, it cannot fulfil the requirements for fabricating highly complex MEMS. Not only are the silicon technologies not adequate, but also silicon itself. Indeed, many micromechanical applications require appropriate materials provided with properties which are not present in silicon. Furthermore, some of them need the integration of different components made of a variety of materials with contradistinctive characteristics. In these cases, hybrid systems are a promising solution for extending the application sec-

tors of MEMS. On the other hand, hybrid approach has its own limitation and difficulties. One of the most crucial processes during the fabrication of hybrid MEMS is the assembling procedure. In this context, innovative handling systems have been studied and the possibilities of controlling and exploiting superficial interactions have been analysed. In particular, the capillary force has been investigated and an innovative handling system has been conceived. A first prototype of a gripper with variable curvature was developed and experimentally tested. Due to the good results obtained, this work is focused on the development of a smaller prototype able to manipulate lighter objects. Such a gripper requires an actuation in agreement with its dimensions. For this reason the use of smart materials and in particular of electroactive polymers (EAP) has been investigated. Due to their low mass, low power and, in some of these materials, the large displacement that can be obtained, EAP are attractive as actuators. A few configurations of the gripper realized with EAP have been analysed and numerical simulations have been done.

### 6413-19, Session 6

#### Application of nanotechnologies in smart textiles

Z. Peng, F. M. She, L. Kong, Univ. of South Australia (Australia)

Classic textiles are flexible, foldable, and able to conform to almost any shape, but not electrically conductive and not smart at all. However, when equipped with nanotechnology and electronics, traditional textiles become smart and are one of the dominating directions of the development of high-tech intelligent clothing. Active intelligent textiles integrated with nanotechnology obtain various advanced properties, such as electricity conductive, anti-chemical and anti-bacterial, wrinkle-free properties, temperature and pH sensitive, colour changing (chameleonic), flame retarding, self-cleaning and water-repellent, etc.

The aim of this paper is to have a deep review on recent developments and trends in smart (intelligent) textiles and reveal its close correlation with nanotechnology in a wide range of applications, such as in intelligent protective clothing, daily life, Force Warrior Systems, bio-monitoring, health monitoring, telemedicine and aerospace. We will also discuss about future challenges in design and manufacturing of smart textiles. It will provide a useful reference to the best and latest technologies in the field.

### 6413-20, Session 7

#### Growth and structure of poly-aromatic thin films on metal and semiconductor substrates

N. V. Richardson, Univ. of St. Andrews (United Kingdom)

The polyaromatic hydrocarbons, such as polyacenes, perylene and coronene, form an interesting class of molecules because their planar aromatic systems gives rise to semiconducting properties in the bulk material. In turn, this has led to potential applications as organic FETs, and, more controversially, other electronic, optoelectronic and even superconducting devices. They are molecules, which are readily deposited by vacuum sublimation techniques, and the resulting monolayer or thin film structure can be markedly influenced by the chemical and structural properties of the chosen substrate. Compatibility with UHV not only allows control of the deposition process but also allows detailed characterisation of the organic layer by techniques such as STM, electron energy loss spectroscopy (EELS), LEED and FTIR.

In this presentation, the results of monolayer deposition studies of tetracene, perylene and coronene on clean Cu(110) will be described. Changes driven by the presence of pre-adsorbed oxygen atoms in the (2x1) structure will be highlighted. In the case of perylene growth on clean Cu{110}, a completely novel thin film structure can be developed which bears no structural similarity to the bulk structure of perylene. The aromatic rings remain parallel to the underlying substrate and, even after deposition of ca 30 layers, excellent STM images can be obtained which reveal a structure which is still 1D commensurate with the underlying copper lattice.

Single crystal surfaces of Si provide a dramatically different substrate for deposition and film growth with highly localised bonding between the Si and the first organic layer. STM reveals remarkable details of the interaction of tetracene with Si(100)-2x1 but this provides a poor template for growth and leads to amorphous or at best polycrystalline thin films.

### 6413-21, Session 8

#### Three-dimensional deposition of silicon from silicate glass with dispersed metallic aluminum by a femtosecond laser

K. Miura, Y. Shimotsuma, S. Hamabe, K. Hirao, Kyoto Univ. (Japan)

Materials processing technology by using femtosecond laser irradiation has attracted tremendous interest from both the scientific and technological communities. The reason is that the strength of its electric field in the focal point of the femtosecond laser beam can reach 10TW/cm<sup>2</sup>, which is sufficient for inducing various nonlinear physicochemical reactions in materials by using a focusing lens, when the pulse width is 100fs and the pulse energy is 1 μJ. The photo-induced reactions are expected to occur only near the focused area of the laser beam due to multi-photon processes.

We demonstrate silicon deposition from silicate glass with dispersed metallic aluminum by femtosecond laser irradiation. This happens through a thermite reaction. That is, the silicon deposition happens as a result of the cutting of the silicon-oxygen combination by the laser energy and the connection of the dissociated oxygen ions to the aluminum. The silicon is transparent for the wavelengths of the optical communication band. In addition, it has a refractive index twice that of glass. This is highly significant because the deposition of silicon in glass with a femtosecond laser may open the door to silicon-based waveguides and photonic crystals.

### 6413-22, Session 8

#### Laser interference deposition of silver-nanoparticles on glass

F. Funabiki, Tokyo Institute of Technology (Japan)

Nano-particles of noble metals like silver and gold are the notable candidates to realize the non-linear optical functional using plasmon absorption. The arrangements of these particles is also required to realize and enhance their functionalities as well as the control of their shape like triangle, rods, etc. Manipulation techniques of nano-particles using laser and AFM (Atomic force microscope) have been developed and utilized to build up the arrangement of nano-particles. However, each operation needs a lot of time to prepare the structure even in the size of 1 mm. In order to attain high accuracy, high speed and high patternability, a new preparation method should be developed.

In this study, we report a new method to deposit nanoparticles periodically on the transparent substrate using the laser interference. The coherence and high peak energy of the laser pulses enable the easy formation of the gratings on transparent inorganic substrate like glass. In the experiments, silver nitrate melt was sandwiched with a couple of glass substrates and held at 250°C. Nd:YAG pulse laser with a wavelength of 1.06 μm was irradiated. The interference of laser light between the substrates caused the deposition of silver nano-particles on the glass substrate to form the periodically aligned lines and circles. These were found to be composed of nanometer-size silver metals. The irradiation of two-laser beam mixing on the substrate was also examined. Silver nano-particles were also deposited on the glass substrate, and formed the gratings. The incident angle between two beams changed the intervals of lines of nano-particles, and showed the Bragg diffraction of visible light from violet to red. This method enables us to prepare the arranged structure of nanoparticles on the substrate very easily and can be utilized to fabricate the optical devices.

### 6413-23, Session 8

#### Nanosized modification of transparent materials using femtosecond laser irradiation

S. Kanehira, K. Miura, K. Fujita, K. Hirao, Kyoto Univ. (Japan)

We have observed periodically aligned nano-void structures inside a conventional borosilicate glass induced by a single femtosecond (fs) laser beam for the first time, to our knowledge. The spherical voids with nano-sized diameter were aligned spontaneously with a period along the propagation direction of the laser beam. The period, the number of voids, and the whole length of the aligned void structure were controlled by changing the laser power, the pulse number, and the position of the focal point. In addition, chemical composition at the voids and around the voids were analyzed using Auger Electron Spectroscopy (AES). The spectra obtained from the measurements show that the specific ion in the borosilicate glass moves into edges of the void simultaneously when the void is formed due to an increase of the local temperature of the glass substrate under the fs laser irradiation. In addition, when the fs laser pulses were focused inside another transparent materials such as single crystals, a unique structure with a micrometer size can be also fabricated around the focal point spontaneously. The fabrication process of voids can be applied to 3D photonic crystals or other photonic devices.

### 6413-24, Poster Session

#### Dielectric and piezoelectric properties of a piezoelectric complex for micropower harvesting

J. Song, S. Jeong, M. Kim, I. Kim, Korea Electrotechnology Research Institute (South Korea)

In this study, the complex type piezoelectric system was proposed to be a mixture of soft piezoelectric materials and non piezoelectric materials. A mixture of a soft piezoelectric material, Pb(MgNbZr)TiO<sub>3</sub>(PMNZT), and a hard material, ZrO<sub>2</sub>, was introduced as a base material of the harvesting system. Up to 2 vol% of ZrO<sub>2</sub> in PMNZT matrix, piezoelectric d<sub>33</sub> coefficient was above 420 pC/N, being 90% of that for the original PMNZT. The dielectric permittivity showed 800, being less than half of original value in pure piezoelectric ceramic. The efficiency of the complex system with 2% ZrO<sub>2</sub>-embedded material was observed to be 1.5 times the value of the pure piezoelectric ceramic.

### 6413-25, Poster Session

#### Lead-free NKN-LT piezoelectric ceramics synthesized by pressureless sintering

M. Kim, S. Cheong, B. Min, J. Song, Korea Electrotechnology Research Institute (South Korea)

Lead oxide-based ferroelectrics are the most widely used materials for piezoelectric transducers due to their excellent piezoelectric properties. Considering lead toxicity, there is great interest in developing lead-free piezoelectric materials, which are biocompatible and environmentally friendlier. Recently alkali oxide materials, including sodium - potassium niobate (NKN), have been given attention in view of their ultrasonic application and also as promising candidates for piezoelectric lead-free system. However, it is difficult to sinter such NKN-based materials via conventional sintering process. In this reason, many researchers have investigated hot press or spark-plasma sintering of NKN-based ceramics. From the industrial point of view, pressureless sintering is required for mass production. In this investigations, as a candidate for lead-free piezoelectric materials, dense NKN-5LT ceramics were developed by conventional sintering process. Additives and atmosphere powders were used during sintering. Grain growth behavior was explained in terms of the change the critical driving force on interface reaction - controlled grain growth, based on crystal growth theory. The piezoelectric properties of NKN-5LT ceramics were investigated as a function of concentration of the additives. Excellent piezoelectric and electromechani-



cal responses were obtained for NKN-5LT samples with dopants sintered with atmosphere powder.

## 6413-26, Poster Session

### Measurement of mechanically induced luminescence from microparticles

T. Koga, K. Sakai, S. Maehara, N. Terasaki, Y. Imai, C. Xu, National Institute of Advanced Industrial Science and Technology (Japan)

Recently, Xu et al. discovered the material which emitted light by the mechanical stress in the elastic deformation range. This material is extensively used smart sensor and other applications. Though the much research has been made on the emission properties of this material, the characteristics of a single microparticle are not clarified still. We developed a new apparatus which applies the micro-force to a microparticle by the atomic force microscope (AFM) probe, and then, succeeded in the quantitative measurement of the emission intensity from the single microparticle (SrAl<sub>2</sub>O<sub>4</sub>:Eu<sup>2+</sup>) in the elastic deformation range. In this conference, we will report the correlation between the emission intensity and the micro-stress.

Using this new apparatus, we examined the emission intensity as the functions of applied micro-force and the speed of the applying micro-force. The emission intensity was almost proportional to the speed of the applying micro-force, and it showed the positive correlation with the applying micro-force. In addition, the emission intensity was almost proportional to the square of the micro-stress clarified, when the micro-stress was estimated from the applied micro-force.

## 6413-27, Poster Session

### Mechanical response of low-temperature sintered body consisting of clusters of submicron gold particles

Y. Fujisawa, Yokohama National Univ. (Japan)

Sintered materials formed by sub-micron powder have been attracting attention as next generation functional materials. Since the surface energy of sub-micron particles is high, the sintering temperature is relatively low. Once a sub-micron powder is sintered, its structure is stable in the used temperature range. Therefore, sintered body of sub-micron particles are expected to be alternatives to current interconnect materials that have reached the limits of miniaturization. However, the mechanisms of deformation and fracture in sintered body formed from sub-micron particles are unclear yet. Specially, low temperature sintered body consisting of clusters of sub-micron particles provide several interesting mechanical properties. In this study, mechanical response of low temperature sintered body was examined. The gold powder and solvent were mixed into a paste and that was then sintered. Tensile strength and elongation of the sintered body were evaluated experimentally. Because microstructure of sintered body affects several mechanical properties, cluster structure was simulated using DLA (diffusion-limited aggregation) model and tensile properties of cluster structure were extracted from finite element analysis. Comparing with experimental results, the validity of cluster model simulation was examined. Low temperature sintered body has lower tensile strength and elastic modulus because of network of clusters. Cluster structure depends on the porosity and the sintering temperature. Simulated elastic stiffness depends cluster structure and its value is lower than bulk. The fracture behavior of particles in clusters connects macroscopic tensile strength and elongation of sintered body. It agrees with the SEM observation of the fracture surface. Cluster of particles characterizes the macroscopic mechanical properties of sintered body.

## 6413-30, Poster Session

### Silica nanostructure formation from R5 peptide

I. Tajuddin, N. H. Voelcker, J. Mitchell, Flinders Univ. (Australia)

Diatoms have the ability to generate highly ornamented nanostructured silicified cell walls under ambient conditions and without harsh chemicals, yet the molecular mechanisms underlying biosilification are still not well understood. The understanding of biomolecular and physico-chemical processes that steer biosilica formation is importance for the design of process technological innovations for the production of industrial silica under mild reaction conditions, environmentally friendly and more economically. The idea of this study is to mimic silica biomineralization of diatom cell walls that may provide the key to the development of new routes towards novel tailor-made silicas. Here the ability of R5 peptide, a peptide from the silaffin-1 protein derived from diatom species of *Cylindrotheca fusiformis*, to generate silica nanostructure in vitro was investigated. The R5 peptide was synthesized using Fmoc Solid-Phase Peptide Synthesis and purified using reverse phase high performance liquid chromatography. To characterize the synthetic peptide, MALDI-MS was used. MALDI analysis showed that the peptide was successfully synthesis. With the application of silicic acid as a silica precursor and the peptide as catalyse, the formation of silica nanostructure was achieved. Atomic force microscopy and Scanning electron microscopy were used to image the precipitated silica. AFM analysis of the precipitated silica from the mixture of silicic acid and the peptide revealed the nanostructure of silica spheres that varied in size ranging between 50 - 100 nm in diameter. Silica precipitate was not obtained in the absence of R5 (negative control) and when the silicic acid was mixed with poly-L-lysine (positive control), a network of large aggregates of fused silica particle was observed.

## 6413-31, Poster Session

### Application of nanostructured biochips for efficient cell transfection microarrays

Y. Akkamsetty, A. L. Hook, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); J. P. Hayes, MiniFAB (Aust) Pty Ltd. (Australia); N. H. Voelcker, Flinders Univ. (Australia)

Microarrays, high-throughput devices for functional genomics, are developed by varying the interfacial properties of biomolecules. This variation is controlled spatially and temporally by certain smart materials containing both switchability and patterned surface chemistry. A system had been developed to spatially manipulate both DNA and cell growth based upon the surface modification of highly doped silicon by plasma polymerisation and poly(ethylene glycol) grafting followed by masked laser ablation for formation of a patterned surface with both bioactive and non-fouling regions. This platform has been successfully applied to transfected cell microarray applications with the parallel expression of multiple genes by utilising its ability to direct and limit both DNA and cell attachment to specific sites. One of the greatest advantages of this system is its application to reverse transfection, whereupon by utilising the switchable adsorption and desorption of DNA to the surface by application of a voltage the efficiency of cell transfection can be enhanced. The optimisation of transfection efficiency in multiple cell lines on these surfaces by application of a voltage and the mechanism by which this process improves the transfection efficiency has been studied.

## 6413-32, Poster Session

### Morphology controlled cellular localization of inorganic nanoparticles

K. Porazik, M. Niebert, Z. P. Xu, M. Lu, P. Gray, The Univ. of Queensland (Australia)

Cellular delivery involving the transfer of various drugs, proteins and nucleic acids through the cell membrane has attracted increasing attention because of its importance in medicine [1-4]. However, the direct delivery of drugs and biomolecules is generally inefficient and suffers from various kinds of problems. This is the main reason why increasing efforts in research and development worldwide have been devoted to search for efficient and safe transport vehicles. In the last decade various inorganic materials have attracted attention as novel non-viral carriers [5-8] as they generally possess versatile properties suitable for cellular

delivery. One very promising group of materials are layered double hydroxides as shown by Choy et al. [9, 10].

Layered double hydroxides (LDH), also known as hydrotalcite-like materials or anionic clays, are a large group of natural and synthetic materials readily produced when suitable mixtures of metal salts are exposed to base. They consist of layers, mixing the hydroxides of two (or more) different kinds of metal cations and possessing an overall positive charge, which is neutralized by the incorporation of exchangeable anions [11]. Due to their chemical nature and structure, LDH materials possess a number of advantageous properties suitable for cellular delivery, such as good biocompatibility, low cytotoxicity [12, 13], high loading of anionic/polar molecules, pH controllable release [14], protection of guest molecules in the interlayer [13] and controllable particle size [8, 12, 15].

More particularly, LDH nanoparticle morphology has substantially influenced the cellular uptake and localization. Besides the already known hexagonal shape of LDH, we are also able to produce rod-like particles. We have found that alteration of the particle shape influences uptake kinetics as well as cellular localization of LDH nanoparticles. Hexagonally shaped LDH nanoparticles are distributed in the cytoplasm while rod-like LDH nanoparticles are concentrated into the nucleus after cellular uptake. Thereby, we are able to control LDH delivery to specific cellular loci and control the uptake kinetics between 30 min and 48 hours. This finding enables the targeted and timed delivery of drugs or bio-molecules to specific cellular compartments.

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## 6413-33, Poster Session

### Zinc Phthalocyanine(ZnPc) thin films as nanomaterials

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ZnPc is a promising candidate for photovoltaics applications. It can be easily synthesized and is non-toxic to the environment. It is a self-assembly molecule developed from deep-blue-green pigment. It exhibits a characteristic structural self organization which is reflected in an efficient energy migration in the form of extinction transport. In the present work thin films of ZnPc have been prepared on glass substrate under strict vacuum conditions (10<sup>-6</sup> torr), thickness of few nanometers. Absorption spectra in Visible and IR regions have been observed which is good for fabrication of Photovoltaic cells and Nanostructures for Photodynamic Cancer Therapy. Investigations have been made from different stacking positions of Molecular ZnPc thin films for studying their self-assembling nature that can be useful for their applications as Molecular-Recognition in Drug delivery and sensors which is one of the key features of Nanotechnology.

## 6413-35, Poster Session

### Studies on parameters measurement and analysis of optic fiber

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The parameters of optical fibers, such as geometrical characters, numerical aperture and capability of micro bend, are important indicators of their application. This paper puts forward an effective and practical analytical method based on principles of the digital image processing to measure geometrical parameters of optical fibers such as the diameter. The experiments on the measurement of four types of optical fibers' geometrical characters have been conducted in this paper. The four types of fibers are quartz optical fiber, plastic optical fiber, hollow-core optical fiber and self-made novel liquid-core optical fiber respectively. The feasibilities of these optical fibers as means of optical fiber sensors are studied via comparison their feature parameters. The capabilities of micro bend of these types of optical fibers are carried out through a load-added setup. The figures of the output intensity of each fiber vs. displacement of the load-added setup are presented in this paper. Through experimental data and the figures it is found out that the capability of load of the self-made liquid-core optical fiber is better than other types of fibers and it has the highest sensitivity to load as well. The study also demonstrates that the self-made novel liquid-core optical fiber can be used as a sensor to measure the loads and damages added to structures, and self-diagnosis of deformed composite materials and structures can be achieved, which prove the application of this novel liquid-core optical fiber to composite materials

## 6413-36, Poster Session

### Fabrication of embedded conductive layer in polymer by plasma immersion ion implantation and gold assisted sacrificial conductive surface layer

P. C. T. Ha, Z. J. Han, Y. B. Xing, B. K. Tay, Nanyang Technological Univ. (Singapore)

Plasma immersion ion implantation (PIII) offers an alternative to ion beam with the advantage of high implantation rate. However, problems inherent to the application of PIII to non-conducting materials such as polymers are due to surface charging. To overcome these difficulties and to have a controllable implantation depth, we sputtered a thin layer of gold before PIII is applied to the polymer substrate. The result is a controllable implantation depth that can be correlated from the energy of the incoming ions and compare to the implantation depth produced by the TRIM modeling program. Cross-sectional Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) are pre-

sented, showing the extent of implantation depth while conductive AFM confirmed the conductivity of the embedded layer. The future applications, difficulties and limitations using this technique for fabrication of conductive embedded layer in polymers are discussed.

### 6413-38, Poster Session

#### Synthesis and electrical properties of Chitosan-g-poly(aniline)/Fe<sub>2</sub>O<sub>3</sub> nanocomposite

A. Tiwari, S. P. Singh, National Physical Lab. (India)

The naturally occurring, chitosan was chemically modified with polyaniline and resulting co-polymer was water-soluble, biodegradable and electrically active in nature. The co-polymer was biocompatible having good shelf life and better sickness on the glass plates with electrical conductivity in the range  $28.4 \times 10^{-3} \text{ Scm}^{-1}$  at room temperature. The produced co-polymers have hybrid properties of native biopolymer and polyaniline conducting polymer. In the present work, prepared materials are solving all the difficulties facing by the technologist for making devices by using bio-resources. The major emphasis of present work is the combination of a biopolymer, isolated from the natural resources and synthetic polymer from petrochemical origin is to be combined and get eco-friendly materials of high performance. This work also deals the effect of Fe<sub>2</sub>O<sub>3</sub> in quantum size as dopant in the conducting co-polymer polymer and observes the effect of nanostructure composition of Fe<sub>2</sub>O<sub>3</sub> on their conductivity. It has been found that conductivity was increased with increasing the amount of Al<sub>2</sub>O<sub>3</sub> incorporated to the material. Using UV, FTIR, XRD, TGA and SEM analysis did the characterization of material. The varying all the parameters like concentrations of biopolymer, aniline and other ingredients in order to found suitable biopolymer based materials having electrical conductivity.

### 6413-39, Poster Session

#### Development of SMART fabrics for potential wound dressing applications

V. Cornelius, N. Majcen, M. Snowden, J. C. Mitchell, Univ. of Greenwich (United Kingdom); B. Voncina, Univ. of Maribor (Slovenia)

Wound dressings and other types of wound healing technologies are experiencing fast-paced development and rapid growth. As the population ages, demand will continue to rise for advanced dressings used to treat chronic wounds, such as pressure ulcers, venous stasis ulcers, and diabetic ulcers. Moist wound dressings, which facilitate natural wound healing in a cost-effective manner, will be increasingly important.

In commercially available hydrogel / gauze wound dressings the gel swells to adsorb wound excreta and provide an efficient non adhesive particle barrier. An alternative to hydrogels are microgels. Essentially discrete colloidal gel particles, as a result of their very high surface area to volume ratio compared to bulk gels, they have a much faster response to external stimuli such as temperature or pH. In response to either an increase or decrease in solvent quality these porous networks shrink and swell reversibly. When swollen the interstitial regions within the polymer matrix are available for further chemistry; such as the incorporation of small molecules. The reversible shrinking and swelling as a function of external stimuli provides a novel drug release system. As the environmental conditions of a wound change over its lifetime, tending to increase in pH if there is an infection combining these discrete polymeric particles with a substrate such as cotton, results in a smart wound dressing.

Castro Lopez V and Snowden MJ. The role of colloidal microgels in drug delivery. *Drug delivery Systems & sciences*, 2003; 3; 19-23

### 6413-40, Poster Session

#### The use of colloidal microgels for the controlled delivery of proteins and peptides

V. J. Cornelius, M. Snowden, J. C. Mitchell, Univ. of Greenwich (United Kingdom)

Colloidal microgels may be used for the absorption and controlled release of conformationally sensitive molecules such as proteins and peptides. These monodisperse microgels are easily prepared in a single pot reaction from e.g. N-isopropylacrylamide, butyl acrylate and methacrylic acid in the presence of a cross-linking agent and a suitable free radical initiator. The resultant materials display dramatic conformational changes in aqueous dispersion in response to changes in e.g. environmental pH.

Colloidal microgels are capable of absorbing a range of different proteins and peptides at one pH, affording them protection by changing the conformation of the microgel following a pH change. A further change in environmental pH will allow the microgel to adopt a more extended conformation and therefore allow the release of the encapsulated material. In the case of e.g. insulin this would offer the possibility of an oral delivery route. At the pH of stomach the microgel adopts a compact conformation, "protecting" the protein from denaturation. As the pH increases passing into the GI tract, the microgel changes its conformation to a more expanded form and thereby allows the protein to be released. Colloidal microgels offer an opportunity for the controlled release of conformationally sensitive protein and peptide molecules via an oral route.

Ramkisson-Ganorkar Liu, Banyä M, and Kim SW. Modulating insulin-release profile from pH/thermosensitive polymeric beads through polymer molecular weight. *J. Control Release*, 1999; 59; 287-298.

### 6413-42, Poster Session

#### Micro-array printing and analysis of fluorescently labeled proteins on reactive substrates

M. D. Kurkuri, Flinders Univ. (Australia); C. Driever, H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); N. H. Voelcker, Flinders Univ. (Australia)

Tissue engineering and stem cell technologies have led to a rapidly increasing interest in the control of the behaviour of mammalian cells growing on tissue culture substrates. Multifunctional polymer coatings can assist research in this area for example by providing low non-specific protein adsorption properties and reactive functional groups at the surface. The latter can be used for immobilization of specific biological factors. In this study, glass slides were coated with copolymers of glycidyl methacrylate (GMA) and poly(ethylene glycol) methacrylate (PEGMA) in three different molar ratios (1:2, 1:1 and 2:1). The coatings were prepared by three different methods: dip coating, spin coating and grafting. Quenching of the reactive oxirane groups with the aim of creating a low cell attachment surface was investigated using several amines, including poly(ethylene glycol) amine. Coatings were characterised by X-ray photoelectron spectroscopy, surface sensitive infrared spectroscopy, ellipsometry and contact angle measurements. Fluorescently labelled proteins were deposited onto reactive coatings using a contact microarrayer. Printing of a model protein (FITC labelled albumin) was performed at different protein concentrations, pH, temperature, humidity and using different micropins. Here, microarraying performed at a protein concentration of 75 µg/mL prepared in pH 5 phosphate buffer showed favourable results. The arraying of proteins was studied with a microarray scanner. Cell culture experiments on the coatings were performed using HeLa cells. Cell culture results show that the coatings are non-toxic and suitable in regard to cell attachment.

# Conference 6414: Smart Structures, Devices, and Systems III

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## 6414-01, Session 1

### Design of a high-performance electrothermally driven vertical microactuator

M. Mayyas, The Univ. of Texas at Arlington (USA)

A vertical microactuator based on electrothermal actuation is fabricated in PolyMUMPS. The device actuation mechanism utilizes the asymmetrical thermal expansion of the hanging over polysilicon. In a symmetrical circular arrangement, beams of two silicon layer are hanging over each other and separated by an airgap. For each beam, one end is anchored to substrate and the other end is only free to translate in vertical direction. Where the actuator center is a circular mirror that is suspended by the anchored beam's end. In each beam, the generated heat in lower polysilicon has greater thermal expansion than that of upper polysilicon. And thus, the actuator center deflects upward with large vertical deflection and lifting force. Moreover, the temperature profile and the structural response are analytically derived and compared with finite element simulations. The dynamical models of vertical actuator are experimentally parameterized based on fourth order identification. We conclude that the designed vertical actuator provided fast structural response, high lifting force and deflection. Such developed design is a building block that provides practical applications on the areas of optical measurement and display, temperature transducers, and micro vertical positioning and actuating.

## 6414-02, Session 1

### State estimation of nonlinear piezoelectric stack actuator hysteresis and creep model

J. L. Minase, T. Lu, F. Wornle, The Univ. of Adelaide (Australia)

The state estimation of a non-linear model of a piezo-electric stack actuator showing hysteresis and creep is proposed. Model uncertainties related to hysteresis and creep effects in piezo-electric stack actuators, most prominently in the higher frequency zone; can make the closed-loop control system unstable. Furthermore they may lead to inaccurate open-loop control frequently causing harmonic distortions when the stack is driven with sinusoidal input signals. In order to solve the above issues, it is very important to determine an accurate non-linear model of the piezo-electric stack actuator. The Unscented Kalman Filter (UKF) algorithm will be used to accurately estimate the states of the non-linear model of the piezo-electric stack actuator such that hysteresis and creep effects can be accurately predicted. The states of the piezo-electric stack actuator model are assumed to be zero-mean Gaussian random variables (GRV). The UKF uses the Unscented Transformation (UT) method to choose the minimal number of samples points such that the true mean and covariance of the GRV is completely captured. On propagation through the true non-linear model of the piezo-electric stack actuator, these sample points capture the posterior mean and covariance accurately to third order for Gaussian inputs. The accurately estimated model will thereby assist studies aiming at a better understanding of the hysteresis and creep effects as well as be useful in robust control system design.

## 6414-04, Session 1

### A two-level comb-driven electrostatic microrelay with low-actuation voltage

G. Xu, Hefei Univ. of Technology (China)

Microrelays are widely used in the field of electrical-mechanical control, test equipment, telecommunications, and so on. Electrostatic actuation is the most frequently applied principle combining versatility and simple technology. Since the previously

reported electrostatic-microrelay have too actuation voltage for common applications, the purpose of this paper is to present a novel bulk micromachined relay with two-level comb-driven with silicon-glass wafer bonding and deep reactive ion etch technologies. The microrelay has a lateral contact structure, and it is electrostatic driven by two-level comb driven actuators. The processing is very simple, and only two masks are used. By optimization design for the structure, depending upon geometrical parameter choices, Only a 10 V actuation voltage of the microrelay can be achieved. Using sputtered gold as contact materials and the contact resistance is below 100m $\Omega$ , which is satisfy the requirements of weak current applications. The proposed electrostatic microrelay is suitable for common applications.

## 6414-05, Session 2

### TCAM core design in 3D IC for low-matchline capacitance and low power

E. C. Oh, P. D. Franzon, North Carolina State Univ. (USA)

Ternary Content Addressable Memory (TCAM) has been an emerging technology for fast packet forwarding, commonly used in longest prefix match routing. Large table size requirements and wider lookup table data widths have led to higher capacity TCAM designs. However, the fully parallel characteristic of TCAM makes large TCAM design more challenging and limits its capacity due to intensive power consumption. This paper proposes 3D IC technology as a solution to reduce the power consumption by reducing the interconnect capacitances of TCAM. In 3D IC, multiple wafers are stacked on top of each other, and the tiers are vertically connected through 3D vias. 3D vias reduce metal interconnect lengths and parasitic capacitances, resulting in power reduction. In this paper, 3D vias are used to replace matchlines, whose transition during parallel search operations is a major source of high power consumption in TCAM. An analysis of parasitic interconnect capacitance has been done using a quasi-static electromagnetic field simulation tool, Ansoft Q3D Extractor, on a TCAM memory core in both conventional 2D IC structure and 3D IC structure with the process parameters of the MIT Lincoln Labs 0.18 $\mu$ m FDSOI process. Field analysis and spice simulation results using a capacitance model for interconnects show that a 40% matchline capacitance reduction and a 25% power reduction can be achieved by using a 3-tier 3D IC structure instead of the conventional 2D approach.

## 6414-06, Session 2

### A broadband 8-18GHz 4-input 4-output Butler matrix

L. E. Milner, M. E. Parker, Defence Science and Technology Organisation (Australia)

Butler matrices can be used in antenna beam-forming networks to provide a linear phase distribution across the elements of an array. The development of an 8 to 18GHz micro-strip implementation of a 4-input 4-output butler matrix is described. The designed Butler Matrix uses March hybrids, Schiffman phase shifters and wire-bond crossovers integrated on a single 60mm x 70mm alumina substrate.

## 6414-08, Session 2

### An optimized low-power voltage controlled oscillator

K. V. Shah, H. P. Le, J. J. Singh, La Trobe Univ. (Australia)

This paper presents an optimised low-power low-phase-noise Voltage Controlled Oscillator (VCO) for Bluetooth application. The system level design issues and tradeoffs related to Direct Con-

version Receiver (DCR) architecture for Bluetooth application will be first discussed. Subsequently, the critical VCO performance parameters will be derived from system specifications. The VCO presented in the paper is optimised by implementing a novel biasing circuit that employs two current mirrors, one at the top and the other at the bottom of the cross-coupled complementary VCO, to give the exact replica of the current in both the arms of current mirror circuit. This approach, therefore, will significantly reduce the system power consumption as well as improve the system performance. The VCO has been implemented in Cadence Spectra RF using 0.25-micron TSMC technology. Results show that, the VCO consumes only  $281\mu\text{W}$  of power at 2V supply. Its phase noise performance are  $-100\text{dBc}/\text{Hz}$ ,  $-115\text{dBc}/\text{Hz}$  and  $-130\text{dBc}/\text{Hz}$  at the offset frequency of 1MHz, 3MHz and 5MHz respectively. The results present a significant improvement of phase noise as compared to traditional VCO and therefore resulting in the better system performance. Results also indicate that 31% reduction in power consumption is achieved as compared to the traditional VCO design. These characteristics make the designed VCO a better candidate for Bluetooth wireless application where power consumption is the major issue. The detailed design, results and analysis of the optimised VCO will be presented in the full paper.

### 6414-09, Session 2

#### A high-frequency divider in 0.180 $\mu\text{m}$ SiGe BiCMOS technology

N. Kamal, Y. Zhu, S. F. Al-Sarawi, The Univ. of Adelaide (Australia); N. Weste, Macquarie Univ. (Australia); D. Abbott, The Univ. of Adelaide (Australia)

High frequency dividers are critical parts of frequency synthesizers in wireless systems. These dividers allow the output frequency from the voltage controlled oscillator to be compared with a much lower external reference frequency that is commonly used in these synthesizers. Common trade-offs in high frequency dividers are dividing speed, power consumption, real estate area and output signal dynamic range. In this paper we demonstrate the design of a high speed frequency, low power divider in 0.180  $\mu\text{m}$  SiGe BiCMOS technology. The divider utilises a regenerative architecture and is a part of 60 GHz frequency synthesizer. The design was simulated in Cadence simulation environment using Jazz design kit. Simulation results show that the divider achieves a high frequency operation of 48 GHz and consumes 18 mA from a 1.8 supply voltage. The design was submitted for fabrication and measurement results will be included in final paper.

### 6414-10, Session 3

#### A novel strain sensor using organic semiconductor films on polymeric substrates

S. Jung, T. Ji, V. K. Varadan, Univ. of Arkansas (USA)

In this study, organic semiconductor strain sensors based on pentacene are fabricated employing serpentine and square shapes on flexible substrates, Kapton(r) polyimide and polyethylene naphthalate (PEN) films. They were tested with different bending conditions, perpendicular, parallel, and  $45^\circ$  to the bridge bias direction, with respect to the different bending diameters, 100 mm, 80 mm, 65 mm, 55 mm, and 20 mm that corresponds to strain ranges of  $1 \times 10^{-3} \% \sim 5 \times 10^{-3} \%$ . It was noted that the smaller sensor size the better performance in terms of sensitivity. The both stain sensors show reasonable repeatability at the range of 100 mm to 20 mm bending diameter. The organic semiconductor strain sensors fabricated on flexible substrates are expected to possess better reliability as compared with conventional metallic foils and inorganic semiconductor strain sensors because of their low Young's modulus ( $\sim 5\text{GPa}$ ). For instance, the high Young's modulus of micro crystalline silicon ( $\sim 200\text{GPa}$ ) limits its applications for sensors when fabricated on polymeric substrates due to the large modulus mismatch between them.

### 6414-11, Session 3

#### Physical modeling of a highly sensitive linear MOS sensor array system for 2D detection of magnetic fields

A. Abou-Elnour, Ajman Univ. of Science & Technology Network (United Arab Emirates); O. Abo-Elnor, Ajman Univ. of Science and Technology (United Arab Emirates)

The full CMOS process-compatibility of MOSFET based magnetic sensors allows them to be successfully integrated in various electronic circuits and systems to detect the strength of magnetic field, to realize a magneto-electric function, and to recognize a magnetic field patterns. The impact of different device and technological parameters on the performance MOSFET magnetic sensors (MS) is thoroughly investigated and resulted in a strong enhancement in their performance and consequently in their applications. However, to accurately characterize the operation and to precisely optimize the function of MOSFET-MS, rigorous systematic modeling of their physical properties is a must.

Theoretical models had been developed to determine the effect of magnetic fields on the electrical performance of MOSFET-MS. The absence of direct coupling between the magnetic field and the semiconductor transport equations in analytical models limits the ability of these models in determining the effects of all device parameters and operating conditions on the sensor sensitivity. Other sophisticated numerical models which fully coupled Maxwell's equations with the device transport equations require high CPU time what limit the usage of these models as efficient CAD tools in the optimization process of MOSFET-MS structure. MOSFET-MS macro circuit models are attractive tools which are efficiently used to investigate the behavior of integrated systems based MOSFET-MS. However, the accuracy of MOSFET-MS macro circuit models are limited by the validity of approximations used to find the value of the additional circuit elements which modeled the current deviation due to external magnetic field.

The aim of the present work is to develop an accurate physical device simulator that can be efficiently and systematically used to characterize the operation and to optimize the structure of both single MOSFET-MS and integrated systems based on MOSFET-MS. First, the coupling scheme of the magnetic field equation together with the semiconductor carrier transport equations is described. Using the developed physical simulator, the performance of a single MOSFET-MS is investigated and the effects of varying device geometric parameters, biasing conditions, and magnetic field on the current deflection and on the MS relative sensitivity under dc and ac magnetic fields are determined. From the simulation results, an enhanced equivalent circuit model for MOS magnetic sensor is proposed and used to predict the performance of a suggested precise integrated smart structure to show its ability to detect the magnetic field variations in two-directions. It is found that the present system has excellent linearity, wide dynamic range of operation, excellent resolution, and sensitivity enhancement without need to scale down the device geometry. Moreover, the presented smart magnetic sensor configuration enables us to give a 360 polar indication of the B directions and hence overcomes the challenging problem of inability to determine the orientation of the magnetic field in conventional magnetic sensors.

### 6414-12, Session 3

#### Optimization of integrated antennas for wireless sensors

M. Mussetta, A. Gandelli, R. E. Zich, Politecnico di Milano (Italy)

Modern advances in sensor technology, digital electronics and radio frequency design have enabled the development of cheap, small, low-power sensory devices, integrating sensing, processing and communication capabilities.

This work aims to present an overview of the benefits and of the most recent advances in antenna technologies, investigating the possibility of integrating enhanced solutions in a large distributed wireless sensor network for the environmental monitoring.

The antenna in fact is the key element in order to fully integrate a wireless microsystem on a single chip. The integration requires a small antenna on a low-loss substrate material compatible with the microelectronic devices.

In fact, communication is usually the most energy intensive operation a node performs. Therefore, at each terminal the application of integrated and miniaturized antennas can have a significant impact, in terms of not only system performance but also cost, energy consumptions and terminal physical size.

An integrated design technique of a microstrip antenna on a complex dielectric substrate is here presented. For small bit rate wireless networks, microstrip antennas are a good choice. The simplicity of realization, the low cost, the flexibility of use and the reduced dimensions make perfect for the on-chip integration. These objectives are instrumental in selecting elements that can conform to the geometry of the device.

The optimization of the wireless device is also presented, to carefully adjust also parameters as the shape and dimensions of the antenna, in order to develop different layers of communication in the same device, thus endowing with multiband capabilities; this gives the possibility to have inter-sensor link and GPS information retrieving.

### 6414-13, Session 3

#### Thin metal foil sensors

A. R. Wilson, P. J. McMahon, R. F. Muscat, O. Vargas, P. S. Vincent, Defence Science and Technology Organisation (Australia)

Defence Science and Technology Organisation (DSTO) is engaged in the development of sensor systems to monitor the environment and condition of high value structures and machinery. The development of this technology promises to contain escalating costs associated with the through-life support of major capital platforms, including high-rise buildings, bridges, aircraft, ships and offshore oil/gas structures. As part of this work a laser micromachining process for fabricating thin foil sensors has been developed. Laser micromachining has some inherent advantages over other processes such as metal deposition and chemical etching for the production of thin foil sensors. A chief advantage of the process is the ability to make relatively thick (100um) micro-patterned sensors (20um features) out of a very wide variety of metals with only minor changes to the process. This last feature makes feasible the manufacture of sensors out of the same material as the bulk structure that is being monitored. This paper presents results for some laser micromachined thin foil corrosion and environmental sensors and compares these with similar sensors made using different fabrication processes.

### 6414-14, Session 3

#### Potential system efficiencies for MEMS vibration energy harvesting

S. Behrens, Commonwealth Scientific and Industrial Research Organisation (Australia)

Reliable power sources are needed for portable MEMS devices such as wireless automobile tire pressure/temperature sensors. Vibration is a ubiquitous energy source that maybe 'harvested' as electrical energy at the site of the device. Existing vibration energy harvesting use either a piezoelectric or an electromagnetic transducer to convert vibrations into electrical energy. Electrical energy for the device is then conditioned using a passive rectifier DC-DC converter circuit. Such vibration harvesting techniques focus on conditioning circuit efficiency and, hence, neglect the system efficiency i.e. mechanical-to-electrical efficiency.

Results from a generic prototype can be extrapolated to predict potential system efficiencies for MEMS vibration energy harvesting. Results from the generic prototype, using a common speaker as the transducer, have demonstrated system efficiencies of 16%. Simulations suggest MEMS system efficiencies of more than 80% can be achieved with better transducers. Research is continuing to demonstrate these higher system efficiencies with the generic prototype.

### 6414-15, Session 4

#### Modeling of a fluid-filled ionic polymer-metal composite cylindrical shell

L. Zhang, Y. Yang, Nanyang Technological Univ. (Singapore)

Ionic polymer-metal composite (IPMC) is a type of wet electro-active polymers (EAP). It consists of a thin polyelectrolyte membrane, such as Nafion or Flemion, and a type of noble metal, gold or platinum, chemically plated on both sides of the membrane. IPMC can undergo a fast and large bending motion when a low electric potential is applied to its electrodes. Conversely, IPMC will generate a measurable electric potential when it is subjected to a sudden bending. Thus, the IPMC can sever as both actuators and sensors. IPMC offers many advantages over the conventional EAP materials, such as compliance, light weight, low operation voltage, relatively insensitive to damages and capability of working in aqueous environments. These properties make it promising for numerous applications in biomedical, robotic and microelectromechanical system (MEMS) engineering.

In this paper, an infinite IPMC cylindrical shell filled with fluid is studied. The IPMC shell is plated with discrete electrodes. Electric signal is applied on the electrodes resulting in vibration of the shell-fluid coupled system. By proper control of the electric signal, the contained liquid can be pumped through the shell. Nemat-Nasser's hybrid actuation model is simplified to account for the force input due to electric potential in the motion equations. Analytical solutions are obtained by the wave propagation method for the displacement field of the cylindrical shell and the pressure in the contained liquid. The axial velocity of the liquid due to the electric excitation is also derived. This model is useful for devices using IPMC cylindrical shell structures with or without contained liquids.

### 6414-16, Session 4

#### Asymptotic analysis of thermal behavior of smart materials

A. Almajid, Z. Abduljabbar, M. AlSadoon, King Saud Univ. (Saudi Arabia)

The thermal behavior of smart materials is investigated using the asymptotic expansion approach. The analysis adopts a configuration consisting of a piezoelectric plate on the upper and lower surfaces and a metal plate in the middle. The thermal load consist of incident radiation and convective heat transfer at the upper and lower surfaces. Different thermal boundary conditions are considered at the ends of the structure; including fixed temperature (isothermal), thermally insulated (adiabatic), and convective. The analytical analysis in the asymptotic expansion simplified the governing equations without resorting to the classical plate and shell assumptions. The asymptotic theory reduces the exact equations to an asymptotically exact form whose solution is valid to a predetermined level of accuracy. The accuracy of the solution depends on the number of terms retained in the asymptotic expansion. The closed form solutions obtained by these schemes usually of simple form and can be used in the design and analysis of smart structures.

### 6414-17, Session 4

#### Bending analysis of functionally graded piezoelectric actuator using Timoshenko beam theory

H. Xiang, Beijing Jiaotong Univ. (China); J. Yang, S. Kitipornchai, K. Liew, City Univ. of Hong Kong (Hong Kong China)

Functionally graded piezoelectric materials (FGPM), comprising a new class of smart composite materials, have received more and more attention since they were proposed. Due to the fact that the bonding layer in the traditional smart devices may crack at low temperature or peel off at high temperature, which will reduce the lifetime and reliability of these piezoelectric devices, more and more sensors and actuators have been designed with graded

properties. It is hoped that the mechanical stresses can be significantly reduced or eliminated in FGPM sensors and actuators. In present paper, the Timoshenko beam theory is employed to solve the bending behavior of functionally gradient piezoelectric actuators subjected to transverse loads and voltage. It is assumed in analysis that the properties of the beam vary continuously through the thickness and obey a power law distribution of the volume fraction of the constituents. The types of supports may be free, simply supported or clamped. Differential quadrature method is employed to convert the partial differential equations and the associated boundary conditions into a set of algebraic equations. The numerical results in the present paper are compared with the results based on Bernoulli-Euler beam theory, the FEM results simulated by FEMLAB code and the experiment results obtained by other investigators, which show that the Timoshenko beam theory is accurate enough to consider the effect of shear deformation on the bending of functionally graded beam. At last, the design and optimization of actuator are discussed.

## 6414-19, Session 5

### Integrated microphotonic beamformer for broadband adaptive nulling in smart antennas

B. Juswardy, K. Alameh, Edith Cowan Univ. (Australia)

The enormous growth of the number of broadband wireless subscribers has driven the need for increasing the capacity of wireless networks to accommodate larger volumes of broadband subscribers. Digital signal processing is currently thwarted by the limited bandwidth of analog-to-digital converters and conventional radio frequency (RF) signal processing is also limited by the loss of metallic media at RF frequencies. Photonic RF signal processing is a promising approach which allows wideband RF signals to be delayed in the optical domain with negligible loss. This paper presents an integrated MicroPhotonic beamformer that processes RF-modulated optical signals to adaptively synthesise multiple broadband nulls in smart phased-array antennas. In this system, the incoming RF signals are split and converted into modulated optical beams via a Vertical Cavity Surface Emitting Laser (VCSEL) array and routed into a multi-cavity optical substrate, which generates different true-time delayed versions of the input RF signals. A photoreceiver array, operating in ON-OFF mode, integrated onto the optical substrate converts the modulated light beams into RF signals and combines them to produce the output RF signal. By selecting and combining appropriate delayed signals arbitrary broadband spatial nulls can be synthesised. The beamformer is designed to operate at 5.6 GHz with 1 GHz bandwidth. Results showing the design and performance of the different photonic and RF components will be presented.

## 6414-20, Session 5

### Microwire fibers for low-loss THz transmission

S. Atakaramians, S. Afshar Vahid, H. Ebendorff-Heidepriem, B. M. Fischer, T. M. Monro, D. Abbott, The Univ. of Adelaide (Australia)

THz spectroscopic techniques have attracted a lot of interest due to their applications in detection of biological and chemical materials over the last decade. Low loss THz transmission is one of the key main issues of these techniques. To date, metal parallel plates and bare metal wires are the promising metal-based guiding techniques reported in the literature with attenuation constants less than  $0.3 \text{ cm}^{-1}$  [1] and  $0.03 \text{ cm}^{-1}$  [2] respectively.

Chen et al. have recently reported [3] loss values less than  $0.01 \text{ cm}^{-1}$  near 0.3 THz in plastic fibers [4]. The concept of THz guided propagation in these fibers is similar to nanowire optical fibers. Optical nanowires are filaments of dielectric media whose tailorable sub-wavelength dimensions (order of nm) allow a substantial fraction of the guided light (wavelength of 1-1.5  $\mu\text{m}$ ) to propagate outside the structure. Such an enhanced evanescent field behaviour happens for micrometer size fibers in THz spectrum (30-3000  $\mu\text{m}$ ), for which we coin the term microwires.

Microwires, due to their sizes, are more robust and do not have the fragility issues associated with nanowires.

In this paper we compare the THz loss for bulk glasses (F2, SF6, SF57 and Bismuth) and a polymer (PMMA). We investigate if the effective loss (apart from scattering loss) of a microwire is the material loss, inside (dielectric) and outside (air), averaged over the transversal mode. The effect of refractive index of the above glasses and polymer, microwire diameters and wavelength on effective loss will also be discussed.

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## 6414-21, Session 5

### Opto-VLSI-based reconfigurable free-space optical interconnects architecture

M. Aljada, K. Alameh, Edith Cowan Univ. (Australia); Y. Lee, I. Chung, Gwangju Institute of Science and Technology (South Korea)

This paper presents a short-distance reconfigurable high-speed optical interconnects architecture employing a Vertical Cavity Surface Emitting Laser (VCSEL) array, Opto-very-large-scale-integrated (Opto-VLSI) processors, and a photodetector (PD) array. The core component of the architecture is the Opto-VLSI processor which can be driven by digital phase steering and multicasting holograms that reconfigure the optical interconnects between the input and output ports.

The optical interconnects architecture is experimentally demonstrated using high-speed  $1 \times 3$  VCSEL array and  $1 \times 3$  photoreceiver array in conjunction with two  $1 \times 4096$  pixel Opto-VLSI processors. Different optical interconnects scenarios are used to demonstrate the flexibility of the architecture to perform single, multicasting, and parallel reconfigurable optical interconnects at 1.5 Gbps. Measured results show adequate eye diagram openings for all interconnects scenarios. The minimisation of the crosstalk between the output ports is achieved by appropriately aligning the VCSEL and PD elements with respect to the Opto-VLSI processors and driving the latter with optimal steering and multicasting phase holograms.

## 6414-22, Session 5

### Design and optimization of programmable lens arrays for adaptive optics

Z. Wang, S. H. Eng, Edith Cowan Univ. (Australia); K. Alameh, Edith Cowan Univ. (Australia)

The ability of Opto-VLSI processors to generate lens and lens arrays of variable focal lengths and selectable fields of view (FOV) makes them excellent candidates for many adaptive optics applications including retinal imaging, astronomy, and free-space optical telecommunications.

In this paper, we report a range of dynamic lens and lens array designs and optimizations using an Opto-VLSI processor comprising an array of liquid crystal (LC) pixels that can be independently addressed by a Very-Large-Scale-Integrated (VLSI) circuit. Computer algorithms based on Fourier transformation for lens synthesis are developed to address the Opto-VLSI processor and generate appropriate phase holograms that emulate lens and/or lenslet arrays with programmable focal lengths, tilting angles, and diameters. Experimental results demonstrating the dynamic generation of lens arrays of variable focal lengths, diffraction efficiencies, fields of view, and dimensions at red, green and blue wavelengths, will be presented. Preliminary experimental results show that a focal length as small as 70mm and a field of view as wide as  $25^\circ$  can be realised.

## 6414-23, Session 5

### Review of THz near-field methods

H. Lin, B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia)

Terahertz (THz) imaging offers many attractive advantages over existing modalities such as enhanced optical contrast, ability to obtain spectroscopic information and imaging of dielectric materials. However, one of the major limitations of THz images is low spatial resolution, as determined by Rayleigh's criterion with a comparatively longer wavelength (0.3 mm at 1 THz). As a result, various techniques have been proposed in the literature with an aim of breaking the diffraction limit. Much of the existing techniques draw inspiration from near-field scanning optical microscopy, with the near-field methods being used in conjunction with THz time domain spectroscopy. Other techniques utilize tightly focused optical beams to reduce the size of the generated THz beams. This paper presents a review of the existing THz near-field methods in the literature and offers comparisons of their respective performances, experimental setup and practical feasibility.

## 6414-24, Session 6

### Thin films of zinc phthalocyanine (ZnPc) for optoelectronic devices

M. Puri, Guru Nanak Dev Univ. (India)

ZnPc is a promising candidate for photovoltaics applications. It can be easily synthesized and is non-toxic to the environment. It is a self-assembly molecule developed from deep-blue-green pigment. It exhibits a characteristics structural self organization which is reflected in an efficient energy migration in the form of extinction transport. In the present work thin films of ZnPc have been prepared on glass substrate under strict vacuum conditions (10<sup>-6</sup> torr), thickness of few nanometers. Absorption spectra in Visible and IR regions have been observed which is good for fabrication of Photovoltaic cells and Nanostructures for Photodynamic Cancer Therapy. Investigations have been made from different stacking positions of Molecular ZnPc thin films for studying their self-assembling nature that can be useful for their applications as optoelectronic devices, Molecular-Recognition in Drug delivery and sensors which is one of the key features of Nanotechnology.

## 6414-25, Session 6

### Template synthesis of nano-/microresonant tunneling diodes

S. K. Chakarvarti, National Institute of Technology/ Kurukshetra (India)

The tunneling phenomenon assumes significant role in devices which are put to use in information processing, data storage and transmission, digital functioning etc. The requirements call for low dimensions, low weight, low power consumption, high frequency etc. Template synthesis is an elegant approach for synthesizing nano/micro sized resonant tunneling diodes (RTDs). Using track-etch membranes as templates, we report here on the nano/micro fabrication of RTDs using binary systems like Cu-Se, Zn-Se etc and present their I-V characteristics, besides the effect of temperature and size variation of the structures.

## 6414-26, Session 6

### Fuzzy control of shear-mode MR damper under impact force

J. Joh, J. Cho, Changwon National Univ. (South Korea)

Recently, many types of semi-active magnetorheological (MR) dampers have been proposed for vibration attenuation of various dynamic systems. MR dampers are relatively inexpensive to manufacture because the fluid properties are not sensitive to contaminants. Other attractive features include their small power requirements, reliability, and stability. Requiring only 20~50W of power, these devices can operate with a battery, eliminating the need for

a large power source or generator. Because the device forces are adjusted by varying the strength of the magnetic field, no mechanical valves are required, making a highly reliable device. Additionally, the fluid itself responds in milliseconds, which allows for the development of devices with a high bandwidth.

MR devices are classified as semi-active devices. Semi-active devices are characterized by their ability to dynamically vary their properties with a minimal amount of power. Because semi-active devices can only absorb or store vibratory energy in a structure by reacting to its motion, they are considered to be stable. Thus, semi-active devices are expected to offer effective performance over a variety of amplitude and frequency ranges.

Recently, a number of researches about linear MR damper using valve-mode characteristics of MR fluid have sufficiently undertaken, but researches about rotary MR damper using shear-mode characteristics of MR fluid are not enough.

Jansen and Dyke proposed clipped inverse model which determines the command voltage based on how the damper force compared with the target force. Tse et al. (2004) designed a small-scale rotary type of MR damper and proposed relatively accurate inverse dynamic model that can directly relate the damper force to the input voltage using Bouc-Wen model.

In this paper, we performed vibration control of rotary type MR damper for unlimited rotating actuator of mobile robot. MR damper test equipment is designed and implemented to excite MR damper using MR brake (LORD Corporation's MRB-2107-3) and LVDT (SENSTECH co.'s LPS).

In the case of MR damper is used for dynamics systems, it may be desirable to have an inverse model to predict preliminarily the applied voltage in order to generate the required control force. Therefore, we obtained inverse model of shear-mode MR damper. Also, fuzzy logic based vibration control for rotary MR damper is suggested. The parameters, like scaling factor of input/output and center of the triangle-shape membership functions associated with the different linguistic variables, are fine tuned by genetic algorithm. Experimental results clearly demonstrate the effectiveness of the fuzzy logic controller for vibration control of rotary MR damper under impact force.

## 6414-27, Session 6

### Development of a mechanical mover device by compositing hydrogen storage alloy thin films with a perfluorosulfonic acid layer

T. Ogasawara, H. Uchida, Y. Nishi, Tokai Univ. (Japan)

Perfluorosulfonic Acid (PFSA) film, commonly used in the Polymer Electrolyte Fuel Cells (PEFC), indicates conductance of proton and permeability of H<sub>2</sub>O. In this study a mechanical composite mover device with this PFSA and hydrogen storage alloy (HSA) thin films was made up for expecting the movement driven by volume change in the course of hydrogen migration between PFSA and HAS layers. Hydrogen storage alloy, such as LaNi<sub>5</sub> indicates as much as 25% of volume change in the course of H<sub>2</sub> absorption in gas phase. Using this characteristics, a mechanical mover device was made of PFSA film of an electrolyte polymer sandwiched by hydrogen storage alloy thin films with Au-Pd intermediate layers. The mover device was operated by migrating hydrogen ions from the PFSA layer to the HSA layer, which were generated by electrolysis of H<sub>2</sub>O in a PFSA layer. Electrical potential was given from the outside lead wires. All experiments were carried out in the water. We confirmed large interesting movement generated by migration of hydrogen ion by applying electric potentials.

## 6414-28, Session 6

### Electro-acoustic and acousto-optic communications for robotic agents in smart structures

G. Wild, S. Hinckley, Edith Cowan Univ. (Australia)

Electro-Acoustic and Acousto-Optic communications channels have been investigated. The communications channels are in-



tended for use by robotic agents in the non-destructive evaluation (NDE) of structures containing distributed acoustic emission sensors. The acoustic emission sensors can be based on either piezoelectric or optical fibre sensors. The communications channel comprises of a piezoelectric transducer as the transmitter, an aluminium panel as the transmission medium, and either a second piezoelectric transducer or a fibre optics sensor as the receiver.

Distributed acoustic emission sensors are used in structural health monitoring (SHM) for the detection of impacts and/or strain, in real time. Secondary damage may result from the initial impact or strain. This damage may include surface pitting, erosion, or cracking. These types of secondary damage may not be detectable, and hence may not be able to be monitored by the SHM system, specifically in fibre optic based sensing systems. The integration of NDE by robotic agents into SHM enables the detection and monitoring of a wider variety of damage. Acoustic communication represents a wireless communication method that does not require the addition of any additional hardware, as piezoelectric transducers are commonly used in the NDE of materials.

Various encoding methods were investigated for the communications channel. These include phase shift keying, frequency shift keying, and amplitude shift keying. Successful communication was achieved using both the piezoelectric and fibre optic receivers. The fibre optic sensors used as receivers included fibre Bragg gratings, and various fibre optic interferometers.

### 6414-30, Session 7

#### **A hybrid magnetic and piezoelectric polymer microactuator**

Y. Fu, Silverbrook Research Pty Ltd. (Australia); M. K. Ghantasala, Western Michigan Univ. (USA); E. C. Harvey, Swinburne Univ. of Technology (Australia)

A hybrid microactuator based on a piezoelectric polymer composite cantilever in combination with an electromagnetic permalloy-solenoid system is proposed to increase the total achievable force and the actuator displacement. A microactuator with a footprint of 9 mm<sup>2</sup> was designed with optimal parameters using FEM simulation. Detailed analytical calculations were also carried-out to ascertain some of the design parameters. The planar microstructures including the copper microcoil, its central permalloy core and a nickel post for suspending the cantilever were fabricated by employing SU-8 lithography, laser micro-machining, micro-embossing, as well as copper and permalloy electroplating.

The microcoil was designed to have 20 turns with a line width and spacing of 20  $\mu\text{m}$  and a thickness of 20  $\mu\text{m}$  to 30  $\mu\text{m}$ . The permalloy core dimensions were fixed at 500  $\mu\text{m}$  x 500  $\mu\text{m}$  x 60  $\mu\text{m}$ . The nickel post has dimensions of 500  $\mu\text{m}$  x 1000  $\mu\text{m}$  x 150  $\mu\text{m}$ . These three microstructures with different dimensions and different aspect ratios were fabricated on the silicon substrate using the same seed layer but in three different steps. The fabricated microcoil was tested for any possible short or open circuit by passing a driving current of up to 50 mA thus estimating its resistance. Similarly, the magnetic properties of the electroplated permalloy layers were also characterized. The hybrid microactuator was assembled and tested by applying a potential of 100 V on the cantilever and a current of 50 mA through the microcoil. The composite cantilever latched on and off the Permalloy core as per the design specifications.

Test results showed good agreement between the experimental and theoretical predictions based on FEM simulation and analytical calculation. The microactuator was demonstrated to cover an air gap of 100  $\mu\text{m}$  as a microswitch.

### 6414-31, Session 7

#### **Gold electrode fabrication to a cellulose surface for operating microwave-driven paper actuator**

K. S. Kang, Inha Univ. (South Korea)

It is essential to fabricate high quality metal electrodes to a cellulose surface to operate microwave-driven paper actuator. There

are several difficulties to fabricate metal electrodes to the paper, such as deformation of paper during the lithography process in aqueous medium, rough surface of the cellulose film, difficulty to form dense self-assembled monolayer (SAM) due to a limited number of -OH moieties (3 -OHs per cellulose unit) to apply soft-lithography. Indirect fabrication of metal electrode was performed in this paper. Root mean square cellulose surface roughness of about 1.2nm was achieved by spin coating and in situ pressurized hydrolysis process. The self-assembled monolayer of mercaptopropyltrimethoxysilane (MPTMS) was fabricated before soft-lithography application. Rectina structures of soft-stamp were fabricated using polydimethylsilane (PDMS) and deposited gold electrode to the stamp. The gold electrodes were transferred to the cellulose by micro-contact printing method. The electrodes were investigated using scanning electron microscope (SEM) and atomic force microscope (AFM). Isolated gold islands were formed instead of continuous gold electrode. The number of MPTMS may not enough to completely transfer the gold electrode due to the lack of MPTMS. For this reason we developed polymer-solvent method. The electrodes were fabricated using conventional photolithography method to a silicon wafer. Thin polymethylmethacrylate (PMMA) was coated to the cellulose and exposed to a solvent. The sticky polymer-cellulose was contact and pressurized to the gold electrode and peel out the electrode. The electrode was investigated using SEM and AFM. High quality of gold electrodes was formed to the cellulose surface, and no discontinuous problem was occurred for this method.

### 6414-32, Session 7

#### **Magnetic actuation for microfluidics based on ferrofluid droplets**

N. Nguyen, X. Huang, Nanyang Technological Univ. (Singapore)

The field of microfluidics recently witnessed a paradigm shift from the continuous-flow to the droplet-based concepts. Magnetic force is an interesting option for the manipulation of micro droplets. Magnetic force is proportional to both magnetic moment and the gradient of the magnetic field. Due to the small size, a high magnetic field gradient can be achieved with microcoils. Rida et al. used an array of planar microcoils to transport magnetic beads in a glass capillary. Recently, the same research group utilized magnetic beads suspended in liquid droplets as actuators. The magnetic beads were able to induce magnetic forces, which are strong enough to complete tasks such as droplet transport and droplet splitting. The drawback of using magnetic beads is that the magnetic force acting on each bead can redistribute the beads inside the droplet and separate themselves from it.

In this paper, we report a system for magnetic manipulation of ferrofluid droplets and their dynamic behavior. The magnetic particles in a ferrofluid have a diameter on the order of few nanometers. At this size, the random movement of the particles is larger than the magnetic force. Thus the dispersion of these particles is stable even under a strong magnetic field. The magnetic field was generated by an array of planar coils, which were fabricated on a double-sided printed circuit board (PCB). The permanent magnetic moment of the ferrofluid droplet was created by the field of a pair of permanent magnets. The motion of the ferrofluid droplet is further aligned in a virtual channel formed by a pair of planar coils. Two other planar coils on the other side of the PCB drive the droplet along this virtual channel. The direction of the droplet motion can be controlled by reversing the electric current in the coils. Different parameters affecting the motion of the ferrofluid droplet such as the droplet size, the viscosity of the surrounding medium, and the electric current were experimentally investigated.

### 6414-33, Session 7

#### **Improving the security and actuation of wireless controlled microvalve**

A. C. Tikka, S. F. Al-Sarawi, D. Abbott, The Univ. of Adelaide (Australia)

A wireless microvalve would have a wide range of applications, including biomedical applications such as fertility control and nano-litre drug delivery. Arguably the most important aspect for

such a device is a secure method to actuate the valve, such that it is not actuated through the spectrum of electromagnetic radiation already present in our surroundings. Additionally, many of the possible applications are sensitive to electromagnetic (EM) radiation so the device should be designed to only require the minimum amount of EM input to achieve valve actuation. To overcome this problem the research explores the design of an interdigital transducer (IDT) in an acoustic wave device which responds to coded signals. For the wireless microvalve to be useful in biomedical applications, the IDT's response to a coded RF signal must be much greater than its response to another coded RF signal, even if the two codes are very similar, i.e. improve the signal ratio of the device. In this research we will demonstrate how Barker sequences, which are a group of binary codes that have a correlation function such that the peak response is  $20\log(N)$  dB higher than at all other times ( $N$  is the length of the sequence), can be used to provide a high signal-to-noise ratio (SNR) surface acoustic wave that will result in a unique activation of the device when the interrogating RF signal Barker code matches the stored Barker code in the device. Also we will investigate the trade-off between code length needed to ensure secure operation and the area constrain of the device within the context of biomedical application. For this purpose, the IDT is modelled as a pulse compression filter, which correlates the input signal with a stored replica.

### 6414-35, Session 8

#### Design of a multiple input sensor for strain threshold testing

D. S. Macnamara, D. V. Thiel, P. Lisner, Griffith Univ. (Australia)

This article describes work performed in the design of an ASIC for multiple strain input sensing using a 0.5 micron n-well CMOS process. In this application, the strain sensor is to form part of a network of sensors to monitor the state of stress in a surface. The onset of deformation in the material usually coincides with its shear strength. The elastic properties of many materials can be estimated using Lamé's elastic constants. On this assumption, a 45 degree strain gauge rosette is used to determine the maximum shear strain in a surface. A gate array has been designed to compare the maximum shear strain against a structural health limit. The algorithm depends on the difference in strain as opposed to an absolute value. Thus any offset in the front end circuitry is of little consequence.

Results of an earlier prototype single input strain sensor ASIC are included. Commercial and new high resistance strain gauges were used. The multiple-input strain sensor has been modified to minimize power consumption down to tens of microwatts. This is achieved through switching at relatively low sample rates ( $<100$  s<sup>-1</sup>). The facility to change the sample rate and the option of continuous power-on is included. With a high clock frequency, the sampling time is minimized allowing sufficient time for processing and serial communication.

Discussion of the tradeoffs and limits of data resolution against functionality, size and power consumption are made.

### 6414-37, Session 8

#### Influence of loading on structures actuated with piezoceramic transducers (PZT) for use in structural health monitoring

V. G. Annamdas, Y. Yang, C. K. Soh, Nanyang Technological Univ. (Singapore)

Piezoceramic (PZT) transducers are extensively used in electro-mechanical impedance (EMI) based structural health monitoring (SHM) of engineering structures. In the EMI models, the PZT transducers are generally surface bonded to the host structure and then subjected to actuation, so as to interrogate the structure for the desired frequency range. The interrogation results in the prediction of electro-mechanical (EM) admittance signatures, which is the inverse of mechanical impedance of the structure. These signatures work as indicator to predict the health/integrity of the structure, as any change in these signatures during the life of the

structure is the indication of crack or damage or failure in the structure. However in real life, engineering structural components such as slabs, beams and columns are constantly subjected to one form of loading or another. Traditional and present practices of SHM concentrate mostly on damage assessments of structures for dead loads. Moreover, the structures are not only subjected to dead loads but are also subjected to many other types of imposed loads. EM admittance signatures obtained for such a constantly loaded structure is different from signatures obtained when damages are present in structure. That is, the properties of the EM admittance signatures obtained due to structural imposed loadings are different from the properties of EM admittance signatures obtained during to damages in structures. Hence this paper presents experimental and numerical investigation to show the differences between the EM admittance signatures due to damage in structures and loading on structures. Three specific objectives are addressed in this paper, the first objective is to investigate the influence of loadings on the EM admittance signatures of three lab-sized structures of different dimensions. The second objective is to determine the influence of stiffness of the structure on the EM admittance signatures. The third objective is to study the influence of mechanical and electrical properties of the PZT transducer on the EM admittance signatures. Numerical analysis is performed to obtain the structural response for predicting the EM admittance signature. The predicted EM admittance signatures are experimentally verified. The impedance analyzer via multiplexer box set-up is used to obtain the experimental EM admittance signature. For this purpose, the lab sized specimens are loaded for different magnitudes of loading and experimental admittance is recorded and compared with predicted. Thus, finally the differences between the EM admittance signatures due to damage and loading are presented, which is expected to be applicable for the non destructive evaluation of most engineering structures.

### 6414-38, Session 8

#### Multi-zone HVAC control systems from existing single-zone systems using wireless sensor networks

A. Redfern, M. Koplow, P. Wright, Univ. of California/Berkeley (USA)

Most residential heating, ventilating, and air-conditioning (HVAC) systems utilize a single zone for conditioning air throughout the entire house. While inexpensive, these systems lead to wide temperature distributions and inefficient cooling due to the difference in thermal loads in different rooms. The end result is additional cost to the end user because the house is over conditioned. To reduce the total amount of energy used in a home and to increase occupant comfort there is a need for a better control system using multiple temperature zones. Typical multi-zone systems are costly and require extensive infrastructure to function.

Recent advances in wireless sensor networks have enabled a low cost drop-in wireless vent register control system. The register control system is controlled by a master controller which collects sensor data from a distributed wireless sensor network. Each sensor node samples local settings (occupancy, light, humidity and temperature) and reports the data back to the master control unit. The master control unit compiles the incoming data and then actuates the vent registers to control the air flow throughout the house. The control system also utilizes a smart thermostat with a movable set point to enable the user to define their given comfort levels. The new system can reduce the run time of the HVAC system and thus decrease the amount of energy used and increase the comfort of the home occupations.

### 6414-42, Session 8

#### Health assessment of bonded composite repairs with frequency response techniques

C. M. White, Royal Melbourne Institute of Technology (Australia); B. Wittingham, Monash Univ. (Australia); H. C. H. Li, Royal Melbourne Institute of Technology

(Australia); I. Herszberg, Cooperative Research Ctr. for Advanced Composite Structures Ltd. (Australia); A. P. Mouritz, Royal Melbourne Institute of Technology (Australia)

Structural health monitoring (SHM) technology may be applied to composite bonded repairs to enable the continuous through-life assessment of the repair's efficacy. This paper describes an SHM technique for the detection of debonding in composite bonded patches based on frequency and acoustic response techniques. The external doubler repair, commonly used to patch aircraft structures is examined in this paper. An experimental investigation was conducted; using carbon/epoxy repairs to carbon/epoxy substrates and piezoelectric devices to investigate variations in the frequency response of the repaired structure due to debonding of the external doubler. The acoustic response was also determined. Two piezoelectric devices were adhered to the structure; the actuator to the external doubler and the sensor to the parent component. To simulate real repair design requirements (minimum surface perturbation) both piezoelectric devices were installed on 'internal' surfaces. Clearance for the actuator was created by the removal of damaged material. The frequency response signature of the repaired structure with simulated debonds is analysed with respect to the response of fully bonded repairs. A comparison is made between frequency and acoustic response signatures. Results are discussed with implications for the development of a technique to monitor the integrity of external bonded repairs. Such a system would help promote acceptance of adhesive bonding as well as composite materials.

#### 6414-39, Session 9

##### **A small low-power networked and versatile sensor interface**

P. S. Vincent, P. J. McMahon, R. F. Muscat, L. Zeve, A. R. Wilson, Defence Science and Technology Organisation (Australia)

Defence Science and Technology Organisation (DSTO) has developed a low power RS485 sensor network that can be hardware configured at design time from a number of modules, depending on its final application. A core predesigned module includes network communications, microprocessor control and digital input/output. A number of analog interface modules can easily be added to this module. In addition, the software is also of modular design consisting of a set of core operating routines and a set of routines for controlling sensor operation that can be downloaded or upgraded in the field. Prime consideration in this development has been given to the need for small size, low weight, low power and versatility of operation. The hardware is based around the Texas Instruments MSP430® micro-controller and a complete circuit board including a dual channel, high impedance variable gain current/voltage interface measures 50mm x 40mm x 12mm. This paper will present some of the considerations leading to the design and examples of applications of the sensor network.

#### 6414-40, Session 9

##### **Fourth-order discrete-time variable center frequency bandpass Sigma-Delta modulator**

Y. Zhu, Univ. of Adelaide (Australia)

A design for a variable centre frequency bandpass Sigma-Delta modulator is presented. The modulator is based on a tunable discrete-time resonator using only one control parameter. The noise transfer function of the modulator is controlled by a 4-bit digital signal, which provides nine different centre frequencies distributed between 0.1-0.4 normalized frequencies. The measurement results show a stable modulator at all centre frequencies.

#### 6414-41, Session 9

##### **An open source synthesisable VHDL model of a 64-bit MIPS-based processor**

D. R. Kelly, B. J. Phillips, S. F. Al-Sarawi, The Univ. of Adelaide (Australia)

This paper describes an open source VHDL description of a 64-bit MIPS-based processor. The presented model includes a pipeline that can execute most instructions from the MIPS III instruction set architecture (ISA). The pipeline is an 8-stage RISC machine based on the MIPS R4000 series processors. It can perform common arithmetic operations on 32- and 64-bit operands, with full IEEE 754 floating point support. This paper describes the architecture and component modules of the MIPS-based processor. The model will be available to the research community as synthesisable VHDL code to serve as a platform to test and develop modules as a part of a complete computing system.

#### 6414-43, Session 9

##### **A data transport layer for parallel matrix computation**

A. Burdeniuk, C. Lim, M. Liebelt, The Univ. of Adelaide (Australia)

No abstract available

#### 6414-45, Session 10

##### **Optimal configurations of active fiber composites based on asymptotic torsional analysis**

D. Harursampath, A. K. Tamrakar, Indian Institute of Science (India)

Active Fiber Composites (AFC's) have been successfully employed in active twist control of rotorcraft blades, and recently, proposed for health monitoring based on twist sensing too. The matrix and piezoelectric fiber choices, volume fractions, ply angles and positioning in/on the base structure contribute to the tailorability of AFC. Depending on the applications, there are also many established choices for the electrode configuration viz., Inter-Digitated Electrodes (IDE - used to apply constant electric field along the length of the piezoelectric fibers); Circular Linked Inter-Digitated Electrodes (CLIDE - to avoid large stress concentrations in the fibers due to electric field gradients at the electrode edges); and conventional sheet electrodes (where the cost of IDE/CLIDE is beyond a level warranted by the performance gains). Hence for a general AFC design & optimal choice of electrodes, it is essential to investigate all possible directions of the electric field. The work on AFC available in the literature is insufficient to optimise the design of AFC laminates cost effectively and efficiently. This situation can be overcome if closed form expressions relating twist and all three components of applied/measured electric fields are made available.

This paper is intended to present a general approach for the design of AFC laminates for smart applications by interpreting the closed form expressions derived via Variational Asymptotic Method (VAM) for the cross-sectional analysis of thin generally anisotropic AFC beams. The presented closed form equations can be easily used to make or design a class of smart materials capable of collocated actuation and sensing that can be used in smart structures with self-sensing circuits.

#### 6414-46, Session 10

##### **Macro-fiber composite (MFC) as a delamination sensor in antisymmetric laminates**

S. Hari Krishna, Indian Space Research Organisation (India); H. Dineshkumar, Indian Institute of Science (India)

The change in extensional twist coupling due to delamination in antisymmetric laminates is experimentally measured. Experimental results are compared with the results from analytical expression existing in literature and finite element analysis. It is observed that all the approaches are well in agreement with each other.

The application of the macro-fiber composite (MFC) developed at the NASA Langley Research Center for sensing the delamination in the laminates has been investigated. Many applications have been reported using the MFC as an actuator. Here use of MFC as twist sensor has been studied. The application is envisaged as the structural health monitoring of laminated composite flexbeams using the symmetry of the structure. Apart from the defect detection under symmetric conditions, other methods of health monitoring are reported. Results show that MFC works well as a sensor.

### 6414-47, Session 10

#### All-optical fiber switching based on cross-phase modulation in a high-nonlinear photonic crystal fiber Sagnac loop mirror

J. Liu, Nankai Univ. (China)

We designed a novel and low switching-power all-optical fiber switching. The switching is realized based on cross-phase modulation because the balance of the loop is broken by simultaneous inserting the high nonlinear photonic crystal fiber (HN-PCF), whose zero dispersion wavelength locates at the center of control pulse and signal light, and the bi-directional pumped Er-doped fiber amplifier (BP-EDFA) into the Sagnac loop mirror. The theoretical analysis and the experimental results show that the switching-power is inversely proportional to the product of the BP-EDFA gain and the HN-PCF nonlinear coefficient, the transmission of the signal light is cosine proportional to the peak power of the control pulse. All these results will pave the way for promising compact, fast and stable all-optical switching.

### 6414-48, Session 10

#### Study on micro-bend light transmission performance of novel liquid-core optical fiber in smart structures

J. Ma, Qingdao Univ. (China) and Nanjing Univ. of Aeronautics and Astronautics (China); Z. Zhimin, W. Kaisheng, G. Linfeng, Nanjing Univ. of Aeronautics and Astronautics (China)

With the increasing development of material technology and electronic integration technology, optical fiber and its using in smart structure have become hot in the field of material research. And liquid-core optical fiber is a special kind of optical fiber, which is made using liquid material as core and polymer material as optical layer and protective covering, and it has the characteristics of large core diameter, high numerical aperture, large-scope and efficient spectrum transmission and long life for using. So the liquid-core optical fiber is very suitable for spectrum cure, ultraviolet solidification, fluorescence detection, criminal investigation and evidence obtainment, etc, especially as light transfer element in smart structures for the measurement of some signals, such as concentration, voltage, temperature, light intensity and so on. In this paper, the novel liquid-core optical fiber is self-made, and then through the test of its light transmission performance in free state, the relation between axial micro-bend and light-intensity loss are presented. When the liquid-core optical fiber is micro-bent axially, along with the axial displacement's increase, output power of light is reducing increasingly, and approximately has linear relation to micro-displacement in a range. According to the results liquid-core fiber-optic micro-bend sensor can be designed to measure micro-displacement of the tested objects. Experimental data and analysis provide experimental basis for further application of liquid-core optical fiber in smart structures.

### 6414-49, Session 11

#### Pixel-wise adaptive imaging

R. S. A. Brinkworth, E. Mah, D. C. O'Carroll, The Univ. of Adelaide (Australia)

The range of luminance levels in the natural world varies in the order of  $10^8$ , significantly larger than the 8-bits employed by the majority of digital imaging. To help overcome their limited dynamic range traditional imaging systems rely on the fact that the dynamic range of any one scene is typically much lower, and by adjusting a global gain factor (shutter speed) it is possible to acquire usable images. However in many situations 8-bits of dynamic range is insufficient, meaning potentially useful information, lying outside of the dynamic range of the imaging device, is lost. Traditional approaches to solving this issue have involved using nonlinear gamma tables to compress the dynamic range, hence reducing the contrast of the digitised scene, or using 16-bit imaging devices, which use more bandwidth and are incompatible with most recording media and post-processing.

This paper describes an algorithm, based on biological vision, which overcomes many of these problems. The algorithm reduces the redundancy of visual information and compresses the data from the high dynamic range observed in the real world into a significantly lower bandwidth signal, much better suited for traditional 8-bit image processing and display. However, most importantly, no potentially useful information is lost and the contrast of the scene is enhanced in areas of high informational content (where changes are occurring) and reduced in areas containing low information content (where no changes are occurring). Thus making higher-order tasks, such as object identification and tracking, easier as redundant information has already been removed.

### 6414-51, Session 11

#### MOEMS development of infrared security sensors

K. C. Liddiard, Electro-optic Sensor Design (Australia)

This paper discusses progress in the development of a new generation of passive infrared (PIR) security sensors for the high volume military, industrial and consumer markets. Current PIR sensors are based on decades-old pyroelectric detector technology. The challenge is to adapt current high performance infrared technology to this market at affordable cost, and to achieve a paradigm shift in manufacture culture.

Novel MOEMS technology described in this paper provides significant enhancement in performance, in terms of IR sensitivity and spatial resolution, and resolves a number of limitations in existing technology. The new sensors are capable of target recognition, target counting and direction of movement, detection of approaching targets, and detection of slowly varying temperature changes such as in equipment failure or a developing fire situation. Signal processing gives a very low false alarm rate. The sensor output is displayed on a small LCD display which may include an image of the field of view.

Recent work on patented sensor technology will be described, including the mosaic pixel focal plane array concept (MP-FPA), which enables high performance to be achieved with lost optics and cheap packaging. Each pixel comprises a number of sub-pixels, each being a functional silicon microbolometer IR detector. It will be shown how this concept gives a large reduction in detector noise and allows a higher bias to be used, resulting in superior performance to existing sensors at comparable cost.

FPA are integrated on-chip with a CMOS readout integrated circuit, and can be fabricated by large scale production methods in a silicon-based MEMS foundry.

### 6414-52, Session 11

#### Bio-inspired optical rotation sensor

D. C. O'Carroll, The Univ. of Adelaide (Australia); P. A. Shoemaker, Tanner Research, Inc. (USA); R. S. A. Brinkworth, The Univ. of Adelaide (Australia)

Traditional approaches to calculating self-motion from visual in-

formation in artificial devices have generally relied on object identification and/or correlation of image sections between successive frames. Such calculations are computationally expensive and require fast computers using large amounts of power making them unsuitable for deployment in applications, such as miniature unmanned aerial vehicles (mUAVs), where size and power consumption are limited. In contrast flies arrive at essentially the same outcome, the estimation of self-motion, in a much smaller package using vastly less power.

Despite the potential advantages and a few notable successes, few neuromorphic analog VLSI devices based on biological vision have been employed in practical applications to date. This paper describes a newly developed analog VLSI device that mimics the way in which motion is computed in biology through adaptive motion detectors, and the integration of this device with optics and photodetectors to form a visual rotation sensor. Applications for such devices relate to the development of miniature autonomous systems in defence and civilian roles, including robotics, and collision avoidance detectors in mUAVs.

### 6414-53, Session 12

#### An integrated MEMS design synthesis architecture using case-based reasoning and multi-objective genetic algorithms

C. L. Cobb, Y. Zhang, A. M. Agogino, Univ. of California/Berkeley (USA)

A Micro-electro-mechanical Systems (MEMS) Design Synthesis architecture incorporating a Case-based Reasoning (CBR) knowledge base and a multi-objective genetic algorithm (MOGA) for design optimization has been developed for MEMS design automation. CBR utilizes previously successful MEMS designs and sub-assemblies as building blocks stored in an indexed case library, which serves as the knowledge base for the synthesis process. Designs in the case library are represented in a parameterized object-oriented format, incorporating MEMS domain knowledge into the design synthesis loop as well as restrictions for the genetic operations of mutation and crossover for the MOGA optimization. Reasoning tools locate cases in the design library with solved problems similar to the current design problem and suggest promising conceptual designs as the starting design populations for the MOGA evolutionary optimization process. Surface micro-machined resonators are used as an example to introduce the new MEMS Design Synthesis architecture. The results of resonator test cases demonstrate how starting design populations selected by CBR techniques can guide MOGA to optimal MEMS design concepts.

### 6414-54, Session 12

#### Response improvement of a mover device using hydrogen storage alloy powder by addition of a catalyst

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Recently we proposed a mechanical rubber mover in a unimorph structure with hydrogen storage alloy powder dispersed. A rubber sheet with the alloy was piled up on another rubber sheet, then mechanical movement was generated by hydrogen gas absorption and desorption.

Because the response of the movement was slow, therefore, in this research we tested the additive effect of catalyst of Pd-Al<sub>2</sub>O<sub>3</sub> powder into the hydrogen storage alloy powder before mixing with rubber. The mover device with the catalyst indicated drastically modified responses, such as larger initial moving rate and also larger displacement. The results suggested explicability of the device for medical purpose such as catheter because of a powerful but tender characteristic of the device.

### 6414-55, Session 12

#### Nickel and titanium silicide formation from sputtered and evaporated metals: a comparison

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Specific contact resistivity (SCR), sometimes referred to as specific contact resistance or contact resistivity, is the parameter used to quantify the resistive effect of an ohmic contact interface. Silicides have been used in CMOS technology for some years mainly to reduce sheet resistance in the source and drain regions, but also because of their low values of SCR. This paper compares the formation of titanium silicide (TiSi<sub>2</sub>) and nickel silicide (NiSi). The transition from nickel silicide (NiSi) to nickel di-silicide (NiSi<sub>2</sub>) at temperatures greater than 700 °C was also studied. The quality of silicides formed using sputtered and evaporated metal (titanium or nickel) is also discussed. Analysis of the silicide material formed was carried out using X-Ray Photoelectron Spectroscopy (XPS) and Auger Electron Spectroscopy (AES) depth profile. Measurements of sheet resistance were carried out using the standard four-point probe technique and the specific contact resistivity (SCR) of metal (aluminium)-to-silicide (TiSi<sub>2</sub> or NiSi) was measured using Cross Kelvin Resistor (CKR) test structures. The paper also discusses Finite Element Modelling (FEM) of the test structures. Since the stress induced by the silicides in neighbouring silicon plays an important role in optimizing device characteristics, stress measurements were also carried out and are discussed.

### 6414-56, Session 12

#### Structural, optical, and electrical characterization of cadmium oxide thin films

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Cadmium Oxide thin films of different thickness ( $t = 87 - 620$  nm) have been prepared on glass substrate at 625 K temperature by spray pyrolysis method. Detail studies on the structural, optical and electrical properties of the films have been made. X-ray diffraction spectrum of films annealed at 675K shows highly resolved peaks indicating polycrystalline nature of the films. The structure is cubic with lattice constant  $a \approx 4.69$  Å. The direct and indirect band gap energies were determined from optical transmittance spectra and values of optical band gap obtained are  $E_g \approx 2.35$  eV and  $\approx 1.95$  eV respectively. The dc conductivity and Hall effects have been investigated in the temperature range 300 to 550 K. For all films conductivity and Hall mobility show two distinct regions and the values reaches to a maxima at about 450 K. The position of maxima changes slightly with the thickness of the films. Activation energy in the higher temperature region is  $\approx 0.24$  eV, which indicate a free band conductivity originating from levels within the band gap. In the low temperature region activation energy is  $\approx 0.01$  eV and this value suggest that in this region conduction is due to hopping between localized levels. From voltage - current characteristics it is found that conduction mechanism involved is Poole- Frankel type.

### 6414-50, Poster Session

#### Prototype ROIC with differential pixel readout for uncooled IR detector arrays

S. J. Hwang, Y. Kim, M. Sung, Korea Univ. (South Korea)

A simple and robust method for minimizing the fixed pattern noise of the ROIC for uncooled microbolometer infrared sensor arrays is presented. One of the serious problems in designing the ROIC is that resistances in the bolometer and replica resistor have process variation. This means that each pixel does not have the same resistance, causing serious fixed pattern noise problems in sensor arrays operations. To improve the mentioned problems, differential input stage readout architecture is suggested for realizing high noise immunity and high sensing margin. Using this scheme, the effects of a process variation problem and noise problems due to the bias level fluctuation, are reduced. In this paper,

a prototype ROICs, intended for uncooled microbolometer infrared focal plane array, is designed and fabricated. The proposed architecture is demonstrated by fabrication of a prototype consisting of 32 x 32 pixels fabricated in a 0.25- $\mu\text{m}$  CMOS process and evaluated by making the test board with external resistors.

## 6414-58, Poster Session

### Sanitizing solid state USB drives: how much destruction is enough?

B. J. Phillips, C. Schmidt, The Univ. of Adelaide (Australia)

There are circumstances in which confidential data must be quickly and reliably removed from USB solid-state storage devices. We consider the situation in which there is no computer to hand and a commercial off-the-shelf USB flash memory drive must be sanitised in 10 seconds. Are high temperatures or USB terminal voltages effective ways to erase the memory? Is it sufficient to crush the drive under your boot, or is it better to douse it in petrol and set it alight? What happens when you shoot it? This paper presents the results of experiments in which we explore these questions.

## 6414-61, Poster Session

### A reconfigurable photonic bandpass RF filter employing a semiconductor optical amplifier and an opto-VLSI processor

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Photonics-based RF filters have the capability of processing very high speed signals directly in the optical domain, thus removing the bandwidth bottlenecks encountered in conventional electrical signal processors.

In this paper, we present a transversal photonic bandpass filter architecture utilizing a semiconductor optical amplifier (SOA) that minimises optical interference through coherent-to-incoherent light conversion in conjunction with an Opto-VLSI processor that reconfigures the weights of the filter through optical spectral equalisation. A high-coherence CW laser signal modulated by an RF signal is fed into an SOA which generates, through cross-gain modulation, a low coherence RF-modulated amplified spontaneous emission (ASE). By spectrally slicing the ASE by an optical comb filter, RF-modulated wavebands of different centre wavelengths are generated. These RF-modulated wavebands are then processed by an Opto-VLSI processor which arbitrarily shapes the intensity profile of the wavebands. A high-dispersion optical fibre introduces linear true-time delays between the different wavebands so that after photodetection a photonic bandpass RF filter with multiple taps is realised. The proof-of-concept of the photonic bandpass filter is experimentally demonstrated, and results show that the filter can operate at 3.6 GHz with more than 25 dB rejection.

## 6414-62, Poster Session

### Thin silicon shadow masks for organic light-emitting diodes deposition processes

G. J. Su, National Taiwan Univ. (Taiwan)

In this paper, we discuss thin silicon shadow masks used in organic polymer deposition for manufacturing compact-size OLED (organic light emitting diodes) displays. Currently, the OLED displays attract many attentions because of novel low-cost organic materials for emitting the light. The fabrication processes of OLED make use of shadow masks for thermal deposition of organic materials due to etching difficulties. The metal shadow masks are widely used because of easy access. However, the openings of the metal shadow masks are limited to vertical sidewall, which cause the rounded profile at the edge of deposited organic layers. This may cause the potential step coverage problem and low device efficiency. In order to overcome the deposition profile of

organic materials, we propose to use thin silicon shadow masks. Due to the crystal orientation of (100) silicon wafers, the etched aperture slope of the silicon shadow mask will have approximately 54 degree sidewalls. This slope will increase the accepting angle of the openings around the edge that results in a better side profile of deposited organic materials. The simulation model for deposition profile is based on Monte Carlo methods. The simulation results show improved deposition profile by using silicon shadow masks with the aperture slope. The silicon shadow masks are fabricated by TMAH wet etching techniques and are used in the vacuum deposition of organic polymers. The SEM pictures of organic films and side profiles measured by alpha stepper will be applied to verify the simulation models and to optimize the deposition factor. We demonstrate that the thin silicon shadow masks can provide deposition advantages over traditional metal shadow masks in terms of side profiles of organic layers for making OLED displays.

## 6414-63, Poster Session

### Fabrication of high-aspect-ratio coil for electromagnetic actuators using LIGA process

D. Noda, Y. Matsumoto, S. Yamashita, M. Setomoto, T. Hattori, Univ. of Hyogo (Japan)

Actuators are finding increasing use in the various fields and many applications. It is one of the most important parts in machine because of determine its performance. Recently, the requests for actuator are small size, high output power and lower electrical power, and so on. On the other hand, LIGA process can be fabricated nano and micro parts for devices. We achieved development of the three-dimensional (3D) deep X-ray lithography technique for the spiral micro-coil with a high inductance. Therefore, we have fabricated and estimated the solenoidal electromagnetic type actuator of a low driving power by using this technique. This actuator having the high aspect ratio of coil line is also expected a great force in spite of miniature size. The surface of acrylic pipe for a screw thread structure, this is the coil part, has made using LIGA process. To make 3D structure of micro coil, an acrylic pipe was rotated by the stepping motor and a movement of the X-ray mask stage was controlled by piezoelectric elements. Now we have obtained the coil line with the width of 10  $\mu\text{m}$  and the aspect ratio of 5. In concluded, we have achieved development of the 3D deep X-ray lithography technique for solid microstructures such as the spiral micro coil. The magnetic type actuators with high aspect ratio spiral micro coil have been fabricated using this LIGA process. Using this technique, the actuators have been expected to manufacture with high output force.

## 6414-64, Poster Session

### A novel photoelectric system for optical intelligent structure health monitoring

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Composite structure with optical fiber network buried can feel various degrees of loads, so it is regarded to be smart and is widely applied. This paper presents details of a novel photoelectric system for intelligent structural health monitoring in aircrafts. Through light intensity-based experiments about loads and damages of an aircraft composite structure conducted in this paper, the potential for structural health monitoring of the composite material is discussed. Firstly, the paper demonstrates the design of a novel photoelectric system including an optical part and a circuit part. The former part consists of a light resource group and fiber optical sensors. And the latter part of this system is composed of a monitoring host and a computer, both of which work together under the instructions given by self-designed software. The schematic hardware diagram and the flow chart of the main program of the software are specified in this paper. In order to assess the monitoring effect, the loads experiments are carried out at different locations of a test object in which special optical fibers are buried. This test object is a sample of E-51 epoxy-resin composite materials that are commonly used in aircrafts. Finally, the degrees of loads and damages are measured

and the experimental results are discussed. Results obtained offer feasibilities of employing the proposed photoelectric system as a monitoring device for load and damage detection in intelligent composite structures.

### 6414-65, Poster Session

#### The effect of structure perturbation on PBG of one-dimensional photonic crystals

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One dimensional photonic crystal is fabricated by periodic arrangement of materials with different refractive index in one dimension. Comparing with 2D and 3D photonic crystal, 1D photonic crystal is not only easier to process, but also possesses many particular characteristics, such as photonic bandgap, slow-light effect. It can also be used as "perfect mirror", new type of optoelectric modulation, sensors and band-edge lasers.

Theoretically, 1D photonic crystals have perfect periodicity, including strict periodic distributions of refractive index and thickness. However, perfect periodicity is impossible to realize in practice because of the limitation of manufacturing processes. Some works have investigated factors breaking perfect periodicity, like dielectric interfacial roughness and refractive index change. In this paper, structure perturbation, defined as the error between actual and theoretical thickness distributions, is studied by transfer matrix method (TMM).

By introducing structure perturbation coefficients with different levels, we have detailedly discussed relevant effects on PBG and density of mode(DOM) in 1D photonic crystal under specifying numbers of bilayer and contrast of refractive index. Numerical simulations indicate that there are remarkable influences on optical properties of 1D photonic crystal resulting by structure perturbation, especially for PBG location and DOM at band edge. Generally, both PBG shifting and striking occurs due to disruptive periodicity. In specific case, especially along with perturbation coefficient increasing, it is found that PBG is extended obviously and the higher DOM at the band edge also can be achieved. According to this, we have drawn some conclusions which are significantly valuable to developing omnidirectional reflectors, band edge lasers and other devices based 1D photonic crystals.

### 6414-66, Poster Session

#### Multiwavelength oscillation DFB solid state dye laser with cascade arranged grating

N. Nakai, M. Fukuda, Chitose Institute of Science and Technology (Japan)

Many types of solid-state dye lasers have been studied as compact, low cost, and easy-to-handle laser sources. In this study, we fabricate gratings without etching process and apply the gratings to wavelength-selective devices of DFB solid-state dye laser. In DFB lasers, the grating is a key device to decide the laser characteristics. We have developed a method to fabricate high-quality gratings for solid-state dye lasers quickly and at low cost. The key feature of this method, which we tentatively call "etchless process", is the omission of costly, time-consuming etching processes such as typical wet or dry etching. And we also call the grating, which is fabricated with the etchless process, "photoresist grating".

By coupling photoresist grating with solid-state dyes, novel laser devices can be achieved. One of those unique devices is a multi-wavelength DFB solid-state dye laser. In our previous work, we achieved dual beam DFB solid-state dye laser with 2-dimension photoresist grating consisting of two different stripe patterns. Those patterns are perpendicular to each other and they can have different pitches.

Therefore, the device emits two-different-wavelengths laser beams in perpendicular directions. In order to improve the laser device, we have fabricated gratings in cascade arrangement and achieved triple-wavelengths laser beam in a same optical axis. In this study, we achieved triple wavelength laser oscillation at 600, 605 and 610 nm in a same optical axis simultaneously. Then we obtained high quality multi wavelength laser beam with DFB solid-state dye laser in visible wavelength region.

### 6414-67, Poster Session

#### Fabrication of grating with Moire fringes and its application to solid state dye laser

K. Miura, M. Fukuda, Chitose Institute of Science and Technology (Japan)

We have demonstrated laser oscillation in visible wavelength region with many types of solid-state dye laser device. Those laser devices have high quality gratings fabricated by the "etchless process", which is based on two-beam interference exposure method with He-Cd laser of 325 nm wavelength. The etchless process needs no conservative etching process, such as wet etching, dry etching. Therefore, we can fabricate gratings in short time and at low cost without any toxic gases or liquids. We've just started to extend the laser oscillation wavelength region from visible region to infrared region with solid-state dye laser. In fabrication of gratings for infrared laser device by the etchless process, it is difficult to fabricate wide-area grating on a substrate. Then we came up with applying Moire fringes to fabrication of a long period grating. To fabricate a long period grating with Moire fringes, a lavaged Pyrex slide glass is spin-coated by a photoresist. The slide glass, which is put in a horizontal plane, is exposed to an interference fringe by the two-beam interference of a He-Cd laser. Next, the sample is rotated few degrees around the vertical line, and goes through the second round of exposure. In this way we obtain photoresist grating with Moire fringes pattern. This method allows us to fabricate wide area of grating for DFB solid state dye laser in infrared wavelength region. We will present the results of the experiment of laser oscillation with the long period grating using Moire fringe.

### 6414-69, Poster Session

#### Study of holographic grating in porous silicon optical waveguides

Z. Jia, Xinjiang Univ. (China)

It was found that the porosity of porous silicon has a maximum value under a certain illumination intensity in our experiment. Irradiation can enhance anodization and speed up the etching rate of Si, so the porosity of PS will be high with irradiation on surface of Si wafer. But strong irradiation can make chemical reaction intensely so that a large amount of hydrogen and oxygen bubbles are produced. These bubbles will hinder anodization process on surface of Si. That is why the porosity increases until it reaches a maximum and then decreases as the irradiation increases. This experimental result is the basis for fabricating the grating in porous silicon by controlling illumination intensity. As the refractive index of porous silicon decreases with an increase in the porosity, so the index distributing of porous silicon can be controlled by illumination intensity. A holographic process allows obtaining a mask of light on top layer during we fabricating the multilayer porous silicon optical waveguides. The interference of two coherent Ar<sup>+</sup> laser beams produces at the sample surface bright parallel lines, the porosity is modulated in the plane. The effective deep of modulation is directly related to the penetration of the illuminating beam. We have developed an experimental setup that allows guide light at 1064nm incidently vertically into the grating in porous silicon optical waveguides. The diffractive efficiency of the first order diffraction light in TE and TM polarization are measured in our experiment respectively.

### 6414-70, Poster Session

#### Tunable properties of dielectrics thick film added MgO/Li<sub>2</sub>CO<sub>3</sub> to BST

I. Kim, B. Min, J. Song, Korea Electrotechnology Research Institute (South Korea); S. Jeon, Kyungnam Univ. (South Korea)

The properties of tunable dielectric materials on RF frequency band are important high tunability and low loss for variable resonator, variable capacitor, phased array antenna and other devices application. Various composite of BST (barium strontium titanium) combined with other non-electrical active oxide ceramics have been formulated for such uses. In this paper, Effect of BaSrTi/

Li<sub>2</sub>CO<sub>3</sub> for low temperature sintering and tunable properties of BaSrTi/MgO on thick films has been investigated for variable application devices on RF frequency band. The thick films were fabricated by the tape casting, also microstructure and dielectric properties as a function of an addition composition ratio and sintering temperature were studied. For the thick film sintered at 1100, it was densified to 96 % of BaSrTiO<sub>2</sub> theoretical density by the addition of 3 and 10 w% Li<sub>2</sub>CO<sub>3</sub>. Dielectric constant and tuning range was increased with the increase of BaSrTiO<sub>3</sub>/Li<sub>2</sub>CO<sub>3</sub> content, which probably can be explained by the substitution of Ba<sup>3+</sup>, Li<sup>1+</sup> on Li<sub>2</sub>CO<sub>3</sub> and BaTiO<sub>3</sub> lattice. The tunable range and dielectric loss of the BaSrTiO<sub>2</sub>/Li<sub>2</sub>CO<sub>3</sub> thick film, sintered at 1150 were about 43 % and 0.234 at 10~15 MHz, respectively. In case of BaSrTi/MgO, Dielectric constant decreased and tunability increased with the added of MgO. The ferroelectrics properties were distinct when adding Li to BST ceramic thick film, and paraelectric pattern was distinct when adding MgO.

### 6414-71, Poster Session

#### Temperature-insensitive strain sensing based on measurement of the reflected bandwidth from a tapered fiber grating

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One of the most significant limitations of FBG sensors is their dual sensitivity to temperature and strain. Many methods have reported to avoid this problem by using a tapered fiber grating for the strain measurement free from temperature influence. But all of them are based on the measurement of the reflected power from the tapered fiber grating. In fact, they have abandoned the major advantage that the measured information is encoded in light wavelength instead of light intensity of FBG sensors, and the revolution of these sensors is begin to depend on the light power fluctuation, connection loss and so on. All of these would enlarge the cost of the strain sensing system. On the basis of the theory calculation and experiment, we demonstrate the feasibility to make a temperature-independent strain sensor by measuring the bandwidth of the reflected light from the tapered fiber grating. In this paper, we also present a novel method based on a tunable Fabry-Perot interferometer to measure the bandwidth of the reflected light. From the experimental results, it could be seen that the influences of the light power fluctuation and connection loss are eliminated thoroughly. This simple and low-cost sensor approach has a considerable potential, particularly application of strain sensing in the smart structures.

### 6414-72, Poster Session

#### Sensitivity calibration of a fiber Bragg grating strain sensor

H. Ji, B. A. Wedding, L. Kong, H. Hsu, G. C. Lin, Univ. of South Australia (Australia); K. Fan, National Taiwan Univ. (Taiwan)

Fibre optic Bragg grating (FBG) sensors have been successfully applied to a number of systems. "Smart structures" incorporate these sensors to monitor structural integrity and provide a "quasi-point" sensing function. Due to its intrinsic structural nature, this type of sensor presents a good sensing sensitivity of strain and temperature.

In order to apply FBG based sensors to high precision dimension measurement (for example, for coordinate measuring machine (CMM) application), quantifying the sensitivity and the absolute calibration of the FBG sensor is required. Our modelling indicates that a FBG based strain sensor with a strain sensitivity of 0.02me will result in a wavelength shift of 0.015pm at wavelength of 980nm, which is sufficient for dimensional measurement requirements.

For a 5mm Bragg grating strained on a piezoelectric element, we have resolved a 25pm wavelength shift in the 980nm reflected signal using a standard spectrometer. More accurate wavelength shift measurements are being developed which utilise optical fibre based interferometric techniques. In this paper, results for the strain and temperature sensitivities of a FBG sensor will be presented along with modelling of the expected performance of the strain sensor for CMMs application.

### 6414-73, Poster Session

#### Camphor sulfonic acid-doped polyaniline nanofiber-based 64° YX LiNbO<sub>3</sub> SAW hydrogen gas sensor

W. B. Wlodarski, Royal Melbourne Institute of Technology (Australia)

A template-free, rapidly-mixed reaction was employed to synthesize polyaniline nanofibers using chemical oxidative polymerization of aniline. Camphor sulfonic acid (CSA) was used in the synthesis to obtain 50 nm average diameter polyaniline nanofibers. The nanofibers were deposited onto a 64° YX LiNbO<sub>3</sub> SAW transducer. The sensor was tested towards hydrogen (H<sub>2</sub>) gas while operating at room temperature. A fast response and recovery with high sensitivity and good repeatability were observed.

The polymerization is performed in an aqueous solution where aniline is rapidly polymerized in 1M CSA acid by the quick addition of the oxidant (ammonium peroxydisulfate ((NH<sub>4</sub>)<sub>2</sub>S<sub>2</sub>O<sub>8</sub>)). Due to the immediate interaction between the monomer and the oxidant, the primary reaction product, nanofibers, is the main morphological component present. After completion of the reaction, the product is collected for purification. Washing or dialyzing with water gives pure doped polyaniline. The average diameter of the polyaniline nanofibers is about 50 nm with length up to several microns.

Nanofiber dispersions were drop cast onto the active area of the 64° YX LiNbO<sub>3</sub> SAW transducer using a micro pipette. They were then left to dry in a clean, dry environment for one day. The sensor was placed in a multi-channel gas calibration system and exposed to H<sub>2</sub> gas. The sensor response, defined as the variation in operating frequency of oscillation due to the introduction of the gas, was 79 kHz towards 1% of H<sub>2</sub> in synthetic air. A fast response of 1 min and a recovery of 5 min with good repeatability were observed at room temperature. Due to room temperature operation, the gas sensor is promising for environmental and industrial applications.

### 6414-74, Poster Session

#### The modeling of coplanar waveguide transmission lines in multiple metal layer processes

E. Heading, Flinders Univ. of South Australia (Australia); M. E. Parker, H. J. Hansen, Defence Science and Technology Organisation (Australia)

Accurate characterisation of transmission lines is essential in enabling the design of Monolithic Microwave Integrated Circuits (MMICs) or Radio Frequency Integrated Circuits (RFICs). One RFIC technology currently being pursued is Silicon on Sapphire Complementary Metal Oxide Semiconductor (CMOS) technology. CMOS processes typically involve stacked metal layer structures and the correct method of modelling coplanar waveguides in CMOS is unclear. This paper reports on preliminary studies into electromagnetic design, with an emphasis on correctly predicting losses associated with these structures.

### 6414-75, Poster Session

#### Motion detection with a view toward VLSI implementation

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A small low-cost motion detector would have widespread applications in visual control systems such as miniature unmanned aerial vehicles and collision avoidance systems. In the last 20 years a number of analog VLSI chips have been developed which incorporate both photodetection and motion computation on the same chip. Nevertheless, artificial real-time vision and simple seeing systems remain a massive challenge mainly because the environment greatly impacts on their performance. On the other hand, biological systems have, through years of evolution, come up with a number of simple but clever solutions. The Reichardt



Correlator is a biologically inspired model for motion detection. However, the basic model is not a robust estimator of velocity. The accuracy and reliability of this model can be significantly improved through various elaborations. VLSI is ideally suited to the parallel processing seen in nature because it allows for high device integration density and complex implementation of complex functions. However, VLSI poses some serious bounds on the types of elaborations that can be implemented. We have explored this problem and will present a number of improved models with robust outputs that are practical in terms of real time implementation in microchips.

### 6414-76, Poster Session

#### The effect on crosstalk and maximum quantum efficiency of inter-pixel ridges incorporated in a stacked gradient homojunction vertical single-junction photodiode architecture

P. V. Jansz, S. Hinckley, Edith Cowan Univ. (Australia)

Stacked gradient homojunction vertical single junction photodiode architecture has demonstrated one dimensional control of photocarrier transport towards the photodiode depletion region with subsequent benefit to relative crosstalk suppression and sensitivity enhancement as compared to the conventional photodiode. Response resolution may be enhanced further by including a laterally stacked gradient homojunction in the form of inter-pixel ridges that extend from each epilayer towards the frontwall of the photodiode: lower ridges cupping into higher ridges. The rationale is that having both laterally and vertically stacked gradient homojunctions will give two dimensional control of photocarrier transport: the vertical stacking reducing diffusion towards the backwall while the lateral stacking reducing diffusion out of the pixel laterally. This should result in additional improvement in pixel sensitivity and crosstalk suppression.

In this study, we have simulated the effect of ridge height and width on the response resolution of a two dimensional CMOS compatible photodiode array. The results demonstrate enhanced relative crosstalk suppression and slightly enhanced maximum quantum efficiency compared to the stacked gradient homojunction photodiode architecture without ridges. With the lower ridges cupping into upper ridges, as ridge height increases the relative crosstalk reduces and the maximum quantum efficiency increases. As the lateral gap between ridge cups increases and the ridge width reduces more rapidly through the underlying epilayers, the relative crosstalk decreases while the maximum quantum efficiency remains constant. Frontwall illumination is still advantaged in reduced relative crosstalk while backwall illumination is superior in maximum QE.

### 6414-77, Poster Session

#### Terahertz detection of substances for security related purposes

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Terahertz (THz) radiation has many far reaching applications - of specific interest that many non-metallic and non-polar substances are transparent in the THz frequency range. This provides many practical uses for security purposes, where it is possible to detect and determine various substances that may be hidden or undetectable via conventional methods such as X-rays. In addition to this property, terahertz radiation can either be used in reflection or transmission.

This paper will look into the use of reflection and transmission techniques to detect various substances using a terahertz system. Common materials used in bags and suitcases such as nylon, PVC, and PVA will be tested for reflectivity and transparency. These materials will then sandwich various illicit substances, and be scanned by the terahertz system to obtain spectral data, simulating scanning a suitcase. The sample materials are then subtracted from the obtained data, which is then compared with previously obtained data of known substances, and a correlation algorithm is executed to estimate if a substance is present in the sample.

### 6414-78, Poster Session

#### Grooved infrared polarizers with a reduced reflectance

I. Yamada, Ryukoku Univ. (Japan); J. Nishii, National Institute of Advanced Industrial Science and Technology (Japan); M. Saito, Ryukoku Univ. (Japan)

Infrared polarizers are indispensable elements that are used in spectroscopic polarimetry and night-vision analysis. Conventional wire-grid polarizers consist of metal wires of hundreds nanometer width that are deposited on an infrared-transmitting material such as CaF<sub>2</sub> and KRS-5 (TlBr). However, these halide materials are insufficient as regards chemical durability, mechanical strength, machinability, and adhesiveness to metals. Consequently, special care must be taken when using these wire-grid polarizers. Si can be a suitable substrate for the wire-grid due to microfabrication capability and durability. However, the high refractive index of Si causes a high reflection-loss (46%). Therefore the Si plate usually has to be coated with an antireflection film, which requires an additional fabrication process. In this work, we fabricated a subwavelength-grating structure on the Si plate, which acted not only as a wire-grid polarizer but also as an antireflection layer.

We selected WSi as a wire material, since it is absorptive in the infrared region and suitable for microfabrication. We sputtered and deposited WSi on the Si plate (thickness: 600 μm, area: 20x20 mm<sup>2</sup>). After coating a photoresist on this plate, we formed a grating pattern of 400-nm pitch by the two-beam interference of the He-Cd laser (325-nm wavelength). By using this photoresist grating as a mask, both WSi and Si were etched with reactive SF<sub>6</sub> ions. Consequently a grating of 550-nm depth was formed; i.e., 150-nm WSi wire-grids on the 400-nm Si grooves. We evaluated the transmission spectra of this element with a spectrometer. The transmittance for TM polarization was 62% at 4-μm, which was higher than the theoretical transmittance of Si (54%). This happened because the subwavelength-grating structure on the Si surface acted as a low-index layer that reduced the reflection loss. The transmittance for TE polarization was 0.8%, and hence the extinction ratio was 19.0 dB.

### 6414-80, Poster Session

#### Optimized MEMS based reconfigurable VCO for a mobile receiver

H. P. Le, J. J. Singh, La Trobe Univ. (Australia)

The explosive growth of data transfer in wireless communication has resulted in an imperative need for large capacity and more efficient wireless systems. The multi-standard mobile receiver is an integral part of such a multifunctional architecture used to access present and future wireless data services. In the multi-standard receiver, Voltage Controlled Oscillator (VCO) is one of the most important blocks, as the performance of VCO significantly affects the receiver's performance. However, current VCO architectures with fixed inductor and switched capacitor or variable inductor and fixed capacitor are not sufficient for very large tuning requirements. In addition, the efforts to increase tuning range have adverse effect on the phase noise and power performance. There is, therefore, a continued search for architectures and circuit techniques enabling VCO architectures to attain lower power dissipation, better performance and better tuning range.

This paper presents the design and implementation of an optimised MEMS-based reconfigurable VCO for a multi-standard mobile terminal for GSM900, DCS1800 and WCDMA standards. In this VCO design, the passive components, including inductors, capacitors and switches are replaced by MEMS components, to improve the system performance and reduce the system power consumption. Moreover, a phase noise optimisation algorithm is also proposed to optimise the VCO design for optimum system phase noise and minimum power consumption. Three reconfigurable VCOs, without MEMS components, with MEMS components, and with MEMS components and the phase noise optimisation method, are implemented in Cadence RFSpectre using AMI 0.6-micron CMOS process. The MEMS components are implemented using Conventor design suite. Reduced order models of the MEMS components are extracted in from of verilog-A codes and then exported to Cadence. Results

show that a 50% reduction of power consumption is achieved when the MEMS components are used instead of the passive components. A 31% further reduction of power consumption is also achieved when the tail-current optimisation algorithm is applied. This characteristic makes the VCO a better candidate for wireless communication applications where power consumption is the major factor. The design, implementation, results and detailed analysis of the reconfigurable multi-standard VCO and mobile receiver as well as the detailed mathematical phase noise optimisation method will be presented in the full paper.

### 6414-81, Poster Session

#### Design and fabrication of metal oxide based gas sensor system for environmental monitoring

G. Wiranto, R. Manurung, P. Hermida, M. R. T. Siregar, Indonesian Institute of Sciences (Indonesia)

Gas sensors based on metal oxides have proved to be very promising to be used for monitoring air pollutants because of their fast sensing response, simple implementation, and low-cost fabrication techniques. However, some problems associated with their sensitivity and selectivity remain unsolved. The aim of this research is to develop a systematic and comprehensive method in improving the sensitivity and selectivity of metal oxide based gas sensor devices. The approaches are based on using dopant material and nanosize particles to improve the sensor's sensitivity, and incorporating the sensors in an array configuration to increase their selectivity. The sensors have been fabricated using thick and thin film technology on alumina substrates, with SnO<sub>2</sub> and ZnO as the metal oxide materials. Pd has been used as the dopant material. The sensors will be used in real-time monitoring of environmental pollutants. Thus, they will be connected with electronic data collection and telemetry system necessary for the remote operation of the sensors. The design and fabrication of these sensors will be described in this paper.

### 6414-82, Poster Session

#### Development of a tendon driven system using a pneumatic balloon

R. Sato, N. Saga, S. Chonan, Akita Prefectural Univ. (Japan)

This paper is a study on a new type of a tendon system driven by a pneumatic balloon.

It consists of a tendon and a silicon tube. Both ends of the silicon tube are closed and the tube expands like a balloon with the supply of air, which distends the silicon tube and pulls the tendon.

Two types of actuation systems are considered. One is a high power system while the other a long stroke type. These two actuation systems have a difference in the mechanism of driving the tendon. In the high power system, the tendon is wound around the balloon. On the other hand, for the long stroke type, one end of the tendon is clamped near the balloon.

The states of expansion are examined for both the high power type and the long stroke type. A cover is introduced to prevent the excessive expansion of the inflated balloon.

The basic characteristics of the two tendon systems are discussed. A comparison with a human muscle is also presented.

### 6414-83, Poster Session

#### A compact optical fiber scanner for medical imaging

N. Dhaubanjari, H. P. Hu, D. P. Dave, P. Phuyal, J. Sin, H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA)

A compact fiber optic scanner for biomedical applications such as optical coherent tomography has been designed, fabricated and tested. The scanner is designed as an in vivo device and composed of an optical fiber coated with nickel-powder loaded

gel for external magnetic actuation. The compactness of the imaging device makes it suitable for applications where size, precision and low power consumption is critical.

We have previously demonstrated the principles utilizing magnetic actuation for the fiber scanner coated with magnetic gel. This work focused on verification and optimization of the scanner operation. The magnetic properties of the nickel particle gel were characterized using an alternating gradient magnetometer. The optical scanner is externally actuated by an electromagnet and so it does not require a voltage or current supply in the probe itself. The displacements of the scanner were recorded using a position sensitive detector. The results showed a 0.8-mm linear displacement under the influence of a static magnetic field of 17.6 KA/m in a fiber with a moveable length of 4.2cm. Dynamic analysis showed linear displacement of 0.83mm with an input current amplitude of 41mA and a magnetic field of 2.4 KA/m. The measurements are in good agreement with the theoretical lumped-element calculations. Finite-element analysis was performed and the results agree with the theoretical and experimental results. The static and dynamic displacements of the fiber optic scanner depend on the thickness and length of the magnetic coating. Thus, scanners for different displacements and operating frequencies can be designed by varying the coating thickness and length.

### 6414-84, Poster Session

#### Investigation of vertical displacement thermal actuators

N. Dhaubanjari, S. M. N. Rao, H. Lun-Chen, M. Luquire, D. Popa, The Univ. of Texas/Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada); H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA)

In this paper, we presented design, modeling, fabrication, testing techniques and experimental verification for a bi-directional thermal actuator. The actuation principle is based on the asymmetrical thermal expansion of pseudo-bimorph microstructures due to the difference in the electrical resistance of two stacked polysilicon layers. Bi-directional actuation is achieved depending upon the application of currents on either the top or bottom layers. Various designs were fabricated using the commercial foundry process PolyMUMPS and characterized with a reflective microscope and an optical profiler.

Previous designs demonstrated had a limited vertical displacement due to the mechanical limitation imposed by the flexural lengths of the actuator arms. We proposed a new design allowing an increase of the maximum displacement by 75% with the same input voltage of 8V. The flexure arm is incorporated in the top silicon layer such that the torsional forces on the flexural arms are minimized. This enables larger deflection of the actuator arm without significant increase in the temperature.

Different device configurations have been designed and tested. The temperature distributions on the actuator arms and displacements of the actuators at various conditions were analyzed using finite-element analysis. The simulations were verified experimentally. We will discuss the design configuration, testing techniques and practical issues. The potential applications of the out-of-plane actuators include flow sensors, variable capacitors, resistive sensors, optical switches and RF switches.

### 6414-85, Poster Session

#### A cantilever-type electrostatic zipping actuator

N. Dhaubanjari, S. M. N. Rao, Y. Cai, D. Popa, The Univ. of Texas/Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada); J. Chiao, The Univ. of Texas/Arlington (USA)

This paper discussed modeling, design, fabrication and characterization of a new cantilever-type electrostatic zipping actuator. The actuator was designed to achieve high displacements and fabricated using multi-layer polysilicon foundry fabrication process PolyMUMPS. The high out-of-plane displacement is to satisfy the requirements in microwave and millimeterwave waveguide

applications for switching, tuning and phase shifting. In this paper we will present the design considerations in displacement, electrostatic forces and electrostatic stability.

The electrostatic force between the curved cantilever and the bottom electrode on the substrate pulls the cantilever down. With a warped cantilever, the force closes the gap from the anchor end and gradually the zipping effect actuates the entire cantilever without increasing the biasing voltages. Previous electrostatic zipper actuators require a thin layer of dielectric material on top of the bottom electrode to prevent electrical shorting. They may have an issue with electrical breakdown of the thin dielectric layer due to the film quality.

We designed a new mechanical structure to avoid the electrical shorting problem without a layer of dielectric material. Our analysis and experimental results demonstrated that the proposed design can withstand high voltage without shorting and is capable of high deflection. The vertical displacements of different devices configurations were found ranging from 26  $\mu\text{m}$  to 450  $\mu\text{m}$  while the actuation voltages varied in the range of 12 V to 45.3 V for complete actuation. Pull-in voltages for various configurations were analyzed and will be presented.

### 6414-86, Poster Session

#### An RNS public key cryptography accelerator

T. Coleman, J. Kitchener, D. Pudney, K. Wauchope, B. J. Phillips, The Univ. of Adelaide (Australia)

A new implementation of a hardware accelerator for RSA cryptography is described. The accelerator performs long integer (1024-bit) modular exponentiation using the Residue Number System (RNS). It is implemented on an FPGA and interfaced to a host PC via the PCI bus. The accelerator uses the RNS to break the long operands into short channels that are processed in parallel. The performance of this architecture is evaluated and an enhanced architecture is proposed in which the channels are pipelined to achieve high throughput.

### 6414-87, Poster Session

#### Control performance of pneumatic artificial muscle

N. Saga, Akita Prefectural Univ. (Japan)

The robot in the future will be lightened and, in addition, the complex tasks will be done by the consumption of less energy. To achieve this, the development of an artificial muscle actuator which is as soft as a human-being becomes indispensable. At present, the artificial muscle actuator used is the McKibben type, but the heat and mechanical loss of this actuator are large because of the friction caused by the expansion and contraction of the sleeve. Therefore, we developed the artificial muscle tube where the carbon fiber of the high intensity had been built into the silicone tube. Our actuator is long-lived because it does not need the sleeve, and can give the aeolotropic property of the actuator by how to knit the fiber built into the tube. This study aims to clarify the fundamental control performance of a pneumatic artificial muscle.

### 6414-88, Poster Session

#### Implementation of saturation for modeling pattern noise using naturalistic stimuli

S. Rajesh, T. J. Rainsford, R. S. A. Brinkworth, D. Abbott, D. C. O'Carroll, The Univ. of Adelaide (Australia)

Insects with their amazing visual system are able to perform exceptional navigational feats. In order to understand how they perform motion detection and velocity estimation, much work has been done in the past 40 years and many models of motion detection have been proposed. One of the earliest and most prominent models is the Reichardt correlator model. We have elaborated the Reichardt correlator model to include additional nonlinearities that mimic known properties of the insect motion pathway, including logarithmic encoding of luminance and saturation

at various stages of processing. In this paper, we compare the response of our elaborated model with recordings from fly HS neurons to naturalistic image panoramas. Such responses are dominated by noise which is largely non-random. Deviations in the correlator response are likely due to the structure of the visual scene, which we term Pattern noise. Pattern noise is investigated by implementing saturation at different stages in our model and comparison of each of these models with the physiological data from the fly is performed using cross covariance technique.

### 6414-89, Poster Session

#### An active locking mechanism for assembling 3D microstructures

P. Zhang, M. Mayyas, W. H. Lee, D. Popa, P. S. Shiakolas, H. E. Stephanou, J. Chiao, The Univ. of Texas/Arlington (USA)

Microassembly is an enabling technology to build 3D microsystems consisting of microparts made of different materials and processes. Multiple microparts can be connected together to construct complicated in-plane and out-of-plane microsystems by using compliant mechanical structures such as micro hinges and snap fasteners.

This paper presents design, fabrication, and assembly of an active locking mechanism that provides mechanical and electrical interconnections between mating microparts. The active locking mechanism assembly is beneficial in designing microgrippers as it reduces mating forces, which often are the reason to cause fracture in microgrippers.

Microgrippers and microparts with the active locking mechanism included were fabricated on silicon substrate using the deep reactive ion etching DRIE processes with 100 $\mu\text{m}$  SOI (silicon on insulator) wafers. A precision robotic assembly platform with a dual microscope vision system was used to automate the manipulation and assembly processes of microparts. The assembly sequence includes (1) tether breaking and picking up of a micropart by using an electrothermally actuated microgripper, (2) opening of a socket area for zero-force insertion, (3) a series of translation and rotation of mating microparts to align them onto the sockets, and (4) deactivation and releasing of locking fingers. As a result, the micropart was held vertically to the substrate and locked by the compliance of Chevron beams. Microparts were successfully assembled using our active locking mechanism and the normal angle was measured as 88 $\pm$ 6 $^\circ$ .

This active locking mechanism allows electrical interconnections which can potentially be used to implement a reconfigurable microrobot that requires complex assembly of multiple links and joints.

### 6414-90, Poster Session

#### Characteristic comparison between McKibben type artificial muscles and straight fibers type artificial muscles

T. Nakamura, Chuo University (Japan)

A wearable device and a rehabilitation robot which assists a human muscle should have characteristics similar to those of human muscle. In addition, because the wearable device and the rehabilitation robot should be light, an actuator with a high power/weight ratio is needed. At present, the McKibben type is widely used as an artificial muscle, but in fact its physical model is highly nonlinear. Further, the heat and mechanical loss of this actuator are large because of the friction caused by the expansion and contraction of the sleeve.

We have already developed pneumatic artificial muscles reinforced by glass fibers in axial direction (straight fibers type artificial muscles). This type muscle has high contraction rate and force. However, the domination of this artificial muscle to conventional McKibben type artificial muscles has not reported. In this study, straight fibers type artificial muscles are compared with conventional McKibben type artificial muscles.

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## 6415-02, Session 1

### Effect of annealing temperature on the formation of silicon nanocrystals in a nitride matrix

G. Scardera, T. Puzzer, E. Pink, T. Fangsuwannarak, G. Conibeer, M. A. Green, Univ. of New South Wales (Australia)

Superlattices of silicon nanocrystals or quantum dots (QDs) are fabricated by depositing alternating layers of stoichiometric and sub-stoichiometric silicon nitride by dual-mode PECVD and subsequent high temperature annealing. NH<sub>3</sub>, SiH<sub>4</sub> and Ar are used as processing gases. The formation of QDs is monitored for varying annealing temperatures using TEM, micro-Raman and GI-XRD. Samples composed of 50 bi-layers are grown under the same conditions and annealed for two hours at temperatures ranging between 600 and 1150°C. A processing regime is established to allow these NH<sub>3</sub> based PECVD nitride films to withstand the thermal cycling involved with high temperature annealing. FTIR is used to monitor molecular changes in the films. The IR absorbance spectra for samples containing nanocrystals show the Si-N stretching peak accompanied with a distinct shoulder around 1000-1100 cm<sup>-1</sup> corresponding to the Si-O bond. This paper also investigates the use of FTIR spectroscopy as a complementary technique for verifying the formation of silicon nanocrystals in a nitride matrix.

## 6415-03, Session 1

### Effect of sonication on the mechanical properties of poly (vinyl alcohol)/carbon nanotube composites

V. Truong, K. Tsang, S. Keough, N. St John, Defence Science and Technology Organisation (Australia)

Several sonication procedures were performed on multi-walled carbon nanotubes (MWNTs) in water by varying the length of time, the output power and the type of sonicating horn. Depending on the sonicating conditions, the multi-walled carbon nanotubes (MWNTs) could be well or poorly exfoliated and dispersed. Poly (vinyl alcohol) (PVA) and MWNT composites were cast from the PVA/MWNT aqueous mixture. The poorly dispersed solution produced nanotube agglomerates with the size of 50-100 μm that did not induce crystallization at the polymer/nanotube interface. They became stress concentrators reducing the Young's modulus and the tensile strength. On the other hand, the well-dispersed nanotube agglomerates at submicron dimensions efficiently enhanced the mechanical properties. Centrifuging the PVA/MWNT casting mixture confirmed this observation. As the centrifugation facilitated the removal of large agglomerates noticeable enhancement of mechanical properties of the composites was achieved. Crystallinity formed at the interface between the PVA and nanotubes was the main factor enhancing the Young's modulus and the tensile strength of the composites. By adding 0.5 wt % MWNTs to PVA and using the optimized sonicating conditions the Young's modulus and the tensile strength increased by 29 % and 18 %, respectively. For the composite cast from centrifuged solution the increase was 12 % and 37 %.

## 6415-04, Session 1

### Optical properties of covalently anchored single-walled carbon nanotube arrays on silicon (100) surfaces

J. Yu, J. G. Shapter, J. S. Quinton, M. Johnston, Flinders Univ. (Australia); D. Beattie, Univ. of South Australia (Australia)

Carbon nanotubes are often touted as the next great revolution in material science. Many results have shown that SWCNTs may have potential applications in diverse fields. For most of these applications, well-ordered arrays of nanotubes are highly desirable. The direct growth of aligned carbon nanotube arrays has been widely explored and successfully developed based on chemical vapor deposition techniques. However this method has some limitations in large-scale applications on device assembly because of high growth temperature required, poor adhesion between carbon nanotubes and the substrates, growth of only multi-walled carbon nanotubes and the close ends of carbon nanotubes. Many researchers and our group have demonstrated the formation of short SWCNT assemblies oriented normal to a gold substrate through surface reaction. In view of the importance of silicon as the primary semiconductor material in modern microelectronic devices, efforts to control its electronic properties and to tailor the chemical and physical characteristics of its surface are of major importance. In our paper we present a new approach for directly organizing single-walled carbon nanotubes (SWCNTs) onto a silicon (100) surface by the surface condensation reaction with hydroxyl terminated silicon. X-ray photoelectron spectra, Raman spectroscopy, atomic force microscopy and scanning electron microscopy show that the shortened SWCNTs have been organized successfully on silicon. The optical properties of SWCNT array exhibit strong fluorescence in the visible wavelength range from 650-800 nm. The fluorescence can be attributed to the coupling effects between attached SWCNTs and silicon substrate.

## 6415-05, Session 2

### In(Ga)As/GaAs quantum dots for optoelectronic devices

K. Sears, S. Mokkaapati, M. Buda, J. Wong-Leung, H. H. Tan, R. Chennupati, The Australian National Univ. (Australia)

Self-assembled quantum dots are of interest because of their 3D carrier confinement and potential for improved opto-electronic device performance. This presentation will discuss the self-assembled growth of In(Ga)As/GaAs quantum dots by metal-organic chemical vapor deposition and the application of these quantum dots to diode lasers and integrated opto-electronic devices. After an extensive study of the growth parameters high density, defect free quantum dot ensembles have been achieved and ground state lasing demonstrated for diode lasers with 5 stacked layers of quantum dots in their active region. This presentation will review the important growth parameters and the lasing characteristics of these quantum dot lasers. Selective area epitaxy of quantum dots using SiO<sub>2</sub> patterning will also be discussed. This has enabled the formation of different wavelength/bandgap quantum dots on different regions of the wafer and has led to the integration of a quantum dot laser and waveguide.

## 6415-06, Session 2

### Study of size dispersion and trapped states with aging for CdS<sub>x</sub>Se<sub>1-x</sub> quantum dots in glass matrix

S. Nagpal, Univ. of Delhi (India)

CdS<sub>x</sub>Se<sub>1-x</sub> quantum dots (QDS) were synthesized using colored glass filter, by the process of nucleation and crystallization. To reduce the size dispersion a double step annealing process was adopted. Since these glasses do not get supersaturated after the growth of quantum dots, the diffusion of semiconductor particles continues to take place at room temperature which leads to aging effects. In the present work a comparison has been made between freshly grown and 18 months aged CdS<sub>x</sub>Se<sub>1-x</sub> nanocrystals, in context of size distribution, volume fraction and

density of trapped states. Study of nanocrystal size and size distribution is important because these directly effect the band gap tuning and 3rd order Non-Linearity coefficient respectively in optoelectronic devices. The importance of trapped states lies in the fact that it directly effects the Ultra fast response times. To conduct the above mentioned studies, optical absorption and Photoluminescence was conducted. The size dispersion was calculated by simulating the 1s-1s absorption peak with the theoretical curves generated, using Effective Medium theory.

Our studies conclude that the sizes of nanocrystals do not change with aging although the volume fraction increases with time, which is a positive aspect. They are in the strong The quantum dots synthesized seem to lie in the strong quantum confinement regime since the average size is much less than the Bohr exciton radius. The size dispersion decreases from 9.5% to 6.75 % for a typical case of annealing duration. The PL studies conducted reveal a red shifted luminescence along with the presence of only shallow trapped states. The density of trapped states shows a broad distribution which overlaps the band edge. The PL intensity decreases with aging although the energy position does not change. This shows that the nature and origin of trapped states do not change with time although the density of trapped states decreases with time.

## 6415-07, Session 2

### Effects of silicon nanocrystallite density on the Raman-scattering spectra of silicon quantum dot superlattices

T. Fangsuwannarak, E. Pink, Y. Huang, G. Scardera, G. Conibeer, M. A. Green, Univ. of New South Wales (Australia)

Silicon nanostructures based on silicon quantum dots (SiQDs) in a silicon dielectric are being investigated for application to Si based tandem cells. The main challenge for such a structure is to obtain sufficient carrier mobility and hence a reasonable conductivity. It is believed that the conductivity of such novel (SiQDs) embedded in a silicon dielectric matrix is controlled by the close spacing of the SiQDs. In this study we grew a-SiO<sub>x</sub>/a-SiO<sub>2</sub> ordered arrays by reactive RF magnetron co-sputtering. The composition of the SiO<sub>x</sub> (x<2) ordered arrays has been controlled by varying the coverage percentage of the silicon target. On high temperature annealing phase separation occurs into nano-crystalline Si and amorphous SiO<sub>2</sub>. The Raman scattering spectra presented in this study suggest a dot size-dependent peak at 510-518 cm<sup>-1</sup> (Inc) and an inter-dot spacing-dependent shoulder between 495 and 498 cm<sup>-1</sup> (Is). The correlation between crystalline silicon density and ratio of the relative integrated intensity of SiQDs and its shoulder bands are presented. The size of the SiQDs is also confirmed by structural analysis through transmission electron microscopy (TEM) and X-ray diffraction (XRD). Initial analysis of the relationship between the relative integrated intensity (Inc/Is) and conductivity of SiQD superlattices with various composition of the SiO<sub>x</sub> are presented.

## 6415-08, Session 2

### GaN membrane MSM ultraviolet photodetectors

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GaN exhibits unique physical properties, which make this material very attractive for a range of applications. These include optical devices for ultraviolet detection.

For the first time a MSM type UV photodetector structure was manufactured on a 2.2 μm. thin GaN membrane obtained using micromachining techniques. The GaN layer structure, with a low native doping, was grown by MOCVD techniques on high resistivity (ρ>10kOhmcm), <111> oriented silicon wafers, 500 μm thick. The grown epitaxial layer includes thin AlN layers in order to reduce the stress in the GaN layer and avoid cracking. Conventional contact lithography, e-gun Ni/Au (10nm /200nm) evaporation and lift-off techniques were used to define the interdigitated Schottky metalization on the top of the wafer. Ten digits with a width of 1 μm and a length of 100 μm were defined for each electrode. The interdigit width was 1μm. After the backside lapping of the wafer to a thickness of about 150 μm, a 400nm thick Al layer was deposited on the backside, to be used as mask for the selective reactive ion etching of silicon. The backside mask, for the membrane formation, was patterned using double side alignment techniques and silicon was etched down to the 2.2 μm thin GaN layer using SF<sub>6</sub> plasma. A very low dark current (30pA at 3V) was obtained. Optical responsivity measurements were performed at 1.5V. A maximum responsivity of 18mA/W was obtained at a wavelength of 370nm. This value is very good and can be further improved using transparent contacts for the interdigitated structure.

## 6415-09, Session 2

### Using silver nanorods to construct nontouched near-field optical systems

S. Chen, Far East College (Taiwan); T. M. Chang, D. P. Tsai, National Taiwan Univ. (Taiwan)

At subwavelength scale, the diffraction limit has hindered many applications because of the insufficient resolution. However, this barrier has been broken by near-field optical technologies, for example, SNOM, near-field optical disk and so forth. The near-field wave is an evanescent wave, thus, the detector should be put very closely to the sample, or even touching with the sample, to pick up the signal. This characteristic has forbidden many usages, such as bio-sensing, lithography, and so on.

Silver nanorods have an excellent effect on localizing the transmitted wave, especially, the intensity of the localized hot spot below the bottom of the nanorods still has enhancement. Based on this property, one can construct many kinds of structures by silver nanorods, and they can be applied to visible light nanolithography, soft matter scanning or bio-sensor. We have numerically studied the relations of the intensity of the localized field with the size and the alignment of the nanorods, the availability of these applications is expected if the optimal conditions can be carried out.

## 6415-11, Session 3

### MEMS microshutter arrays for James Webb Space Telescope

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MEMS microshutter arrays are being developed at NASA Goddard Space Flight Center for use as an aperture array for a Near-Infrared Spectrometer (NirSpec). The instruments will be carried on the James Webb Space Telescope (JWST), the next generation of space telescope after Hubble Space Telescope retires. The microshutter arrays are designed for the selective transmission of light with high efficiency and high contrast. Arrays are close-packed silicon nitride membranes with a pixel size of 100x200 μm. Individual shutters are patterned with a torsion flexure permitting shutters to open 90 degrees with a minimized mechanical

stress concentration. Light shields are made on to each shutter for light leak prevention so to enhance optical contrast. Shutters are actuated magnetically, latched and addressed electrostatically. The shutter arrays are fabricated using MEMS technologies.

### 6415-12, Session 3

#### Millimeter-wave monolithic integrated receivers based on GaAs micromachining

G. Konstantinidis, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Neculoiu, National Institute for Research and Development in Microtechnologies (Romania); A. Stavriniadis, Z. Chatzopoulos, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); A. Muller, National Institute for Research and Development in Microtechnologies (Romania); K. Tsagaraki, Institute of Electronic Structure and Laser of the Foundation for Research and Technology-Hellas (Greece); D. Vasilache, I. Petrini, C. Buiculescu, National Institute for Research and Development in Microtechnologies (Romania); L. Bary, R. Plana, LAAS-CNRS (France)

In recent years, the substrate removal has been proposed in order to reduce losses, for the fabrication of millimetre wave circuits, mostly for silicon substrates. Micromachining of GaAs is an exciting less explored alternative for manufacturing high performance communication systems. GaAs micromachining is very interesting for the millimeter and submillimeter wave applications, due to the easy monolithically integration of micromachined passive circuit elements with active devices manufactured on the same chip.

This paper presents the monolithic integration of a two-director membrane supported Yagi-Uda antenna with a Schottky diode, both having as support the same 2  $\mu\text{m}$  thin GaAs membrane. The design was based on the full-wave electromagnetic simulation software Zeland-IE3D. A MBE structure was grown on a semiinsulating GaAs wafer: 0.2  $\mu\text{m}$  thin Al<sub>x</sub>Ga<sub>1-x</sub>As layer with  $x > 0.55$  (the etch-stop layer) followed by a 2  $\mu\text{m}$  LT GaAs layer ("the membrane layer") and then by a 0.3  $\mu\text{m}$  thin GaAs, (1x10<sup>18</sup> cm<sup>-3</sup> "ohmic layer"). Finally a 0.3  $\mu\text{m}$  thin GaAs (1x10<sup>17</sup> cm<sup>-3</sup> "Schottky layer") was grown. An eight-mask process was developed for the receiver manufacturing. The process includes some difficult steps regarding the integration of a very small Schottky diode (with a diameter of about 3  $\mu\text{m}$ ) with the antenna with dimensions of a few millimeters, the polyimide-bridge manufacturing, and the membrane formation using RIE. The receiver characterization, including the isotropic voltage sensitivity was performed using "on wafer" measurements and has shown a good agreement with the simulated results. Demonstrator receiver circuits for 45 GHz operating frequency have proved very good performances. The technology developed can be used for applications up to 100 GHz.

### 6415-13, Session 3

#### Theoretical and experimental investigation of thermocapillary actuation for microplugs

N. Nguyen, Z. Jiao, X. Huang, Nanyang Technological Univ. (Singapore)

Droplet-based or digital microfluidics has been emerged as an alternative for continuous-flow microfluidics. Microdroplets formed in miniature channels can be used as a means for reagent transport and a platform for chemical reactions. Microdroplets whose lengths are larger than the channel width are considered here as microplugs. Manipulation of microdroplets or microplugs promise a huge potential in this new field of digital microfluidics. This paper reports the analytical model and experimental results of reciprocating thermocapillary motion of a liquid plug in microchannels with two heaters. The heaters are activated alternatively. The paper first describes a one-dimensional analytical model for the transport of micro plugs in a capillary. The model considers the coupling effect between heat transfer in the capil-

lary wall and the surface tension driven movement of the plug. Because surface tension depends on temperature, transient temperature distribution determines the surface tension difference across a plug and thus its movement. In the experiments, the liquid plug was positioned between the two heaters. The periodic temperature gradients generated by the two heaters made the liquid plug to move back and forth. The position of the plugs was captured and evaluated using a CCD camera. Furthermore, this paper compares the results of this motion with different switching frequencies, viscosities and plug sizes. This actuation concept has potential applications in post-processing stages for droplet-based microfluidics.

### 6415-14, Session 3

#### Silicon-on-insulator microdosimeter for radiobiology

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To estimate the cancer risk when exposed to radiation fields, it is of paramount importance to measure the energy deposited by radiation on cellular and subcellular levels, using a technique known as microdosimetry. Usually, gas tissue-equivalent proportional counters (TEPC) are used which are bulky, require a high voltage bias, a gas supply system and are not effective in a confined space. Silicon-on-Insulator (SOI) microdosimeters with rectangular parallelepiped (RPP) p-n junction arrays, working in analogue mode, and modelling of 2D biological cell distribution was previously proposed and investigated [1]. Taking into account the shortcomings of these previous designs, a novel SOI radiation detector structure for microdosimetry is proposed here. We aim to improve the track structure measurement range for high and low energy ions to as low as 0.06 keV/ $\mu\text{m}$ . The new SOI microdosimeters are fabricated by using convenient microfabrication process. The 3D silicon sensitive volume (SV) is well defined, with chord distribution similar to the cylindrical TEPC at an average chord length of about 1-5 microns. The major advantage of the cylindrical SV is that 100% of charge collection can be achieved in contrast to 80% for planar RPP SV in previous designs. 3D SVs of the detectors are connected in a way that the signal-to-noise ratio is improved and the capacitance effect is reduced, while keeping the detection area large. Instead of using a polyethylene converter mechanically attached to the detector array, the new microdosimeter has polymethyl methacrylate (PMMA) coated on the 3D SVs without air gaps to mimic the sensitive site of biological cells. 3D ISE-TCAD modelling of SVs along with Ion Beam Induced Charge (IBIC) analysis of charge collection in SVs using a heavy ions microprobe will also be presented.

References:

[1] P.D. Bradley, The Development of a Novel Silicon Microdosimeter for High LET Radiation Therapy, PhD thesis, University of Wollongong (2000).

### 6415-15, Session 3

#### A hydraulic micro-actuator with an integrated inductive position sensor

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An important technological barrier in the development of microrobotic systems is the lack of compact sensor-actuator systems. This paper presents a hydraulic microactuator with an integrated inductive position sensor. Such a positioning system offers great opportunities for all devices that need to control a large

number of degrees of freedom in a restricted volume. The final objective for this research is to develop a miniature sensor-actuator system with an actuation force of 1 N and a positioning accuracy of 100  $\mu\text{m}$ .

The actuator described in this paper is a miniaturized piston-cylinder hydraulic actuator. The main advantage of these actuators is their high force and power density at microscale. The development of microseals is however challenging from both design and fabrication point of view. The actuator investigated in this paper is sealed by clearance seals. The outside diameter of the actuator is 1.4 mm and the length 15 mm. The stroke is 10 mm, and the actuator is able to generate forces of more than 0.4 N at a pressure of 550 kPa

The position sensor consists of two coils wound around the cylinder of the actuator. The measurement principle is based on the change in coupling factor between the coils as the piston moves in the actuator. The sensor is extremely small since one layer of 40  $\mu\text{m}$  copper wire is sufficient to achieve a resolution of 10 mm over the total stroke. Special attention has been paid to the material selection and to the thermal stability of the sensor.

### 6415-16, Session 3

#### Characterisation of a CMP nanoscale planarisation-based process for RF MEMS micromechanical resonators

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This paper characterises a novel Chemical Mechanical Polishing (CMP) planarisation based process for the fabrication of ultra-thin nanometer wide transducer gaps for RF MEMS resonators. The process requires one photolithographic step less than previously reported fabrication methods and does not suffer from transducer gap widening, which otherwise strongly affects the impedance of manufactured resonators. Test structures were used to evaluate the ability to produce nanometer wide planarised capacitive transducer gaps and to determine the planarity of CMP based processing. As a result of this work, pattern dependent removal rates for polysilicon have been determined and design guidelines defined to optimise the yield of CMP fabricated resonators.

### 6415-17, Session 4

#### Microfabrication of PLLA polymer by X-ray lithography

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Poly-L-Lactides (PLLA) is a biodegradable polymer material which is sensitive to X-ray as a resist and free of stress crack formation. The fabrication technique to generate the PLLA micro structures with the very smooth sidewall is demonstrated. The function of X-ray on PLLA polymer material is breaking the PLLA polymer main chain and generating intermediates which can be degraded further and finally dissolved by the solvent interaction.

In this paper, we have illustrated PLLA polymer is a new resist material for x-ray lithography and can be developed in alkaline developers after x-ray exposure. Desired microstructures have also been fabricated using this novel X-ray lithography technique. The PLLA structure sidewall obtained by this process is very smooth compared with that of other micromachining methods. The result after 0.02Ahour X-ray exposure dosage and developed in NaOH (1N) developer for 1 hour at room temperature shows the smooth sidewall by consuming PLLA to generate lactic acid salts. The depth of the micro PLLA structure is about 150  $\mu\text{m}$  and the RMS value of the sidewall roughness was within 200nm. The data of exposure doses against the processed depth on the PLLA sheet is shown.

### 6415-18, Session 4

#### High-productivity DRIE solutions for 3D-SiP and MEMS volume manufacturing

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Emerging 3D-SiP technologies and high volume MEMS applications require high productivity mass production DRIE systems. Adixen DRIE product range has recently been optimized to reach the highest process and hardware production performances. A study based on sub micron high aspect ratio structures encountered in the most stringent 3D-SiP has been carried out.

The optimization of the Bosch process parameters are showing ultra high silicon etch rate, with unrivaled uniformity and repeatability leading to excellent process yields. In parallel, most recent hardware and proprietary design optimization including vacuum pumping lines, process chamber, wafer chucks, pressure control system, gas delivery are being discussed. A key factor for achieving the highest performances was the recognized expertise of Alcatel in vacuum technology.

These improvements have been monitored in a mass production environment for the mobile phone market. Field data analysis are showing a significant reduction of cost of ownership thanks to an increased throughput and much lower running costs. These benefits are now available for all 3D-SiP and high volume MEMS applications. The typical etched patterns include tapered trenches for CMOS imagers, through silicon via holes for die stacking, well controlled profile angle for 3D high precision inertial sensors, and large exposed area features for inkjet head and Silicon microphones.

### 6415-19, Session 4

#### Surface morphology and stress analysis of piezoelectric strontium-doped lead zirconate titanate thin films

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Strontium-doped lead zirconate titanate (PSZT) is a piezoelectric ceramic with relatively high values of piezoelectric coefficients (according to published literature). Perovskite oriented PSZT thin films are also reported to exhibit a variety of other properties including ferroelectricity and pyroelectricity. This paper reports on a study of the surface morphology and resulting stress of RF magnetron sputter deposited PSZT thin films. The study compares PSZT thin films deposited on metal (gold, platinum, nickel, titanium) coated silicon wafers or glass slides and other substrates like langasite and lithium niobate. The orientation of the deposited PSZT thin films was studied using Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD). Grain size and average surface roughness measurements were used to study the quality of the films. Each thin film layer deposited on silicon results in stress, and the various stress contributions by the thin films on silicon are reported. The stress was determined using the changes in the radius of curvature of the sample due to an added layer of thin film, and by applying Stoney's formula to relate the stress to the radius of curvature. The variations in the level of stress and lattice parameters for different thermodynamic conditions during RF magnetron sputter deposition are also reported.

### 6415-20, Session 4

#### Fabrication of forward type DC-DC converter using nanocrystalline Mn-Zn ferrites

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The present day research activity has been concentrated on the development of high frequency low loss materials for switching mode power supplies (SMPS). In SMPS, the out put power increases with an increase of switching frequency; the frequency operation is imperative to reduce the size of transformers to smaller

size. There have been many efforts to construct megahertz switching power supplies experimentally using different nanomaterials. In this present study a nano-crystalline Mn  $1-x$  Zn  $x$  Fe<sub>2</sub>O<sub>4</sub> (where  $x=0, 0.2, 0.4, 0.6, 0.8$ ) cores has been used for the construction of a forward type DC-DC converter using multilayered transformer.

These ferrites used in the present study have been prepared using the nanosized ferrite powder. The nano-ferrite powder was synthesized using microwave-hydrothermal method at a temperature of 165 C for 30min. The phase identification and morphology of the prepared powder were characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM). Nanophase ferrites with particle size ~15nm with high surface area ~ 8.5 m<sup>2</sup> g<sup>-1</sup> were synthesized. Nanoferrite powders were pressed at a pressure of 190 MPa into different shapes such as rods, transformer cores, etc. The pressed samples were microwave sintered at a low temperature of 900 C/ 30min. The mono-phasic nature of sintered samples was characterized using XRD. The particle size was obtained from TEM studies and it is found to be ~ 50 nm. The performance of the sintered ferrites has been estimated from the studies of dependence of permeability spectra on the frequency and temperature and it was found that the nano-crystalline ferrite shows improved dielectric properties over bulk ferrites.

A multilayered transformer has been fabricated using nano-crystalline Mn-Zn ferrite cores. The primary and secondary conductors positioned alternatively in the vertical and horizontal directions. The conventional planer winding structure is used for the fabrication of transformers. Two-dimensional finite element method has been used for analysis. This method took an account of two conditions and constant input voltage and load current. It was found that the coupling coefficient of the conventional multilayered transformer deteriorated with increasing load current. Finally it was found that a forward type DC-DC converter fabricated using the multilayered transformer which was constructed using Mn 0.4Zn 0.6 Fe<sub>2</sub>O<sub>4</sub> had higher efficiency than that of a converter fabricated using the conventional multilayered transformer.

Keywords: Ferrite, nano-crystalline, Microwave-Hydrothermal synthesis, Multilayered transformer core, dielectrical properties, DC-DC converter.

## 6415-21, Session 5

### Low-stress silicon nitride layers for MEMS applications

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The paper reports a new deposition method to produce near zero residual stress SiN<sub>x</sub> layers using PECVD in high power and high frequency (13.56 MHz). Traditionally, mix frequency mode is commonly used to produce low stress SiN<sub>x</sub> layers, which alternatively applies the HF and LF mode. However, due to the low deposition rate of LF mode, the combined deposition rate of mix frequency is quite small in order to produce homogenous SiN<sub>x</sub> layers. In our new method, a high power which was up to 600 W has been used, may also produce low residual stress (0-20 MPa), but much higher deposition rate (250 to 350 nm min<sup>-1</sup>). That may be because the higher power not only leads to higher dissociation rates of gases which results in higher deposition rates, but also brings higher N bonding in the SiN<sub>x</sub> films and higher compressive stress from higher volume expansion of SiN<sub>x</sub> films, which compensates the tensile stress and produces low residual stress. In addition, the paper investigates the influence of other important parameters which have great impact to the residual stress and deposition rates, such as reactant gases flow rate and pressure. By using the final optimized recipe, masking layer for anisotropic wet etching in KOH and silicon nitride cantilever have been successfully fabricated based on the low stress SiN<sub>x</sub> layers.

## 6415-23, Session 5

### Structural and magnetic properties of cobalt implanted TiO<sub>2</sub> thin films

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Since the observation of room-temperature ferromagnetism (RTFM) in Co-doped anatase TiO<sub>2</sub>[1], there have been many reports on the study of the magnetic properties of Co-doped TiO<sub>2</sub> prepared by various methods with diversified results. It is still a topic of controversy on the origin of the RTFM in these systems. In this work, TiO<sub>2</sub> thin films were prepared by RF sputtering onto thermally grown oxide layers on Si substrates. Cobalt implantation was performed using a metal vapor vacuum arc ion source to various doses ranging from 3x10<sup>15</sup> cm<sup>-2</sup> to 4x10<sup>16</sup> cm<sup>-2</sup>. Postannealing was performed in a vacuum chamber at various temperatures ranging from 400°C to 700°C for 2 hours and 4 hours. Characterization of these films as-implanted and after thermal annealing under various conditions was performed using Rutherford backscattering spectrometry, transmission electron microscopy, x-ray diffractometry, x-ray photoelectron spectroscopy, and vibrating sample magnetometry. The dependence of the magnetic properties on the implantation and annealing conditions were studied in details. Clear RTFM properties were observed. The saturation magnetic moment per implanted Co atom (MS) seems to increase with increasing dose within the implant dose range in this study. At a fixed dose, the MS value also shows a general increase trend with increasing annealing temperature and annealing time. There are quite a number of samples showed MS values exceeding the bulk Co value (1.69 μB/Co) and the maximum MS value observed is about 3.0 μB/Co. Such high MS values indicate that the RTFM must not come from Co clusters alone. Possible origins of the RTFM properties will be discussed in conjunction with the structural properties. This work is supported in part by a Direct Grant for Research from the Engineering Faculty of CUHK.

[1] Y. Matsumoto et al., Science 291, 854 (2001).

## 6415-24, Session 5

### T-ray antireflection coating

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Terahertz time-domain spectroscopy is able to extract optical or dielectric properties of materials, whether in solid, liquid, or gas phases, in the T-ray frequency region. Spectroscopy of liquid or gas requires a receptacle to confine a sample. In order to allow T-rays to probe the sample effectively, a part of receptacle, at which T-rays pass through, must be made of T-ray transparent windows. However, even though windows are transparent to T-rays, there exists a loss, due to reflections at air-window and window-air interfaces, which accounts for a major energy loss. Due to recent emergence of T-ray technology, there has been very little carried out to-date on the reduction of losses due to reflection. This paper analyses the reduction of T-ray reflection loss by means of an antireflection coating. Because T-ray wavelengths are much larger than visible wavelengths, the antireflection layer thickness for T-rays is much larger than the usual optical case. This creates an interesting opportunity for retrofittable antireflection layers in T-ray systems. In the experiment, a coating material, of an appropriate thickness and index of refraction, is applied onto the surfaces of a silicon window. The coated window shows enhancement of the transmittance at a desired frequency.

## 6415-25, Session 5

### Formation of silicon nanoislands on c-Si substrate by thermal annealing of silicon rich oxide deposited by LPCVD

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Si nanoislands on the surface of c-Si substrates show novel physical characteristics related to their dimensions, such as an atom like energy spectrum and quantum size effects. Different methods have been explored to produce Si islands, such as the deposition of very thin Si layer on Si substrate followed by thermal annealing, or Si implantation into the buried SiO<sub>2</sub> followed by thermal annealing. The former requires very precise control of the deposited Si layer thickness (several bilayers) in order to produce disconnected Si islands on Si surface. In this case, Molecular Beam Epitaxial is usually used, which has a better control of the deposition. The second requires precise control of the implantation dose. In any case, the preparation parameters are very strict and not easy to control during fabrication.

In this letter, we report the preparation of Si nanoislands on Si by simply thermally annealing the silicon rich oxide (SRO), which was deposited by using conventional low pressure chemical vapor deposition. Transmission electron microscopy was used to characterize the structure of the Si nanoislands. High density Si nanoislands were formed on the surface of Si substrate during the thermal annealing. The islands are crystalline following the crystalline orientation of the substrate. The density and size of the Si islands can be adjusted by changing the excess Si concentration in the SRO precursor. The strain at the Si/SRO interface is probably the main reason for the nucleation of the self-assembled Si islands that grow epitaxially on the Si substrate.

### 6415-26, Session 5

#### Development of MgSiO<sub>3</sub> biocompatible piezoelectric film for bio-MEMS actuator

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In this study, an sputtering technique of a newly designed biocompatible piezoelectric material MgSiO<sub>3</sub> for Bio-MEMS actuator is developed, which has a tetragonal perovskite lattice structure. This crystal structure was designed by using numerical analyses, such as HSAB rule, the geometrical compatibility assessment, and the first principles DFT calculation. In general, MgSiO<sub>3</sub> has an orthorhombic perovskite structure in nature. Therefore, we adopted 1) the helicon wave plasma sputter (HWPS) method, which can produce large energy atoms under a low working pressure and easy to control the lattice constant for growing the tetragonal structure of MgSiO<sub>3</sub>, and 2) a biocompatible substrate Ir/Ti/Si, to produce a thin film of MgSiO<sub>3</sub> tetragonal perovskite. Ir/Ti/Si substrate has better compatibility with MgSiO<sub>3</sub> (111) plane, because of its close lattice constant.

An optimum condition of HWPS to generate MgSiO<sub>3</sub> tetragonal perovskite structure was sought by using the experimental design method. We found that 1) the substrate temperature and 2) the target composition ratio are significant influent factors for MgSiO<sub>3</sub> film generation. In this searching process, we evaluated the MgSiO<sub>3</sub> films by 1) the surface roughness by AFM, and 2) the chemical compositions by the XPS, and 3) the crystal structure by XRD.

Finally, MgSiO<sub>3</sub> thin film was successfully fabricated and the piezoelectric and ferroelectrics characterization were measured.

### 6415-27, Session 6

#### Packaging challenges and opportunities for micro- and nanosystems-based products

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Packaging of micro and nanosystems is considered to be the major inhibitor to the successful commercialization of micro/nano-based products. The packaging challenge results from the necessity of integration of multiple disciplines (Ex: microfluidics, microchemical, microelectronic, etc) that are inherent in micro/nanosystems. Each discipline has its unique connection, interconnection, and interfacing requirements. To remove packaging as an inhibitor to commercialization, a number of challenges must

be met. To meet packaging process requirements for high-volume production, materials are required that are dimensionally and chemically stable and that will provide structures that do not change in the micro/nano-size scale as environmental conditions change during product usage. Also, engineers must have an interdisciplinary background in engineering and science with an understanding of mechanical engineering, materials, biology, and chemistry. Design engineers must be trained to design in the micro/nano-size scale with an understanding of manufacturing and assembly processes and facility requirements that can provide high-volume production of micro/nano-based products. Beyond an effective design, all aspects of a packaging/micromanufacturing infrastructure that support the micro/nano-size scale must be developed. This infrastructure would include facilities and equipment to develop the pathway from the research laboratory to manufacturable prototypes of design concepts and to provide for high-volume low cost production.

### 6415-28, Session 6

#### Optimization of MEMS fabrication process design by virtual experiments

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Fabrication processes for MEMS are characterized by a variety of different process steps and materials. Unlike in microelectronics the fabrication process is relevant to all design stages within the design flow. The dependency between microstructures and fabrication process leads to application specific fabrication processes. Discovering the correct combination of process steps, materials and process parameters is a tedious task as even minor modifications of the process parameters can strongly affect the three-dimensional shape and the properties of the fabricated micro- or nanostructure. Additionally there are many complex interdependencies between process steps that, in worst case, can cause process failure or unpredictable output.

The PROMENADE process management and design system is currently being developed (as a European research project) to improve the design of fabrication processes by providing a CAD environment based on a comprehensive knowledge base. This knowledge base contains the accumulated process knowledge gained during previous designs and is enhanced by every new design.

The design environment of PROMENADE provides tools for the design and the verification of the fabrication processes. This paper presents a new software module for the system that enables the process developer to follow a design-of-experiments-(DoE)-like approach combined with efficient process simulation in a GRID environment using SILVACO TCAD tools. The module provides graphical representation for the experiments allowing a good overview and easy editing. After the virtual experiments the user select the most promising parameter variations to perform experimental fabrication runs. The overall goal is a speed up of the process design with a reduction of the number of expensive prototypes.

### 6415-29, Session 6

#### Managing design for manufacture and assembly in the development of MEMS-based products

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Design for manufacturability, assembly and reliability of MEMS products is being applied to a multitude of novel MEMS products to make up for the lack of "Standard Process for MEMS" concept. The latter has proved a major handicap in commercialization of MEMS devices when compared to integrated circuits products. Furthermore, an examination of recent engineering literature seems to suggest convergence towards the development of the design for manufacturability and reliability of MEMS products. This review will highlight the advantages and disadvantages of conventional techniques that have been pursued up to this

point to achieve commercialization of MEMS products, identify some of the problems slowing down development, and explore measures that could be taken to try to address those problems. Moreover, these issues of multidisciplinary nature and ongoing research to find expedient avenues to commercialize MEMS products will fundamentally change the way we think about and perceive future trends in the MEMS market.

Successful commercialization critically depends on packaging and assembly, manufacturability, and reliability particularly when it comes to micro scale products. This indeed has proved mighty complicated and has been so since the dawn of microelectronics. However, a methodology that appropriately shadows next generation knowledge management will undoubtedly address most of the critical problems that are hampering development of the MEMS industries. This review will also identify contemporary issues that are challenging the industry in regards to product commercialization and will recommend appropriate measures based on knowledge flow to address those shortcomings and lay out plans to expedient and successful paths to market.

### 6415-30, Session 6

#### Aspects of laser micromachining for sensor prototyping

P. J. McMahon, P. S. Vincent, A. R. Wilson, R. F. Muscat, Defence Science and Technology Organisation (Australia)

Recent advances in UV laser machining have allowed the development of accurate and rapid prototyping of micro scale devices. A few examples are presented of how modern UV laser micro machining may be applied to novel applications in engineering research and the development of state of the art micro sensors for structural health monitoring. We also show how micro device development is now a rapid process where novel procedures allowing the manual handling of work pieces may be used to make two layer laser machined devices with alignment to tens of microns.

### 6415-31, Session 6

#### Maskless lithography using off-the-shelf inkjet printer

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Photolithography is the most important process used to pattern the surface of the silicon wafer in IC fabrication. It has shown high performance but its use is not cost-effective for small series as it necessitates a costly infrastructure (mask aligner) and requires the fabrication of a mask which can be expensive and time-consuming.

Recently, the high resolution achieved by ink-jet printer starts to make an interesting alternative to obtain a patterned protective layer instead of using photolithography. This is particularly true for MEMS which often need a resolution of only 10 to 20 $\mu$ m.

After studying the different architecture of inkjet printer available in the market, a \$100-printer was selected and modified to allow printing on a rigid silicon wafer. We then developed three different patterning processes using the printer.

In a first process the ink was directly used as a protective layer for patterning. A second process modified the photolithography by using the printed ink as a photomask on a spun layer of photoresist. In each case we had to modify the surface energy of the wafer by plasma treatment to improve the resolution. Finally we changed the ink with a modified photoresist solution and directly printed a photoresist mask onto the wafer.

We will report our result for these experiments detailing the processes used and their optimization using DOE technique. Finally we will discuss the possibility to apply these techniques to other fabrication tasks.

### 6415-32, Session 7

#### Microfluidic device with asymmetric electrodes for the delivery of cells and reagents

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Aim:

Developing a microfluidic device to deliver reagents or biological samples without sedimentation problems is a challenging task. In this work, we present a microelectromechanical system (MEMS) for cells and particles delivery without using a mechanical pump. A combination of AC electrokinetic fluidic flow and negative dielectrophoresis (DEP) force is used in this device to achieve anti-sedimentation particle delivery in microchannels.

Methods:

An array of interdigitated asymmetric microelectrode pairs were employed in a planar device. The electrodes produced a net charge in the surrounding fluid, and AC electrokinetic fluidic motion was generated. The electrode pair was modeled, and the effects of the electrode's width and gap and the electrode pair's repeating pattern on the flow rate were determined. Anti-sedimentation of the cells was achieved by generating a non-uniform electric field using the microelectrode pairs. Negative DEP force could be obtained by selecting the appropriate applied frequency to counteract gravitational force and levitate the cells.

The electrode pairs were fabricated by depositing a chromium-gold metal layer on a glass wafer by using standard photolithography and microfabrication methods. The widths of the large and small electrodes were 20-50  $\mu$ m and 5-20  $\mu$ m, respectively. The electrode pairs were actuated via a function generator with a frequency of 2-200 kHz and a voltage of 2.8Vpp. The microchannels for delivering reagents and cells were micromolded using PDMS. This structure was adhered to the glass surface with electrodes.

Results:

Cell delivery speed was found to be significantly affected by the applied frequency. At a cell suspending buffer conductivity of 4.7  $\mu$ S/cm, the flow velocity increased rapidly from 267  $\mu$ m/min to 394  $\mu$ m/min when the applied frequency was increased from 2 kHz to 70 kHz. The delivery speed was also related to the conductivity of the cell suspending buffer. When the conductivity was increased to 47  $\mu$ S/cm with an actuation frequency of 100 kHz, a peak delivery flow velocity of 801  $\mu$ m/min was achieved.

Conclusion:

This electrically actuated cell flow delivery microfluidic device has a small footprint with no moving parts. It is able to deliver cells and particles with high speed. This system does not suffer from the problem of particles sedimentation, and is suitable for lab-on-a-chip applications.

### 6415-33, Session 7

#### BioMEMS for the determination of rheological properties of biological fluids

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The purpose of this research was to model, design and fabricate a biodynamic analysis microsystem required for determination of various molecular transport properties of non-Newtonian biological fluids (e.g. blood in coronary arteries). In order to achieve this, a lab-on-a-chip device is being developed. The microsystem consists of a microchannels system, a gear wheel as rotator pump and a detection system. The developed microchannel system is used to observe fluid and cell behavior in order to make a study of the microcirculation and to characterize the rheological properties, functions and behavior of cells. There are four microchannel types: straight, bifurcated, stenosed and endothelial profiled. Some simulations were made in order to provide an idea about blood flow through blood vessels and microchannels. Thus, blood

was chosen as a model for the fluid properties used in the simulations. The gear wheel was fabricated using the silicon surface micromachining technology and by combining the undercut and refill technique with pin-joint bearing we fabricated bushings that can be used, for example, to elevate the rotor away from the silicon surface. In order to transform the rotor rotation rate into an electrical signal we used a giant magnetoresistive sensor with a non-contacting transduction mechanism. The GMR's were assembled in a full Wheatstone bridge configuration with four active resistors in the middle of the sensitive structure and four shielded reference resistors. The ensemble has proven to be very good for detecting low magnetic fields in lab-on-a-chip applications.

### 6415-34, Session 7

#### **A novel technique for immobilizing nanoparticles on a substrate through the epoxy-amino cross-linking**

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We will present a novel method for immobilized nanoparticles on substrate. This method contains two techniques, which are a preparing technique of self-assembled monomolecular layers(SAMs) terminated an epoxy group or an amino group on surface of nanoparticles or a substrate and a reaction technique between the epoxy and amino groups on the nanoparticles and the substrate.

The epoxy terminated SAM or the amino terminated SAM was prepared on nanoparticles or a substrate by a chemical adsorption technique using 3-glycidoxypropyltrimethoxysilane or (3-aminopropyl) trimethoxysilane. The nanoparticles diluted in organic solvent were coated on the substrate, and the epoxy and amine groups were reacted each other. Unreacted nanoparticles were removed by washing. Then the nanoparticles were immobilized on the substrate through covalent bonds of the epoxy-amine cross-linking.

By using this method, a single layer of nanoparticles will be formed on substrate.

### 6415-35, Session 7

#### **A ferrofluid seal technology for hydraulic microactuators**

M. De Volder, D. F. Reynaerts, Katholieke Univ. Leuven (Belgium)

New industrial and medical applications require microactuators with a high force and power density. During the last decades, it was believed that electrostatic and electromagnetics microactuators would fulfill these needs. However, recent research revealed that microactuators driven by pressurized fluids develop higher power and force densities at microscale. Despite these promising properties, hydraulic actuators are rare in microsystems technology. The main technological barrier in the development of these actuators is the fabrication of powerful microseals with a low leakage.

Classic seal technologies such as rubber O-rings are unfeasible at microscale since small shape or size variations of the rubber O-ring, the seal house or the piston result in either high friction or leakage. In order to avoid the strict production requirements of these seals, this paper investigates liquid seals made of ferrofluid. The implementation of these seals is comparable to that of rubber O-rings but the seal ring is liquid (in this case a ferrofluid) instead of rubber. The ferrofluid is bound to a ring-shape by permanent micromagnets. The liquid nature of these seal rings allows them to adjust their shape to production errors on the piston and the seal house.

This paper presents measurements on miniaturized seal prototypes fabricated by microEDM, micromilling and laser machining. Our current prototypes are able to seal pressures of more than 600kPa without leakage and low friction. These measurements match with a model developed for these seals. Moreover, promising properties such as the restoration of the seal after a pressure overload have been observed.

### 6415-01, Poster Session

#### **Amphiphilic block copolymer nanotubes stabilized by photopolymerization**

R. B. Kishore, A. Jofre, J. B. Hutchison, L. E. Locascio, K. Helmersson, National Institute of Standards and Technology (USA)

We make stable polymer nanotubes, down to 50 nm in diameter and up to one cm in length, from the surface of giant polymersomes by pulling a polymersome membrane with a micropipette tip. The polymersomes were made by the electroformation method using amphiphilic diblock copolymers composed of poly-butadiene and poly-ethylene oxide. The pulled nanotubes were subsequently stabilized by cross-linking the hydrophobic (butadiene) domain of the polymer membrane with UV light in the presence of a photo-initiator. We are using the cross-linked nanotubes to study the transport properties of DNA confined in one dimension.

### 6415-36, Poster Session

#### **Low-temperature synthesis and thermal study of Manganese-Zinc ferrite nanoparticles by a ferriolate precursor method**

M. L. Gera, M. Singh, Himachal Pradesh Univ. (India)

The ferrite formation was found to be quite sensitive to the procedures adopted for preparing the hydroxide slurry prior to hydrothermal treatment. The chlorine ion concentration in the solution and the pH of the precipitation is shown to play a crucial role in retaining the initial stoichiometry of the solution in the nanoparticles. This work had the objective of studying the nanoparticle Mn-Zn ferrite obtained by the ferriolate precursor method. In this process, Mn-Zn ferrite, synthesized through solutions of some specific salts led to the formation of crystalline power (10-30nm as evident from X-ray diffraction analysis) at a temperature of 2000C. The synthesis powders were characterized by X-ray diffractometer for identification of the crystalline phases present, by scanning electron microscopy for identification for their morphological structure and properties, thermogravimetry and differential thermal analysis for identification of the oxidation/reduction behaviour upon firing. The fourier transformation infrared spectroscopy (FT-IR) shows two main absorption bands  $\nu_1$  and  $\nu_2$  in the range of 400-4000 $\text{cm}^{-1}$ . The synthesis route is simple, energy saving and cost effective. Details of the synthesis and characterizations of the resultant products were given.

### 6415-38, Poster Session

#### **Self-operated blood plasma separation using micropump in polymer-based microfluidic device**

W. I. Jang, K. H. Chung, H. B. Pyo, S. H. Park, Electronics and Telecommunications Research Institute (South Korea)

The blood is one of the best indicators of health because blood circulates all body tissues and collects information. This paper describes new blood separation technique based on pumping by microheater in the cavity with PDMS (poly dimethyl siloxane) membrane and sedimentation by RBCs (red blood cells). The blood plasma separation device was composed of a whole blood inlet, microchannel with sedimentation region, micropump with microheater, and nano/micro pillars. Micropump was designed by ANSYS and CFD-ACE+. A COC (Cyclo Olefin Copolymer) wafer of 125mm size was substrate, upper plate was Pyrex glass with a microchannel. A negative DFR (Dry Film Resist) of 10 $\mu\text{m}$  thickness on the wafer was laminated at temperature of 90 $^{\circ}\text{C}$  and pressure of 5kg/cm $^2$  and developed for 14sec in an aqueous solution of 1w% Na $_2$ CO $_3$ . Gold layer of 0.1 $\mu\text{m}$  thickness is evaporated and patterned as a microheater. Microheater was controlled at a temperature less than 35 $^{\circ}\text{C}$  because of protein damages. Nano/micro pillars with 500nm height and gap are defined and patterned by NIL (Nano Imprint Lithography). It is capped by PDMS

182 film on cavity opening by O<sub>2</sub> plasma treatments. Finally, the substrate is packaged with a glass of microchannel of 10 $\mu$ m deep and 20 $\mu$ m wide. By using this device, cell-free plasma was successfully obtained through the sedimentation region of 1, 2, and 5mm from a drop of whole blood without external force of a syringe pump.

### 6415-39, Poster Session

#### Structural studies of SnS films prepared by thermal evaporation

S. Cheng, Fuzhou Univ. (China)

Tin sulphide films with thickness of 500~1000 nm were deposited on ITO glass substrates at 30~150 $^{\circ}$ C by thermal evaporation. All the films were characterized with X-ray diffractograms, microstructure analysis. It was found that the SnS films were polycrystalline with a strong {111} preferred orientation, and they had orthorhombic crystal structure with a grain size of a few ten nanometers and exhibited near stoichiometric SnS composition. Their lattice parameters were  $a=0.4309\sim 0.4313$  nm,  $b=1.1263\sim 1.1273$  nm,  $c=0.3981\sim 0.3990$  nm which closely resembled those of bulk SnS at room temperature.

### 6415-40, Poster Session

#### Accuracy and limitation of improved Rayleigh-Sommerfeld Method 1 for analyzing the focusing characteristics of cylindrical microlenses with small f-number

J. Liu, Beijing Jiaotong Univ. (China)

In recent years, as the development of micro-scale fabrication, such as the micro-photolithography, laser-beam writing, and electron-beam writing, it is possible to fabricate micro-optical elements with small characteristic size and highly refinement. The micro-optical elements with a sub-wavelength structure are widely used in many areas. Rigorous Maxwell's electromagnetic theory should be adopted to analyze the micro-optical elements with a sub-wavelength structure. Several numerical methods have been presented for rigorously solving Maxwell's equations, for instance, the finite difference-time-domain (FDTD) method, finite-element method (FEM), boundary element method (BEM), boundary integral method (BIM), etc. All these methods are efficient tools in numerical simulations of optical field distributions of the faster focusing micro-lens. However, they require a lot of computer reservoirs in computing times and memories. Thus, an urgent thing for performing optimal design of the faster focusing micro-lens is desirable to seek for simpler and faster, even somewhat less accuracy, design approaches. Various approximate scalar methods, such as the Kirchhoff method, Rayleigh-Sommerfeld method 1, Rayleigh-Sommerfeld method 2, plane wave spectrum method, asymptotic Green's function method, Fresnel method, and Fraunhofer method, etc. have been developed under some assumptions and approximations. However, when the characteristic size of the micro-optical lens is comparable to the wavelength of light, these conventional scalar diffraction methods become inadequate, especially, in the analysis of various cylindrical micro-lens with small f-number less than  $f/1.0$ . Recently, Ye et al. proposed an improved Rayleigh-Sommerfeld method 1 (IRSM1) based on the original Rayleigh-Sommerfeld method 1 (ORSM1). The results calculated by the IRSM1 are very close to those by the rigorous BEM even for the cylindrical micro-lens with moderately small f-number. Moreover, the IRSM1 takes much less computing time and saves computer memory because this method averts from solving complex boundary-integral-equations. In the IRSM1, the boundary fields are approximately evaluated by using the local Fresnel transmission coefficient along the real micro-lens boundary, thus, the intricate global coupling effect among the boundary fields is completely neglected. It is believed that the applicability of the IRSM1 should have certain limitations to some parametric regions. Consequently, it is an interesting and important issue to find the appropriate parametric ranges where the IRSM1 is applicable. In this work, the accuracy and limitation of an improved IRSM1 are investigated by analyzing the focal characteristics of various cylindrical micro-lenses with small f-

numbers in both cases of the TE and TM polarizations. The IRSM1 and ORSM1 are employed to calculate, and their numerical results are compared with the results by rigorous BEM based on the average square-root deviation (ASRD) of the intensity distribution on the focal plane for the continuously refractive microlens and diffractive micro-lenses with continuously varying or 8-level quantized profiles and small f-numbers. The results show that the applicability of the IRSM1 has limitation in some parametric ranges, for instance, the number of sampling points, f-number, relatively refractive index, and wavelength of the incident light are restricted to some appropriate values.

### 6415-42, Poster Session

#### Development of nanostructured titanium-oxide thin films using a gas carving technique

D. Dhawan, Y. M. Sabri, S. K. Bhargava, K. K. Zadeh, D. K. Sood, Royal Melbourne Institute of Technology (Australia)

A method is developed for producing nano-structured titanium oxide thin films using H<sub>2</sub> gas interaction with titanium at a high temperature. These nano-structured thin films have been formed on a quartz crystal substrate. Titanium (Ti) thin films were deposited on the quartz crystal using a RF magnetron sputterer. The samples were placed in the oven at 700 $^{\circ}$ C for 5 hours. The gas mixture of 1% H<sub>2</sub> in N<sub>2</sub> was introduced in the oven. The process of annealing Ti in the presence of H<sub>2</sub> carves Ti films into nano-structure shapes. The process is a gas-solid interaction. Thin films were characterised using Scanning Electron Microscopes (SEM) and X-ray Diffraction (XRD) technique. XRD pattern for Ti shows that the dominant faces are [0, 0, 2], [1, 0, 2] and [1, 0, 3]. After annealing XRD pattern revealed that thin films have changed into rutile form of titanium dioxide. The dominant faces of the rutile form are [1, 1, 0], [1, 1, 1], [2, 1, 1] and [2,2,0]. SEM images showed that the rutile nano-structured thin films consist of nano polygonal shapes. These polygonal have dimensions of less than 150nm.

### 6415-43, Poster Session

#### Fabrication processes of MEMS phase shifters on polymer-based substrates

J. Wang, Y. Cai, T. Ativanichayaphong, W. Huang, L. Hsu, J. Chiao, The Univ. of Texas at Arlington (USA); M. Chiao, The Univ. of British Columbia (Canada)

Phase shifters find wide applications in telecommunications, satellite systems, personal wireless communication systems, radar systems, tracking systems and sensors. Currently, most of high-frequency phase shifters are based on semiconductor active devices that have high insertion losses due to high RF series resistances, and are expensive due to fabrication and assembly costs.

The RF MEMS phase shifter approach of a true-time delay utilizing MEMS switches or a distributed-varactor transmission-line utilizing variable airgap MEMS capacitors, provides much lower insertion losses and consumes lower powers, compared to its semiconductor or waveguide counterparts. Many RF MEMS phase shifters and related applications have been demonstrated on silicon, quartz and III-V compound substrates. The results showed great performance and significance.

In this work, we proposed to build RF MEMS phase shifters on polymer substrates. Polymers provide the advantages of low costs, light weights and low RF losses. Polymers are simple to process and require low thermal budgets, thus compatible with existing IC processes. The polymer fabrication processes do not involve toxic chemicals and this further reduces costs. The polymer substrates can be flexible and conformal to certain surfaces, reducing the complexity of interconnects and system sizes.

In this paper, we presented loaded varactor phase shifters on polymer based substrates. The fabrication procedure consists of 4 photomasks in photolithography to define the coplanar waveguide transmission lines, insulator pads, sacrificial areas and the moveable metal airgaps. The fabrication procedures and their considerations will be discussed in details. Our polymer-based devices were characterized from DC to 26 GHz. The measurements show promising performance and low insertion losses.

## 6415-44, Poster Session

### Multiclass T-ray signal classification via support vector machines

X. Yin, B. W. H. Ng, The Univ. of Adelaide (Australia); B. S. Ferguson, Tenix Corp. (Australia); S. P. Micken, D. Abbott, The Univ. of Adelaide (Australia)

The current research effectively extends the binary classification of SVMs to multiple classes with an application to T-ray pulsed signal recognition. One-against-all and one-against-one methods based on Gaussian and polynomial kernels are used in this paper for comparison. Two T-ray frequency feature components — amplitude and phase are computed for each pulsed response. For training, half of the responses from each class are used as training vectors input to the SVMs, and the remaining half of the responses from each class are used to test the classifier. Leave-one-out estimation is used for validation of the current classifier design. The results show that the one-against-one method, based on a polynomial kernel, has desirable performance characteristics in the multi-class classification of T-ray pulsed responses compared to other methods. Simultaneously, different values of the penalty parameter C are used for the comparison of multi-class classification. Visual classification performance is also shown for two dimensional features, which demonstrates the variety of different parameters- the large margin and the number of support vectors for each class in terms of the different penalty parameters. The current classification algorithm has potential in the realisation of identifying heterogeneous layers within a 3D structure via T-ray tomography.

## 6415-45, Poster Session

### Computational thermal analysis of a continuous-flow micropolymerase chain reaction (PCR) chip

S. Dharmalingam, M. A. Ashraf, L. Kong, Univ. of South Australia (Australia)

The first continuous flow micro PCR introduced in 1998 has attracted considerable attention for the past several years because of its ability to amplify DNA at much faster rate than the conventional PCR and micro chamber PCR method. The amplification is obtained by moving the sample through 3 different fixed temperature zones. In this paper, the thermal behavior of a continuous flow PCR chip is studied using commercially available finite element software. We study the temperature uniformity and temperature gradient on the surface of the chips surface, the cover plate and the microchannels. In this study, we use different combination of materials for the chip body and cover plate. The effect of temperature gradient on the chip is also investigated on the interface of the chip main body and the cover plate to determine the thermal stresses induced by the heating. Further investigation is also conducted to determine the effect of thermal heating on the flow of PCR mixture inside the microchannel for different channel geometry.

## 6415-46, Poster Session

### Fabrication of flexible field emitter using electrostatic layer-by-layer assembled carbon nanotube multilayer film

X. Yan, Z. J. Han, P. C. T. Ha, B. K. Tay, Nanyang Technological Univ. (Singapore)

This paper described a new strategy for fabricating flexible field emitter of multi-walled carbon nanotubes (MWNTs) on organic polymer substrates. Firstly, a thin Ti and Au film was deposited on polymer substrate through plasma immersion ion implantation (PIII) and sputtering, respectively. A self-assembly monolayer of organic molecules (3-mercaptopropylsulfonic acid, MPS) then formed on the gold surface using chemistry assembly. Subsequently, MWNTs wrapped by negatively charged surfactant (sodium dodecyl sulfate, SDS) were homogeneously and stably assembled on MPS-modified Au surface with the layer-by-layer (LBL) method, based on alternative electrostatic interaction of positively

charged polyelectrolyte [poly(diallyldimethylammonium chloride), PDDA] and oppositely charged SDS-functionalized MWNTs. This film growth is uniform, almost with the same coverage of the MWNTs in each layer, and that the assembled MWNTs are mainly in the form of small bundles or individual tubes on the electrodes as revealed by scanning electron microscopy (SEM). The field emission measurement showed that the LBL assembled MWNT films could provide stable, high-current electron emission at a low voltage. The emission current monitored over a period of 12 hours fluctuated gently but did not show degradation. The cathode-luminescence (CL) images captured by a CCD camera were bright and their CL intensity was homogeneous. This remarkable performance, combined with the room temperature and large area process of the MWNT films illustrated with the LBL method, suggests this MWNT films are well suited for commercial use in flexible electronic devices, e.g. display.

## 6415-48, Poster Session

### Textural properties of Fe-SBA-15 nanostructured materials by controlling aging time of hydrothermal synthesis

P. T. Dang, P. H. Nguyen, Vietnamese Academy of Science and Technology (Vietnam); K. Q. Dinh, S. T. Le, Hue Univ. (Vietnam)

Iron-substituted SBA-15 materials (Fe-SBA-15) have been synthesized via a hydrothermal method with in situ incorporation of Fe(III)-oxalate complex under strong acidic conditions. By employing the characterization techniques of XRD, UV-vis, AAS and the physical adsorption of N<sub>2</sub> in combination with  $\alpha$ s-plot method, both the textural properties and coordination environment of iron of Fe-SBA-15 materials with different aging time of hydrothermal synthesis were investigated. As the aging time prolongs over a certain time, the textural properties and amount of Fe incorporated to SBA-15 changed dramatically. The total surface areas increases due to the significant increment in the micropore after the aging time of 24 hours, however, the wall thickness of mesopore and the amount of iron oxide formed in Fe-SBA-15 decline remarkably. The desired textural properties and high amount of Fe incorporated to SBA-15 could be attained by controlling the aging time of synthesized gel.

## 6415-50, Poster Session

### Synthesis, characterization, and catalytic properties of Ti-containing SBA-15 nanostructured materials

P. T. Dang, H. G. Le, T. C. Dinh, D. V. Hoang, Y. Hoang, T. A. Vu, L. H. Bui, H. T. K. Tran, Vietnamese Academy of Science and Technology (Vietnam)

Ti-isomorphously substituted SBA-15 (Ti-SBA-15) samples were successfully synthesized by hydrothermal treatment using P123 as surfactant. The samples were characterized by XRD, BET, SEM, TEM and UV-Vis. The results obtained from XRD, BET and TEM revealed that Ti-SBA-15 samples have meso-structure with pore size of ~100Å. Ti-SBA-15 samples with different Ti-content were tested in the photocatalytic oxidation of red-phenol and in the photocatalytic reduction of Cr(VI) to Cr(III). All Ti-SBA-15 samples were active in both reactions. Effect of Ti-content on photocatalytic activities was discussed. For comparison, Ti impregnated on Si-SBA-15 was also investigated.

## 6415-51, Poster Session

### Photocatalytic oxidation and reduction over some nanosized TiO<sub>2</sub> catalysts

Y. Hoang, L. H. Bui, T. C. Dinh, P. T. Dang, T. A. Vu, Vietnamese Academy of Science and Technology (Vietnam)

Nano-sized TiO<sub>2</sub> samples were successfully synthesized by both methods: sol-gel and hydrothermal treatment. The samples were characterized by XRD and FESEM, TEM. The XRD results re-

vealed TiO<sub>2</sub> samples consisted of pure anatase phase and/or mixture of anatase-rutile phases depending on the synthesis condition and calcination temperature. By SEM-TEM, the particle size of all TiO<sub>2</sub> samples was ca. 20-30nm. Nanosized TiO<sub>2</sub> samples were tested in the photocatalytic oxidation of red-phenol and in the photocatalytic reduction of Cr(VI) to Cr(III). All samples were active in both reactions, however, a difference in photocatalytic activities between samples was observed. For comparison, P25 Degussa was also investigated. Photocatalytic performances of the samples were discussed.

### 6415-52, Poster Session

#### Study on photocatalytic performance of nano- and microstructured materials

T. C. Dinh, Y. Hoang, L. H. Bui, L. K. Le, P. T. Dang, T. A. Vu, H. M. Do, V. Q. Tran, Vietnamese Academy of Science and Technology (Vietnam)

Ti-ZSM-5(TS-1), Ti-SBA-15 and Ti-SBA-15 with the wall of nano-TS-1 were successfully synthesized by hydrothermal treatment. The samples were characterized by XRD, FESEM, TEM, Nitrogen adsorption (BET). Nitrogen adsorption measurements reveal the microstructure of TS-1, nanostructure of Ti-SBA-15 and Ti-SBA-15 with wall of TS-1. The samples were tested in the photocatalytic oxidation of red-phenol and in the photocatalytic reduction of Cr(VI) to Cr(III).

Among TS-1, Ti-SBA-15 and Ti-SBA-15 with the wall of TS-1, TS-1 exhibited much lower activity of photocatalytic oxidation of red phenol (big sized molecule of 8.5 Å). This can be explained the diffusion limitation of redphenol in the micropores of TS-1.

In the photocatalytic reduction of Cr(VI) to Cr(III), all samples were active, however, difference in activities of the samples was observed.

The photocatalytic performances of micro, nano-structured materials in both reactions: photocatalytic oxidation and reduction were discussed.

### 6415-55, Poster Session

#### Methane detection with semiconductor oxide SnO<sub>2</sub> obtained by sol-gel method

G. G. Telipan, Jr., M. M. Ignat, Institutul National de Cercetare (Romania); V. Parvulescu, S. Somacescu, Institute of Physical Chemistry (Romania)

The oxide semiconductor SnO<sub>2</sub> is a n-type semiconductor with a wide band gap of about 3.6eV. At the edge of the conduction band the calculated density of states derived from atomic Sn 5s state, is low. Correspondingly the measured Hall mobility of bulk electrons in single crystals are reasonably high, 80 and 200 cm<sup>2</sup>/Vs at 500K and 300K, respectively. For the improve the selectivity and the sensibility to gases, SnO<sub>2</sub> is generally doped with transition metals, such as Pt, Pd, Ag Additive are able to break C-H bonds of the hydrocarbon at lower temperature than the SnO<sub>2</sub>, decreasing in this way the temperature of CH<sub>4</sub> oxidation and sensing. The conductivity of SnO<sub>2</sub> can be increased by same substitution impurities such: fluorine on an oxygen site or antimony on a tin site, which also act as shallow donors. The SnO<sub>2</sub> was prepared by sol gel method on utilize SnCl<sub>4</sub>x5H<sub>2</sub>O and surfactant cetiltrimetilammonium bromide under a hydrothermal treatment at 80oC for 3 hours and impregnated with SbCl<sub>3</sub>, TiCl<sub>4</sub> and small amount of PdCl<sub>2</sub>. The obtained SnO<sub>2</sub> material was characterized by X-ray diffraction, N<sub>2</sub> adsorption-desorption and SEM electron microscopy. SnO<sub>2</sub> obtained by sol gel method has a high surface area 456 m<sup>2</sup>/g and a pores diameter of 27.8 Å and a high pores volume. The structure is specific of mesoporous materials with a ordinate hexagonal structure.. The sharp pore diameter distribution at about 28 Å indicating the uniform mesoporous structure of SnO<sub>2</sub> obtained by sol gel method.

The sensor consists by a tubular alumina support with the dimensions : &#61542;ext=2,2 mm, &#61542;int=0,8 mm l=6,2 mm, obtained by sintering method. The sensible element was deposited by the support by spin coating method in 200 nm thickness and heat treated at 600oC from 1 hour.

The heater is composed by a coil with 5 coils of KANTAL and introduce inside of the support. The sensor is monted on the sticlotextolit support by the electric contacts and pins. Function temperature of the sensor was 200oC for a alimentation supply of 5V, the resistance in air at the function temperature was 93 K&#61527; which decrease in gases atmosphere. For a range of the debit 36-80,36 ml/min CH<sub>4</sub> were obtained the sensibilities of 44-75% and the response time was 30 seconds.

### 6415-56, Poster Session

#### Control of cohesive-force ordering in organic-inorganic hybrid pillar arrays

H. Segawa, S. Yamaguchi, T. Yano, S. Shibata, Tokyo Institute of Technology (Japan)

Periodic pillar arrays are applicable for various devices such as photonic crystals and sieving matrixes in a microchannel. Most of the arrays are fabricated by lithography. In lithography, it is important to control the capillary force exerted during development and rinse. In this study, organic-inorganic hybrid pillar arrays are fabricated by UV lithography. The pillar formation has been controlled by pillar sizes, arrangements of the pillars and types of rinse solvent.

Organic-inorganic hybrid films, which have photopolymerizable organic groups, were prepared by the sol-gel method. The hybrid films were exposed to UV light through a mask with periodic openings of 5 micrometer diameter. The organic groups were polymerized by the UV exposure, and the solubility of the polymerized portion in n-propanol decreased. After the development by n-propanol, the unexposed portions were removed and the remaining portions were rinsed by n-propanol or water, resulting in periodic pillar arrays.

The pillar formations depend upon the height of the pillars, the distance between neighboring pillars and the types of rinse solvent. Several pillars gather on the top due to self-organization and the top-gathering pillars are arranged with a new larger period. From in situ observation of the drying rinse solvent, it is found that the pillar formations are influenced by the capillary force between the neighboring pillars depending on the pillar size and arrangement, and the surface energy at the three-phase-line of a pillar. Top-gathering pillars are partially formed in a homogeneous periodic pillar array by controlling the surface energy.

### 6415-57, Poster Session

#### Fabrication of inexpensive metallic mould for nanoimprinting using colloidal monolayers as a nanomask

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Nanotechnology is looking for ways to generate periodic nanostructures of high quality at a cheaper and faster rate. The current method for making nanoscale patterns mostly involves electron-beam lithography, which is expensive and time consuming, and thus makes it a difficult proposition for both industrial and research applications. In this paper, we demonstrate a technique to fabricate nanostructure in an inexpensive way. A layer of polystyrene (PS) beads (660 nm diameter) was formed using Longmuir-Blodgett technique to get monolayers on silicon substrate. This layer acted as a nano mask to generate regular array of metallic nano structures. The gap (~100 nm), created between the aligned PS beads, was used to deposit metals like Cr, Al, and Au using sputtering process. The thickness of deposited metal was varied to achieve varying height of the structures. Removal of the PS beads was done using di-chloromethane. Silicon substrate along with the regularly aligned metallic nano structure (approximated by an equilateral triangle of side 100 nm) thus formed, acted as a metallic mould for nanoimprinting. The pattern was imprinted on a thin polymer layer, and was analyzed. The nano cavities created on the polymer layer were found to replicate the original pattern accurately. Spot lithography was used to create arbitrary shaped (rectangles and squares), but orderly arranged cluster of nanoparticle array. These regular nano pattern generated are of good quality and has apparent application in photonic crystal formation and other nano application.

### 6415-58, Poster Session

#### Pattern transfer over extreme topographies using a SU-8 leveling process

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In micromachining, there is a growing interest in pattern transfer over extreme topographies. The ability to pattern a sputtered layer on the bottom of an etched recess, tens to hundreds of micrometers deep, or to make an electrical connection from the bottom to the top of such a recess improves the manufacturing abilities of any micromachining facility significantly.

Most pattern transfer techniques used today are based on spin or spray coating of photoresist. However, this often leads to an unreliable coating near the top edge of deep pits, especially when steep sidewalls are present. The reason for this is twofold: gravity that pulls the resist down, and surface tension that tends to pull it back from corners.

When etching a conductive surface, using electroplated resist is an option. However, this is not available widely.

In contrast, the procedure developed in this work can be implemented with completely standard micromachining equipment and also works on non-conductive layers. It relies on ultra-thick high aspect ratio resist su-8 to fill up deep pits completely, using a modified spin coating procedure. A process is demonstrated that allows 25  $\mu\text{m}$  wide metal connections from the bottom to the top of a 250  $\mu\text{m}$  isotropically etched pit to be made, thus demonstrating laying connections over near-90 degrees sidewalls.

### 6415-59, Poster Session

#### A new technique for preparing PSG film using rf magnetron sputtering

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Phospho-silicate-glass (PSG) films have a variety of applications in the fabrication of microelectronic devices and MEMS. APCVD, LPCVD and PECVD are commonly used techniques for preparing PSG films.

In the present work, we report a new technique for preparing PSG films using RF magnetron sputtering process. The RF sputtering has several advantages over CVD techniques as no toxic and pyrophoric gases ( $\text{SiH}_4$ ,  $\text{PH}_3$  etc.) are involved in the deposition process and the films can be prepared for rapid prototyping of devices in small volumes with minimal infrastructure.

For the sputtering process, a 75 mm diameter target of phosphorus-doped silicon dioxide was prepared by conventional solid-state reaction route using  $\text{P}_2\text{O}_5$  and  $\text{SiO}_2$  powders. Since  $\text{P}_2\text{O}_5$  is hygroscopic in nature, special care was taken to prevent lump formation due to moisture incorporation during the target making process.

The PSG films were prepared in a RF (13.56 MHz) magnetron sputtering system at 300-watt RF power, 20-mtorr pressure, and 45 mm target-to-substrate distance without external substrate heating. The thickness, refractive index ( $n$ ) and the absorption coefficient ( $k$ ) of the films were measured using a thin-film analyzer (Filmetric F20).

To confirm the presence of phosphorus in the deposited films, several experiments were performed. PSG films of 1  $\mu\text{m}$  were deposited on p-Si substrate followed by drive-in at 1100  $^\circ\text{C}$  in  $\text{N}_2$ . The hot-probe test and the sheet resistance measurements confirmed the diffusion of phosphorus in silicon from the PSG films. Finally, a p-n diode was fabricated using the sputtered PSG film as a diffusion source of phosphorus in a p-type wafer. The characteristic I-V curve of the diode under forward and the reverse bias conditions further confirmed the incorporation of phosphorus in the films prepared. The etch rate of the PSG film in buffered HF was measured to be about 10 times as compared to films sputtered from an undoped  $\text{SiO}_2$  target under identical conditions. This meets the requirement of sacrificial layer in MEMS fabrication.

### 6415-60, Poster Session

#### Adhesive wafer-to-wafer bonding using contact imprinting

L. Yu, National Univ. of Singapore (Singapore) and Institute of Bioengineering and Nanotechnology (Singapore); A. J. Pang, B. Chen, Institute of Bioengineering and Nanotechnology (Singapore); F. E. H. Tay, Institute of Bioengineering and Nanotechnology (Singapore) and National Univ. of Singapore (Singapore); C. I. Iliescu, Institute of Bioengineering and Nanotechnology (Singapore)

This paper proposes a contact imprinting bonding technique at wafer level using SU-8 negative photoresist as intermediate layer. SU-8 is selected as adhesive layer for its flexibility of layer thickness up to several hundreds of micrometers, its high chemical and thermal stability as well as its good mechanical properties. The method consists of three steps: first SU8 negative photoresist was deposited on a large silicon wafer; then the SU8 adhesive layer was transferred from the surface of a Teflon cylinder to the functional wafer surface; finally, the wafers to be bonded were aligned and performed at temperatures between 100 $^\circ\text{C}$  and 200 $^\circ\text{C}$ , a pressure of 2000 N in vacuum on a classical wafer bonding system. The bonding process presents a high yield, in the range of 95% to 100% and shear strength in the range of 18-25 MPa. The main advantages of the method are: low cost, high yield, low bonding temperature, low stress induced by the bonding process. The method is suitable especially when the classical spinning method cannot be performed due to the surface topography or device functionality. The bonding process was successfully tested for fabrication of microfluidic channels of bioMEMS devices.

### 6415-61, Poster Session

#### Nanosphere lithography using thermal evaporation of gold

B. S. Flavel, J. G. Shapter, Flinders Univ. (Australia); J. S. Quinton, Flinders Univ. of South Australia (Australia)

Nanosphere lithography, which allows for the fabrication of patterned metal surfaces, is a simple, effective and unconventional technique that exploits a self-assembly process. Using this technique, polystyrene nanospheres with diameters of 500nm, and 1 $\mu\text{m}$  were assembled onto a 'muscovite' mica substrate in a hexagonally close packed monolayer array, to provide a physical mask for material deposition. Thermal evaporation was subsequently used to deposit gold through the nanosphere mask layer, to generate a periodic array of gold nanostructures. Upon changing the mask to a multi-layered array of nanospheres, slightly more complex nanostructures were achieved. However due to thermal evaporation being a high temperature process the nanostructures obtained deviated from their predicted quasi triangular shape due to a slight annealing of the polystyrene mask.

### 6415-62, Poster Session

#### Analysis of the sharp increase in the specific heat of single-wall carbon nanotube ropes due to the absorption of helium atoms in the temperature range 2-20 K

Recent experimental results [1] on the specific heat measurements in single wall carbon nanotube (SWNT) ropes show that its specific heat gets increased by a factor of 2 to 2.5 in the temperature range 2-20 K when Helium-4 is allowed to be adsorbed. Beyond 20 K there is hardly any effect of the adsorption on the specific heat of SWNT ropes. Making use of the unfolding technique [2] to obtain the frequency distribution function (FDF) of the dynamical modes from the observed experimental temperature variation of the specific heat and a trial phonon FDF, the observed temperature variation of the specific heat can be explained in the temperature range 2-20 K within 16% of the experimental values. For 20  $\geq T \geq 300$  K, the agreement between computed and calcu-

lated values is within 6% at most of the temperature values. The phonon FDF of the adsorbed SWNT ropes is quite different from that when there is no adsorption, particularly for energies less than 200 K. The most significant feature is the appearance of large number of modes at 15 K.

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### 6415-63, Poster Session

#### A new disposable MEMS-based manometric catheter for in-vivo medical tests

M. Teng, A. J. Hariz, H. Hsu, Univ. of South Australia (Australia)

This paper reports on the development of a new disposable manometric catheter for diagnosis of functional swallowing disorders. The function of this catheter is to measure the intrabolus and peak pressure occurring along the esophageal tract during the swallowing process. Traditionally, the hospital used the water perfusion technique to diagnose the disorder<sup>1</sup>. Disadvantages of this type of catheter are an increased risk of inhaling water into the airways and the pressure reading is difficult to record accurately by an external sensor due to movement artefacts, baseline drift and hydraulic dampening of pressure signal<sup>2</sup>. Current manometric catheters developed elsewhere use a solid state pressure sensor mounted directly on a thin catheter to measure the pressure changes. The advantages of this type of catheter are that it reduces the discomfort to the patient and records accurate pressure readings. Both types of catheters are reusable due to the high running cost<sup>3</sup>, and this in turn increases the risk of contamination among patients, and create hygiene problems. On the other hand, MEMS-based sensors are known to perform well in stability and linearity together with the advantages of low required biasing voltage, extremely small size, and low production cost. This has made the MEMS based pressure sensors excellent candidates for use in the new generation of a low cost and disposable manometric catheters in medical diagnostic tools<sup>4</sup>. We have developed a new disposable manometric catheter which consists of a MEMS-based pressure sensor, a sensor carrier PCB, a medical grade silicon catheter tube and an external data connector. Recent laboratory characterisations and hospital in-vivo testing show the new developed low cost disposable catheter prototype capable of measuring pressure ranges of 0 to 100mmHg. The in-vivo tests have also shown the new catheter prototype capable of measuring peak pressure as well as the intrabolus pressure which is a very important parameter for the doctor to carry out the required diagnosis<sup>5</sup>. These promising results confirm the potential for commercialisation of the developed low cost and disposable manometric catheter which would eventually solve the hygiene problem and increase the accuracy of the diagnosis. We will report on the latest test results and findings.

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### 6415-64, Poster Session

#### Optimization of wireless and batteryless power transmission for micro implants in-vivo environments

V. J. Baxi, A. J. Hariz, Univ. of South Australia (Australia)

For quite some time implantable electronic devices have been a topic of intense research. Such devices play a vital role in saving lives. Batteries were used to power the micro implants in the body, and the quest has been to realise long life batteries. However, the battery size and limited lifetimes have fueled the search for more practical alternatives<sup>1</sup>. Hence the concept of Transcutaneous Energy Transmission (TET) has become a major aim of research in microtechnology for supplying power to micro implants. Among many other endeavors, research to optimize the efficient wireless power transmission to implants<sup>2</sup>, thereby increasing lifetime of the implant and the comfort of the patient, has never been more intense.

In this paper we propose to present research findings related to determination of parameters for optimal design of the power transmission system, including frequency spectrum, orientation, and component sizes. We will particularly focus on optimization of coil design. Coil design is critical to efficient power transmission and data reception. We will look at the spiral and planar geometries<sup>3</sup>, coupling factor, mutual inductance of the coil, quality factor Q, and optimal distance between transmitter and receiver units. We will also carry out frequency and time domains analyses for bidirectional transmission. The power received is processed for rectification and regulation by the power control unit. These will also be looked at for compactness, heat dissipation, and integration.

Electromagnetic simulation will be carried out using 'Agilent Momentum' simulation tool for integrated inductor design<sup>4</sup>. It will give us an estimation of the coupling efficiency of the coil and power efficiency of the link at specified design geometries. Analysis will be done on magnitude of induced voltage with respect to change in operating distance as well as change in lateral and angular misalignments. Electromagnetic compatibility and interference will also be investigated and provision for minimizing stray radiation will be implemented.

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### 6415-65, Poster Session

#### Deformable grating modulator array for use as wavelength-selective switch

A. Pothisorn, A. J. Hariz, Univ. of South Australia (Australia)

Dense wavelength-division multiplexing (DWDM) is the technique of carrying multiple wavelengths on a single fibre to increase optical bandwidth<sup>1</sup>. Traditional DWDM systems use optical-electrical-optical (OEO) conversions at switching points. OEO switches have some disadvantages such as cost, high power consumption and delay<sup>2</sup>. All-optical or OOO (optical-optical-optical) switches, when successfully implemented, have the potential of handling complex optical routing situations and dealing with thousands of inputs and outputs. MEMS technology brings about the means of realising and volume manufacturing of all-optical micro switches.

The field of micro opto electromechanical systems (MOEMS) has



already spawned several micro devices for use in optical applications, including lenses, mirrors, waveguides, and gratings. A dispersive element has the functionality of separating input DWDM signal into its component wavelengths. To achieve this goal, an array of deformable grating light modulators is proposed. Arrays of grating light modulators are currently being developed for display applications 3,4. On the other hand, their use in DWDM applications has the potential of bringing high speed operation, low power consumption and good alignment sensitivity. We thus propose to develop a novel dispersive system for the purpose of realising the ubiquitous wavelength-selective switch. The possibility and limitation of integrating the grating light modulator array into wavelength-selective subsystem will also be examined. Numerical simulations are also being carried out to support experimental results.

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### 6415-66, Poster Session

#### **Optical and micro-structural investigations in nanostructured doped PT and PZT piezoceramics**

E. E. Dimitriu, REGO COM SRL (Romania); M. Sima, V. Ghiordanescu, National Institute for Materials Physics (Romania); R. Ramer, Univ. of New South Wales (Australia); G. V. Aldica, National Institute of Materials Physics (Romania)

An optical method for qualitative information concerning the electronic transitions in non-transparent piezoceramic materials is presented. The method is applied for investigation the electronic transition of poled lead titanate and lead titanate zirconate ceramics doped with rare earth and transitional elements, prepared by the oxide technique. The reflection spectra recorded in visible region have evidenced the presence of titanium, manganese and nickel ions in various oxidation states. Similarly, modifications of oxidation state of the additives in rare earth doped PT ceramics are confirmed by energy dispersive X-ray measurements. Inhomogeneities in the distribution of the elements concentration on the surface of piezoceramic samples, have also been reported. The electrical resistivity of a PZT relaxor material, investigated in the temperature range 20 - 500K, has revealed a metallic non-linear dependence of resistivity as a function of temperature.

### 6415-67, Poster Session

#### **Analysis of AlN/GaN quantum dots: coupled effects**

R. V. N. Melnik, D. R. Mahapatra, Wilfrid Laurier Univ. (Canada)

We consider a general three-dimensional model for the analysis of physical properties of AlN/GaN heterojunctions. The model couples in a consistent manner a multiband Schrodinger model with the Poisson equation for the electric field, and the piezoelectric effect is taken into account by coupling the electric displacement to the mechanical strain in the structure via electro-mechanical constitutive relationships. We present results on the influence of mechanical strain and boundary conditions on the bandstructure calculation, including nonlinear situations. Further, for quantum dot structures, we analyze in detail conduction and valance band energies as functions of strain and electric potential.

# Conference 6416: Biomedical Applications of Micro- and Nanoengineering III

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## 6416-01, Session 1

### DNA-sensors based on functionalized conducting polymers and quantum dots

C. Soeller, H. Peng, T. Kjällman, J. Travas-Sejdic, Univ. of Auckland (New Zealand)

The availability of rapid and specific biosensors is of great importance for many areas of biomedical research and modern biotechnology. This is especially true for DNA sensors where the progress of molecular biology demands routine detection of minute concentrations of specific gene fragments. Current DNA essays are often multiple step procedures that require sample labelling and complex readout methodologies. These drawbacks might be overcome by utilizing novel smart materials, including conducting polymers and nanostructured materials such as quantum dots.

We have constructed a number of DNA sensors based on smart materials that allow rapid one-step detection of unlabeled DNA fragments with high specificity. These sensors are based on functionalized conducting polymers derived from polypyrrole (PPY), polythiophene (PTP) and poly(p-phenylenevinylene) (PPV). PPY and PTP based sensors provide intrinsic electrical readout via cyclic voltammetry and electrochemical impedance spectroscopy. We show that the use of nanoparticle labelled probes can further amplify the response of these sensors enabling detection of specific fragments in the picomole range. Complementary to these electrical sensors we have developed several novel optical DNA essays based on PPV derived cationic conducting polymers. DNA detection in these devices results from sample dependent fluorescence quenching of the novel PPV derivatives synthesized in our laboratories. Initial devices employed organic fluorochromes as quenchers or fluorescence transfer partners. We have also functionalized core shell quantum dots and have used these to make hybrid conducting polymer-nanoparticle sensors. We will present results from these sensor technologies and compare sensitivities as well as the effects of different functionalization strategies on sensor performance.

## 6416-02, Session 1

### EB induced wetting of polypropylene surface

H. Sato, T. Shimmi, K. Iwata, M. Kanda, A. Tonegawa, Y. Nishi, Tokai Univ. (Japan)

Effect of electron beam (EB) irradiation on wettability was studied for polypropylene for Biomedical Application. The EB irradiation enhanced the wettability on polypropylene samples. To discuss the effect of EB irradiation on wettability, the wettability was evaluated by using contact angle of sessile drop. Contact angle decreased when EB irradiation increased. Based on ESR results, the effects of electron beam on the wettability were discussed. EB irradiation broke the weakly bonded pairs and formed the dangling bonds in polypropylene.

## 6416-03, Session 1

### Diffusion of polymeric chains in nano-confined spaces

P. J. Livingston, R. Boysen, D. V. Nicolau, Monash Univ. (Australia)

No abstract available

## 6416-04, Session 2

### Fluorescent intensity-based differential counting of FITC-doped silica nanoparticles: applications of CD4+ T-cell detection in microchip-type flowcytometers

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Although CD4+ T-cells are an important target of HIV detection, there have been still major problems in making a diagnosis and monitoring in the third world and the region with few medical facilities. Then, it is necessary to use portable diagnosis devices at low cost when you put an enumeration of CD4+ T-cells.

In general, the counting of CD4 below 200 cells/micro liter makes it necessary to initiate antiretroviral treatment in adults (over 13 years old). However, lymphocyte subsets (including CD4 counts) of infants and young children are higher than those of adults. This fact shows the percentage of CD4+ T-cells of blood subsets, i.e., CD4/CD45%, CD4/CD8% or CD4/CD3% means a more reliable indicator of HIV infection than absolute counts in children.

To know the percentage of CD4+ T-cell by using two fluorescent dyes of different emission wavelength, at least, one laser and two PMT detectors are in general needed. Then, it is so hard to develop a portable device like a 'toaster size' because this makes such a device more complex including many peripheral modules.

In this study, we developed a novel technique to control the intensity of fluorescent dye-doped silica nanoparticles. I synthesized FITC-doped silica nanoparticles conjugated CD4 antibody 10 times brighter than FITC-conjugated CD45 antibody. With the difference of intensity of two fluorescent dyes, we measured two parameters by using only a single detector and laser. Most experiments were achieved with MicroFACS (microfabricated fluorescence-activated cell sorter) on an inverted microscope (IX71, Olympus).

In conclusion, this method enables us to discriminate the difference between CD4 and CD45 in an intensity domain simultaneously. Furthermore, this technique would make it possible develop much cheaper and smaller devices which can count the number of CD4 T-cells.

## 6416-05, Session 2

### Switchable surface coatings for control over protein adsorption

M. A. Cole, Univ. of South Australia (Australia); N. H. Voelcker, Flinders Univ. (Australia); H. W. Thissen, Commonwealth Scientific and Industrial Research Organisation (Australia); R. G. Horn, H. J. Griesser, Univ. of South Australia (Australia)

Control over biomolecule interactions at interfaces is becoming an increasingly important goal for a range of scientific fields and is being intensively studied in areas of biotechnological, biomedical and materials science. Improvement in the control over biomolecules is particularly important to applications such as arrays, biosensors, tissue engineering, drug delivery and 'lab on a chip' devices. Further development of these devices is expected to be achieved with thin coatings of stimuli responsive materials that can have their chemical properties 'switched' or tuned to stimulate a certain biological response such as adsorption/desorption. Switchable coatings show great potential for the

realisation of spatial and temporal immobilisation of cells and biomolecules such as DNA and proteins.

This study focuses on protein adsorption to coatings of the thermosensitive polymer poly(N-isopropylacrylamide) (pNIPAM) which can exhibit low and high protein adsorption properties based on its temperature dependent wettability. At temperatures above its lower critical solution temperature (LCST) pNIPAM is collapsed and protein adsorbing whilst below the LCST it is hydrated and protein repellent.

Coatings of pNIPAM on silicon wafers were prepared by free radical polymerisation and surface initiated atom transfer radical polymerisation (ATRP). Surface analysis was carried out using X-ray photoelectron spectroscopy, contact angle measurement and ellipsometry.

Protein adsorption was investigated using a quartz crystal microbalance, time of flight secondary ion mass spectrometry and colloid probe atomic force microscopy. This study is expected to aid the development of stimuli-responsive coatings for biochips and biodevices.

## 6416-06, Session 2

### Low-frequency vibrational modes of biologically important isomers

I. Jones, T. J. Rainsford, B. M. Fischer, D. Abbott, The Univ. of Adelaide (Australia)

Being able to distinguish between different isomers of a particular molecule is very important in various fields of science such as biology, medicine and also the pharmaceutical industry. For example, retinoids, a class of chemical compounds that are related to vitamin A, play an important role in vision, bone growth, in the treatment of skin lesions and acne, and as chemotherapy for certain types of leukemia. Many different geometric isomers of retinol, retinal and retinoic acid are possible as a result of either a trans or cis configuration of the four C=C double bonds found in the polyene chain. Terahertz Time-Domain Spectroscopy (THz-TDS) is a suitable technique for the investigation of biologically important molecules since rotational and vibrational transitions of such molecules lie in the far- and mid-infrared spectral ranges. It has been shown that the location and intensity of vibrational modes are highly sensitive to the conformation and structure of a molecule. An a priori knowledge of the expected THz spectra enables the comparison of theoretical and experimental data and allows for improved experimentation through the interpretation of data. Our results on a variety of different retinoids show the potential of both THz spectroscopy and of computational chemistry for studying of biologically important molecules.

## 6416-08, Session 2

### Enzyme electrodes immobilized on hetero-structured metallic nanowire array for glucose sensing

H. Yoon, D. Deshpande, R. R. Chintakuntla, V. K. Varadan, Univ. of Arkansas (USA)

The fabrication of hetero-structured vertically aligned nanowire arrays and enzyme immobilization on their surface are presented for a glucose sensor with high sensitivity. Hetero-structured nanowires of gold and platinum are fabricated by hybrid polycarbonate membrane assembly and electrochemical deposition processes and glucose oxidase are attached on their surface by covalent immobilization. The performance of sensors is initially measured amperometrically with the p-benzoquinone mediator. Subsequently hetero-structured nanoelectrodes with enzyme are evaluated to detect hydrogen peroxide produced in the enzyme reaction without the need for the artificial redox mediator. In addition, current behavior is compared with various scan rates corresponding diffusion layer overlap of nanowire electrodes with neighboring nanowires.

## 6416-09, Session 2

### Binding of mouse immunoglobulin G to polylysine-coated glass substrate for immundiagnosis

S. K. Vashist, Univ. of Genoa (Italy)

We report a method for immobilizing mouse immunoglobulin G (IgG) on polylysine-coated glass substrate for biomicroelectromechanical systems (BioMEMS) based immunodiagnostic applications. Mouse IgG molecules were immobilized on polylysine-coated glass substrate employing 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC) and protein A. The amino groups of the polylysine-coated glass slide were cross linked to the carboxyl groups of protein A employing EDC crosslinker. Protein A was employed as it binds to the constant Fc region of antibodies keeping their antigen binding sites on the variable Fab region free to bind to antigens. The qualitative analysis of surface immobilized mouse IgG was done by fluorescent microscopy employing fluorescein isothiocyanate (FITC) labelled mouse IgG molecules. The immobilization densities of protein A and mouse IgG were determined by 3, 3', 4, 4'-tetramethyl benzidine (TMB) substrate assay employing horse radish peroxidase labelled molecules and were found to be 130 ng/cm<sup>2</sup> and 596 ng/cm<sup>2</sup> respectively. The biomolecular coatings were analyzed by atomic force microscopy (AFM) and were found to be uniformly coated.

## 6416-10, Session 3

### Development of blood extraction pump by shape-memory alloy actuator for bio-MEMS

K. Tsuchiya, Y. Shimazu, Tokai Univ. (Japan); Y. Uetsuji, E. Nakamachi, Osaka Institute of Technology (Japan)

In actuator capabilities of a blood extraction, a quick response, a high output power and a highly precise deflection of the smart material actuator for the blood extraction micro pump are prerequisite for a precise control of the amount of blood extraction. In Bio-MEMS fields, the development of a micro pump driven by an electromagnetic power, a piezoelectric element, electrostatic power and a shape memory alloy (SMA) such as a smart material type and a vacuum type, are investigated. However, the piezoelectric micro pump has a slow extraction speed. On the other hand, a vacuum type micro pump can extract blood very fast, however, it cannot deliver a drug as a drug delivery system(DDS).

In this research, we focus on the development of SMA type micro pump to extract blood by negative pressure generated in extraction chamber using SMA. Because, SMA shows high work output per unit volume, high power to mass ratio and the capability of being driven without high applied electric fields. In this research, the most significant factors in the factors of a needle length, an inner and an outer diameter, numbers of cuts for the SMA disk are optimized by using the experimental design method, which can estimate priority factors from a comparatively small number of experiments are investigated. In the design of factors for the SMA type micro pump, a reduction of the inner and outer diameter of the needle, the blood extraction volume and extraction time are effective factors in order to mitigate a burden of diabetic patients. The effect of the length of the needle, and especially the inner diameter of the needle showed 50% of contributing rate contribution for blood extraction volume.

## 6416-11, Session 3

### Compensation of nonlinearities in a piezoelectric Stack actuator with application in intra-cytoplasmic sperm injection

A. S. Putra, K. K. Tan, T. H. Lee, S. K. Panda, S. Huang, S. Zhao, National Univ. of Singapore (Singapore)

A method for nonlinearities compensation using augmented linear control for a piezoelectric stack actuator is presented in this

paper, with its application in intra-cytoplasmic sperm injection (ICSI). The linear control, realized via a PID control, is enhanced by a chatter PWM-like signal with variation of duty cycle as well as direction (sign), with constant magnitude and period. The main idea is to augment the PID control signal, which does most of the feedback control, in a low hassle manner by increasing or decreasing the signal energy via the chatter signal, which does most of the nonlinearities compensation. The variation of duty cycle and direction (whether increasing or decreasing) is updated via an iterative learning technique, taking into consideration the repetitive motion required in the ICSI application. This device is used for assisting oocyte penetration during ICSI process, where the actuator is required to drive a needle, containing a sperm cell, to penetrate an oocyte and then inject the sperm into the oocyte. This technique is able to satisfy the requirements of the process, where a highly-precise motion is mandatory.

### 6416-12, Session 3

#### Development of the new shape PZT ceramics sounder suitable for a sound source of artificial larynx

K. Ooe, R. Kanetake, A. Tanaka, Y. Sugio, Ritsumeikan Univ. (Japan)

Various speech production substitutes, which aim to reconstruct speech functions, have been developed and used practically by speech impaired individuals. However, conventional speech production substitutes have various drawbacks; therefore, perfect speech production substitutes are expected to be developed. We focused on the PZT ceramics sounder as a sound source in an electric drive artificial larynx.

We first developed the artificial larynx that uses a PZT ceramic sounder and then evaluated its performance. The vocalized sound of the artificial larynx user shows good characteristics at the formant frequency, which is important for vowel discrimination. The characteristic feature of our artificial larynx is its individual structure, and this typical structure implies that the sound source and the implant are separated. This structure facilitates a high biocompatibility in our artificial larynx. In our previous work, the improvement in the acoustic characteristics of the sound source was described. The improvement is achieved by the optimization of the electric control and its structure.

In this paper, we present the results of shape optimization and new shape PZT ceramics sounder evaluation. The optimized shape is decided on FEM analysis, and prototype PZT ceramics sounder based on above analysis is manufactured by way of trial. Additionally, the performance of prototype sounder is evaluated by acoustic analysis.

Until now, we have researched about the immobilization of biomolecules onto the metal surface. It is believed that biomolecular immobilization on the sound source surface improves its biocompatibility. In the future, we aim to realize implantable sound sources that employ biomolecular immobilization technology.

### 6416-14, Session 3

#### Development of a blood vessel searching system for HMS device

T. Kuroda, Osaka Institute of Technology (Japan); T. Uenoya, Advanced Software Technology & Mechatronics Research Institute of Kyoto (Japan); Y. Uetshiji, E. Nakamachi, Osaka Institute of Technology (Japan)

In this study, an automatic blood vessel searching system (BVSS) is newly developed, which is built in the Health Monitoring System (HMS) and the drug delivery system (DDS) to extract the blood, evaluate the blood sugar level and inject the insulin for the diabetic patients. Main subjects of this BVSS development are 1) a transmittance photo imaging of the finger by using the LED light as a near-infrared light source with peak wave length of 870 nm, and 2) an image processing to detect the location of the center of blood vessel.

Images of a finger, which include the blood vessels, were monitored using a CCD camera. A light source is set in the opposite site. A template defined by using quadratic function was matched to raw pictures in order to extract vessel images. The analyzed information led to estimation of the location of the center of blood region precisely.

To estimate the depth of blood vessel, the lens focal method was applied to the BVSS. To confirm the possibility of the method, we carried out experiments using blood vessel phantoms that consist of a cylindrical blood region (Teflon tube) and skin tissue (silicone rubber). The blood region was 0.6 mm in diameter and filled with human blood. The phantoms was embedded in the skin with the different depth (0.9~2.9mm). The experimental results of the estimated depth by our image processing show good estimates with the given depths. The given depth, and the availability of BVSS is confirmed.

### 6416-15, Session 4

#### Active control for droplet-based microfluidics

N. Nguyen, T. Teck-Hui, Y. F. Yap, W. Teck Neng, C. Chee Kiong John, Nanyang Technological Univ. (Singapore)

We used thermal control to actively manipulate aqueous droplets in microchannels. Control of droplet size during the formation process and splitting process was demonstrated. Furthermore, droplet switching can be achieved with the same concept. Numerical simulation using a two-dimensional model agrees qualitatively with the experimental results. The used control temperature of less than 55°C shows that this active control concept is suitable for biochemical applications. Thermal control promises to be a simple and effective manipulation method for droplet-based lab on a chip.

### 6416-16, Session 4

#### Novel microfluidic device for cell characterization by impedance spectroscopy

C. I. Iliescu, Institute of Bioengineering and Nanotechnology (Singapore); D. P. Poenar, Nanyang Technological Univ. (Singapore); K. J. Leck, Institute of Bioengineering and Nanotechnology (Singapore); M. Carp, Nanyang Technological Univ. (Singapore); A. J. Pang, F. C. Loe, Institute of Bioengineering and Nanotechnology (Singapore)

This paper presents an original fabrication process of a glass-based microfluidic device that has been applied for impedance spectroscopy measurements of cell suspensions. This is a novel contribution which is valuable due to its usefulness as an element in lab-on-a chip type of realizations.

The fact that the device is glass-based provides a few key advantages: a wider frequency range for impedance spectroscopy measurements (due to the good isolation properties of the substrate), optical transparency and hydrophilic surface of the microfluidic channel which is actually etched in the bottom wafer. Having a hydrophilic surface is especially important as it enables direct sample suction into the microchannel due to capillarity forces only. Thus, no external pumping is required and only a small volume sample suffices for the measurement.

Furthermore, the originality of the device also results from the usage of the following fabrication methods which hitherto have found little or no usage in standard processing:

- 1) Etching inlet/outlet and via holes through the top glass die using a low stress multilayer composite mask. The results obtained using this type of multilayer mask in such a wet etching process are, to our knowledge, the best reported in literature.
- 2) Developing and applying an original spray coating-based photolithographic method. This was used to pattern the electrodes on top of the microfluidic channel after it has been etched in the glass wafer, as well as the intermedial polymer layer;

3) Wafer-to-wafer bonding by employing a very thin adhesive intermediate layer of polymer (e.g. parylene or SU8) applied selectively by means of an innovative contact imprinting method.

Finally, various realized devices with three different electrode geometries were all successfully tested using DI water, and suspensions of dead and live yeast cells. Clear differences between dead and live cells have been observed.

## 6416-17, Session 4

### An electromechanical filter for bioparticles trapping

C. I. Iliescu, G. Xu, Institute of Bioengineering and Nanotechnology (Singapore); F. E. H. Tay, Institute of Bioengineering and Nanotechnology (Singapore) and National Univ. of Singapore (Singapore); P. L. Ong, Institute of Bioengineering and Nanotechnology (Singapore)

This paper presents chip-filter with a structure similar to a classical capacitor made from stainless steel meshes and bonded on both sides of a glass frame. Round silica beads are contained within the glass frame and solution with suspended particles is made to flow through this filter. The double filtration actions derived from mechanical and dielectrophoretic means had been tested with yeast cells and had achieved a maximum trapping efficiency of about 75% from an initial concentration of 5x10<sup>5</sup> cells/ml. This was done at an applied voltage of 200 V and a flow rate of 0.1 ml/min.

## 6416-20, Session 5

### Detection of inorganic ions on a capillary electrophoresis microchip using a conductivity technique

Y. Zhu, K. Petkovic-Duran, Commonwealth Scientific and Industrial Research Organisation (Australia)

Microchip-based electrophoretic separation systems are essential components in the development of fully integrated micro total analysis systems and have gained dominance over chromatographic separation techniques. In this paper, a miniaturized analytical system for separating and detecting inorganic ions is described. The system was based on a polymethylmethacrylate (PMMA) capillary electrophoresis (CE) chip and a contactless conductivity detector, both being developed at CSIRO Microfluidics Laboratory, Highett, Melbourne, Australia. The PMMA chip was fabricated using the soft lithography technique in conjunction with nickel plating and hot embossing. The detector was based on the sensing of conductivity change. The two sensor electrodes were fabricated on a PCB board using the standard photolithography method and the sensor board was attached on the separation chip bottom surface without contacting the liquid. The thin capping layer (20 micron) of the chip allowed for sensitive detection of conductivity change. The mobility of the PMMA chip was measured prior to the separation experiments. The system was demonstrated to separate 50 micro molar potassium, sodium and lithium ions in a 20mM MES/His buffer. Such a system offers great promise to be integrated into robust handheld devices for in-situ monitoring of chemical and biological samples with high speed, reliability and low costs.

## 6416-21, Session 5

### Capillary flow in polymer microfluidic chips

Y. Zhu, K. Petkovic-Duran, Commonwealth Scientific and Industrial Research Organisation (Australia)

Disposable polymer microfluidic chips have been used more and more in analytical devices due to low fabrication costs. The surface of the polymers often needs to be treated to enable passive pumping of liquids. This study investigated the characteristics of capillary flow in polymer microchips with multiple enclosed channels under different surface conditions and the aim was to understand how the surface property could affect the capillary flow over the shelf life of the chips. The microfluidic chip was made of

Polydimethylsiloxane (PDMS) and fabricated using a soft lithography technique. Multiple channels were used and all channels were connected to the same inlet and outlet ports. All channel surfaces were treated using oxygen plasma and the treatment duration time varied. The flow pattern and velocity were measured by visualization and micron Particle Imaging Velocimetry (MicroPIV) methods. It was found that the flow behavior agreed reasonably with the theory by Washburn (1921). The flow advancing velocity for a freshly treated chip could reach over 4mm/s and it varied significantly with time and channel conditions. The results on a polymethylmethacrylate (PMMA) chip were also presented. This study provided useful data for the design of microfluidic chips with passive means of liquid pumping.

## 6416-22, Session 5

### Blood flow assessment during heart valve testing based on MRI procedure using optical flow analysis

K. K. L. Wong, J. Mazumdar, D. Abbott, The Univ. of Adelaide (Australia); P. Sanders, S. Worthley, Royal Adelaide Hospital (Australia); P. Kuklik, Politechnika Warszawska (Poland)

Effective dynamic modeling can be approached using medical imaging techniques which can provide 3D structural and flow data. A reconstruction of the MRI slices is performed. Optical Flow (OF) evaluation of tagged MRI images is able to provide flow visualization in pathology. This class of approaches has been known in the field of image processing and computer vision for more than two decades but apparently has few applications in medical imaging up to date. We have applied the OF methodology to MRI images of an artificial mock circulatory setup, and performed flow quantification vis-à-vis blood movement through a prosthetic aortic heart valve based on the measured flow field. The intensity-based MRI images can be cross-correlated and compared with the optical flow evaluation. We have used the Optical Flow algorithm and also the cross-correlation on the intensity-based MRI images. The results are compared for accuracy and efficiency. This technique offers potential for the non-invasive flow visualization of cardiac structures in a beating heart that changes its spatial position with time.

## 6416-23, Session 5

### Microfluidic with optical sensor for rapid detection of nerve-agent sarin in water samples

H. Y. Tan, DSO National Labs. (Singapore); N. Nguyen, Nanyang Technological Univ. (Singapore); W. K. Loke, Y. T. Tan, DSO National Labs. (Singapore)

The chemical warfare agent Sarin is an organophosphate that is highly toxic to human as they can act as cholinesterase inhibitors, that disrupts neuromuscular transmission. As these nerve agents are colorless, odorless and highly toxic, they can be introduced into drinking water as a means of terrorist sabotage. Hence, numerous innovative devices and methods have been developed for rapid detection of these organophosphates. Microfluidic technology [1] allows the implementation of fast and sensitive detection of Sarin.

In this paper, a micro-total analysis systems ( $\mu$ TAS), also known as Lab-on-a-chip, fitted with an optical detection system has been developed to analyze the presence of the nerve agent sarin in water samples. In the present set-up, inhibition of co-introduced cholinesterase and water samples containing trace amounts of nerve agent sarin into the microfluidic device was used as the basis for selective detection of sarin. The device was fabricated using polymeric micromachining with PMMA as the substrate material. A chromophore was utilized to measure the activity of remnant cholinesterase activity, which is inversely related to the amount of sarin present in the water sample. Comparisons were made between two different optical detection techniques and the findings will be presented in this paper. The presented measurement method is simple, fast and as sensitive as Gas Chromatography.

## 6416-24, Session 5

### The culture of human embryonic stem cells in microchannel perfusion bioreactors

N. Korin, A. Bransky, S. Levenberg, U. Dinnar, Technion - Israel Institute of Technology (Israel)

Embryonic stem (ES) cells may be used as a source of cells for tissue engineering due to their capacity for long-term self-renewal and their ability to differentiate into specialized cell types. The culture of hES cells in microchannel bioreactors can be highly beneficial for ES cell biology studies and ES tissue engineering applications.

The present work studies the conditions and parameters required for long term culture and proliferation of human fibroblast cells and human embryonic stem cell co-culture with human foreskin fibroblast in a microchannel. The role of design parameters which affect shear stress and transport phenomenon is evaluated and discussed.

PDMS microchannels (depth: 50,130 micron) were fabricated using conventional soft-lithography techniques. The channels were sterilized, coated with a human fibronectin solution and seeded with cells. Following static incubation, the microchannel was connect to a perfusion system comprises a syringe pump , a custom-made oxygenator, a bubble trap and waste container. Culture medium was perfused through the channels at various flow rates thus effecting nutrients supply, oxygen concentrations and shear stress. Cell counting, cell viability and oxygen level at the microchannel outlet were monitored. Additionally, ES colonies were also Oct-4 & SSAE3/4 stained to indicate pluripotency of the cells. Mass Transport and fluid mechanics models were used to evaluate the culture conditions within the micro-bioreactor (shear stress, oxygen level, nutritious etc.). The influence of culture condition on proliferation kinetics is evaluated and the significant differences in long term mammalian cell culture between micro-scale bioreactor systems and traditional macro-scale systems are outlined and discussed.

## 6416-25, Session 5

### A microfabricated bio-sensor for erythrocytes deformability and volume distributions analysis

A. Bransky, N. Korin, U. Dinnar, Technion - Israel Institute of Technology (Israel)

An automated rheoscope has been developed, utilizing a microfabricated glass flow cell, high speed camera and advanced image processing software. RBCs suspended in a high viscosity medium were filmed flowing through a microchannel. Under these conditions, RBCs take different orientations and undergo varying deformation according to their location in the velocity profile.

The rheoscope produces valuable data such as velocity profile of RBCs, spatial distribution within the microchannel and deformation index (DI) curves.

The variation of DI across the channel height, due to change in shear stress, was measured at a constant flow rate. These DI profiles were measured for a Thalassemia and healthy erythrocytes. The results show a clear distinction between the two, suggesting a new technique for diagnosis of deformability blood disorders. This is an improvement of the existing techniques for deformability measurements, in which shear is controlled mechanically, and which do not use disposable elements.

Additionally, the volume and surface area of the cells were calculated based on experimental data and a fluid mechanics model. The histograms of the full distributions of deformability and volume contain useful information that is unavailable when studying average values.

Correlation between mean cell volume and deformability was found which may shed more light on the dynamics of erythropoiesis and red cell senescence.

These devices may be used in the future in clinical healthcare just like hemacytometers, and semen analysis chambers.

## 6416-27, Session 5

### An electrically controlled micromachined drug delivery device employing two silicon wafers

R. Rajan, S. M. Aziz, T. C. Vaithianathan, Univ. of South Australia (Australia)

Delivering drugs to precise locations within the human body has attracted a lot of attention recently due to its potential benefits. Rapid advances in MEMS technologies promise to revolutionize the way drug is administered to areas of the human body which are almost impossible to access by conventional means. For example, the lower part of the digestive tract has been a region of interest to medical researchers and practitioners for decades due to its inaccessibility. Conventional methods of drug delivery have posed significant limitations in treating patients with gastrointestinal disorders. This paper presents the design of a micro fabricated drug delivery system that will be capable of delivering drugs to specific targeted regions of the human body. The design is based on two nearly similar microfabricated silicon wafer chips sandwiched by a secondary reservoir made of Pyrex glass. The glass reservoir can contain up to 5 micro-litres of drug and is anodically bonded onto the silicon wafer. The silicon chips, 5mm x 5mm each, have multiple reservoirs etched into them and is covered by a thin gold membrane. All membranes will rupture simultaneously upon passing a current due to an electrochemical process, exposing the drugs held in the secondary reservoir. Drugs will diffuse out of the device from both sides due to the concentration gradient. The natural contraction of the circular muscles (peristalsis) in the digestive tract will also enable the expulsion of the drugs. We intend to present the details of masks used for fabricating the device and the practical test results in the full paper.

## 6416-44, Session 5

### Integrated microsystems technology for lab-on-a-chip applications

H. Stapert, Philips Research Labs. (Netherlands)

Many biochemical assays can yield better performance and robustness when subsequent process steps are integrated in micro- (or nano)mechanical systems. Additionally it opens the possibility for new devices that are 'easier to use', use lower amounts of expensive reactants and are more reliable. In vitro diagnostic applications may especially benefit from microsystems technology when speed, sensitivity and minimal contamination risks are required. This presentation will address above topics supported by technology development in optomechanical systems, biosensors and actuators at Philips Research for applications in the area of molecular medicine.

## 6416-45, Session 5

### Nature-inspired polymeric actuating materials for micro-fluidic manipulation using external stimuli

H. T. A. Wilderbeek, T. N. Mol, J. de Goede, W. Talen, M. Gillies, Philips Research Labs. (Netherlands); D. J. Broer, Technische Univ. Eindhoven (Netherlands); J. M. den Toonder, Philips Research Labs. (Netherlands)

The anticipated increasing load on the healthcare system will stimulate a shift of the diagnosis from a more laborious, time-consuming and expensive hospital-based central lab to near-patient monitoring. This will bring about a need to downscale the analysis platforms with respect to physical size, cost and time to diagnosis. In this context, lab-on-a-chip devices such as cartridge-based biosensors attract substantial interest, both from academic and industrial point of view.

These cartridge-based devices require the combination of multiple micro-fluidic functions on a small area, such as mixing and displacement of liquids, controlled chemical and physical reactions, and the separation and detection of components. Although significant progress has already led to a variety of individual mi-

cro-fluidic components and principles, by and large it is still difficult to integrate the individual components in a device, and with respect to mixing and displacement of liquids, the area of manipulation is still pre-determined. In particular, the selective on-demand mixing, displacement and routing of liquids, at designated yet non-fixed locations has not yet been demonstrated. One way to fulfill the abovementioned functions on demand is to integrate versatile responsive materials in micro-fluidic devices.

In this contribution, we show a range of working principles and demonstrators based on novel responsive polymeric, micron-sized materials that can manipulate fluids by reversible micro-actuation.

The actuation can be effected by various external stimuli, such as the use of heat, electrical stimulation, magnetism, and the interaction with light, and examples of these stimuli-assisted actuations will be shown. We will address the chemistry and physics of the involved materials, discuss the specific boundary conditions (e.g. anisotropy demands, mechanical properties) that need to be met, and give an overview of the required processing involved. Finally, the relevance of these micro-actuators to actual devices is assessed.

### 6416-28, Session 6

#### **A biologically inspired model for signal compression**

M. D. McDonnell, D. Abbott, The Univ. of Adelaide (Australia)

It is demonstrated using an array of model neurons that the process of action-potential (spike) generation in response to external stimuli in sensory neurons can be described as lossy compression of an information source. Lossy compression is generally characterized by (i) how much distortion is introduced, on average, due to a loss of information, and (ii) the "rate," or the amount of compression. We use conventional theory to measure the performance of the neural model in terms of both distortion and rate, and the tradeoff between each. Our model is then shown to be applicable to a number of situations relevant to biomedical engineering, including cochlear implants, and biosensors.

### 6416-29, Session 6

#### **Toward 'smart' DNA microarrays: algorithms for improving data quality and statistical inference**

D. J. Bakewell, The Univ. of Liverpool (United Kingdom); E. Wit, Lancaster Univ. (United Kingdom)

DNA microarrays are becoming a standard laboratory tool for understanding biological processes at the molecular scale (gene transcription), and future application areas of this genomic technology include healthcare, agriculture, and environment. However, despite their attractiveness, the information from microarrays made available to the end-user is not used optimally, and the data is often "noisy" and of variable quality. Consequently, there is a need for post-microarray information processing that offers more reliable information about gene activity, possibly leading to "smart microarrays".

This presentation describes algorithms we are developing using hierarchical Maximum Likelihood Estimation (MLE) that improves the quality of microarray data and enhances statistical inference about gene behaviour. The presentation will describe two examples of recent work by us that improves microarray performance, demonstrated using data from both Monte Carlo simulations and published experiments. The first example looks at the variable quality of cDNA spots on a typical microarray surface. It is shown how algorithms, derived using MLE, are used to "weight" these spots according to their morphological quality, and subsequently lead to improved detection of gene activity. The second example addresses the "noisy data about too many genes" issue confronting many analysts who are also interested in the collective action of a group of genes, often organised as a pathway or complex. Current work is described where MLE is used to "share" variance information across a pre-assigned group of genes of interest to the end-user. This leads to a more sensitive detection of gene activity than contemporary statistical testing methods.

### 6416-30, Session 6

#### **Prediction of protein adsorption from molecular surface properties**

D. V. Nicolau, Jr., Univ. of Oxford (United Kingdom); G. Solana, D. V. Nicolau, F. Fulga, The Univ. of Liverpool (United Kingdom)

No abstract available

### 6416-31, Session 6

#### **Advanced monitoring systems for biological applications**

A. Gandelli, F. Grimaccia, R. E. Zich, Politecnico di Milano (Italy); R. W. Johnstone, T. Chiffings, The Univ. of Queensland (Australia); U. Cella, Politecnico di Milano (Italy)

The increasing need to manage complex environmental problems demands a new approach and new technologies to provide the information required at a spatial and temporal resolution appropriate to the scales at which the biological processes occur. To date, monitoring systems in the environment have been very limited in their temporal and spatial resolution with the exceptions being few but extremely expensive short-term undertakings. In particular sensor networks, now quite popular on land, still poses many difficult problems in underwater environments. In this context, it is necessary to develop an autonomous monitoring system that can be remotely interrogated and directed to address unforeseen or expected changes in environmental conditions. This system, at the highest level, aims to provide a framework for combining observations from a wide range of different in-situ sensors and remote sensing instruments, with a long-term plan for how the network of sensing modalities will continue to evolve in terms of sensing modality, geographic location, and spatial and temporal density.

The multidisciplinary area of such a project brings together concepts of wireless communications and ad hoc networking, low-power hardware design, signal processing, distributed computing, and embedded software design, and needs to develop technologies for sensing, in-situ sensor configuration, data capture and storage, data collection and transmission, data storage, multi-sensor data fusion, data presentation and visualization, and for analytical mode checking. The established system is intended to cover a range of issues in environmental sustainability, including those related to phenomena such as climate change, as well as more specific areas such as water quality and elements of marine ecology. They should also cover a range of locations including waterways, coastal waters, reefs, and oceanic sites.

The network seeks to operate at multiple scales so that its data collection, analysis, and synthesis are consummate with the nature of the environmental management and research questions of concern. The system is designed to incorporate existing technologies, but will also include new indigenous ICT and sensor technologies such as RF underwater transmission and communication systems, micro- and nano-sensors, and interactive user defined data analysis models and testing platforms. Current research focuses on the development of efficient signal processing algorithms, multi-user communications in the presence of interference, and design of efficient modulation and coding schemes. The advances in sensor technology and digital electronics have made it possible to produce large amount of small tag-like sensors which integrate sensing, processing, and communication capabilities together and form an autonomous entity. To successfully use this kind of systems in under water environments, it becomes necessary to optimize the network lifetime and face the relative hindrances that such a field imposes, especially in terms of underwater information exchange.

### 6416-32, Session 7

#### **T-ray biosensing**

B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia)

The terahertz (or T-ray) spectra of many small molecules of biological relevance show very characteristic, specific features that are sensitive to small changes of the molecular structure and even isomerisation. On the other hand, most packaging materials like plastics, paper or even clothing are transparent for T-rays. Therefore, it is possible to differentiate and identify different substances by their spectral fingerprints, even through their packaging. This supports the potential of this technique in a wide range of applications from safety and security applications via biosensing through to pharmaceutical quality control.

However, most of the molecular vibrations that give rise to the characteristic features in the T-ray spectra are phonon like intermolecular vibrations of weakly bound crystalline compounds. This can be easily demonstrated by comparing the spectra of different crystals of the same molecule. Whereas this sensitivity on the intermolecular structure can be used to probe the crystalline structure and detect phase transitions, it is a hurdle when it comes to identify samples that lack such a well defined intermolecular structure. Yet, we have recently shown that a comparison of the absolute absorption values can still be used to differentiate between complex biomolecules such as RNA.

In this presentation we will demonstrate, based on a wide range of spectra, the potential of T-ray spectroscopy for biosensing and will show examples where this technique can be used to probe the crystalline configuration and phase transitions. We will also discuss the feasibility of using this technique for biosensing of complex biological samples.

### 6416-33, Session 7

#### Investigation of terahertz liquid-spectroscopy for contaminant detection

J. Balakrishnan, B. M. Fischer, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia)

Food contamination is a life-threatening problem for millions of people around the world. This contamination is mainly caused by bacteria, viruses and chemicals in the food itself. Poor hygiene and improper handling of the food may result in food contamination. This paper proposes a technique to identify contaminations, in liquid, using T-ray liquid spectroscopy via double modulated differential time-domain spectroscopy [1].

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### 6416-34, Session 7

#### Enhancing coupling between THz and skin

G. M. Png, B. W. H. Ng, S. P. Mickan, D. Abbott, The Univ. of Adelaide (Australia)

Pulsed terahertz radiation (THz) in reflection mode has previously been used in ex vivo and in vivo inspection of human skin; results have revealed the potential of THz in medical diagnosis of diseases on the skin surface, such as Basal Cell Carcinoma [1,2]. Diagnosis of diseases below the skin surface however has been restricted by the limited penetration depth of THz, due to attenuation by water in the body. One possible method to enhance the Signal to Noise Ratio (SNR) of detected signals from various skin layers is via the application of a suitable non-aqueous medium. This method has not been previously explored, and thus may assist in extending THz medical applications. This paper will first present a variety of commercially available creams, oils and pastes (collectively termed "ointments") and their measured optical properties at THz frequencies. Both hydrophilic and hydrophobic ointments are investigated. Various skin phantoms are then introduced together with their measured optical properties. The effects of the ointments on THz propagation through these skin phantoms are finally elucidated via both simulated analysis and measurements.

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carcinoma", *Journal of Investigative Dermatology*, vol. 120, no. 1, pp. 72-78, 2003.

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### 6416-35, Session 7

#### Terahertz as a diagnostic tool for skin cancer

T. J. Rainsford, M. J. Berryman, The Univ. of Adelaide (Australia); D. Abarno, Univ. of South Australia (Australia)

The early detection of skin cancers is critical with respect to treatment and patient survival. Biopsy techniques that are currently employed for such diagnoses are invasive, time consuming and costly. A Terahertz (THz) imaging system potentially provides a fast and non-invasive way to detect and diagnose skin cancer by imaging the target area at different depths below the skin surface. While there is proof of concept that THz can distinguish cancerous and normal tissue, the mechanisms underlying this differentiation are not well understood. However, we are gaining a better understanding of THz spectral data through computational pattern recognition and related multivariate statistical tools that allow for the differentiation of data into discrete and disjoint groups. Such separation of THz spectra data can provide complex information about skin tissue, which can be used to non-invasively distinguish cancerous from non-cancerous cells as well as, discriminate between skin cancers at various developmental stages and, between different types of cancer. Using a system that combines novel hardware with smart classification algorithms is an important step towards developing THz imaging to a level ready for biomedical study of surface tissue in vivo.

### 6416-18, Poster Session

#### Single-cell impedance spectroscopy: maximum length sequence analysis

T. Sun, N. G. Green, S. Gawad, H. Morgan, Univ. of Southampton (United Kingdom)

High throughput microfluidic cytometers are now used for the measurement and analysis of the dielectric (or impedance) properties of biological particles [1-4]. The systems have potential for rapid characterisation, detection and separation of different bio-particles. Impedance analysis is performed by applying an AC excitation voltage to microelectrodes fabricated within the microfluidic channels. Measurements at discrete frequencies are performed, but this method cannot give a full impedance spectrum.

In this paper, we present a new technique for obtaining high speed single particle dielectric spectra. The method uses Maximum Length Sequences (MLS) as the excitation signal. MLS is based on measuring the response of the system in the time domain, and by applying the Fast M-sequence Transform (FMT), the impulse response of the system is obtained. This is equivalent to the transfer-function of the system in the frequency domain. Fast Fourier Transform (FFT) is then used to convert the data from the time domain to the frequency domain. Theoretical modelling has shown that using sufficiently long MLS together with high sampling rates, the full impedance spectrum of the particle (both magnitude and phase) can be successfully recovered over a wide frequency range. Multi-frequency measurement is thus possible.

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### 6416-38, Poster Session

#### **A wireless sensor for detecting gastroesophageal reflux**

T. Ativanichayaphong, W. Huang, J. Wang, S. M. N. Rao, The Univ. of Texas at Arlington (USA); H. Tibbals, S. Tang, S. Spechler, The Univ. of Texas Southwestern Medical Ctr. at Dallas (USA); H. E. Stephanou, J. Chiao, The Univ. of Texas at Arlington (USA)

Esophageal impedance monitoring is a new technique being used to detect episodes of gastroesophageal reflux that are both acidic and non-acidic in nature. The impedance electrodes are placed in a catheter to be inserted transnasally into the patient's esophagus. The esophageal catheter is connected to an external electrical module for power supply and data acquisition. The system configuration is bulky and very uncomfortable for patients during the study (more than 24 hours) and may limit the clinical utility of the monitoring technique. A miniature wireless device that does not require tethered connection is thus preferred for esophageal reflux monitoring.

In this paper, we propose a method to measure the impedance changes using passive telemetry. The approach is based on inductive links between two coils - an external coil connected to an RF source forming a resonance circuit and a small implantable coil connected to an interdigitated electrode impedance sensor. The voltages coupling between coils provide energy to the electrodes implanted in the esophagus. The resonance changes as the mutual inductances change, reflecting the impedance changes in the esophagus caused by fluid passing the sensors.

We have designed and fabricated planar coils integrated with electrodes on flexible substrates using standard photolithography processes. In vitro experiments were conducted by passing different acidic or non-acidic solutions onto the electrodes and measuring the changes in signal amplitudes at the external coil. Air, drinking water and different concentrations of artificial stomach fluids were used to test the impedance monitoring. We will present the system configuration, device designs, fabrication processes and measurement results in this paper.

### 6416-39, Poster Session

#### **Self-assembled magnosilicate nanocaptor for the in-situ separation of human DNA and proteins**

J. H. Chang, K. J. Kim, Korea Institute of Ceramic Engineering and Technology (South Korea)

This work described the development of self-assembled magnosilicate nanocaptor for the in-situ separation of human DNA and protein with high throughput process involving the amino-functionalized silica coated magnetic nanoparticles. The consequence is that the shell thickness was controlled by changing the concentration of the TEOS precursor on the magnetic nanoparticles. And then amino functionalized magnetic nanoparticles synthesized using amine groups as surface modification. Amino functionalized Si-coated particles with 10-40 nm average diameters were prepared and characterized by XRD, TEM, VSM, BET, FT-IR, Zeta Potential, Electrophoresis. These magnosilicate nanocaptors were used for human DNA and protein purification by electrophoresis method. The adsorption of human DNA and protein molecules on the amino functionalized Si-MNPs was affected by a number of the amine groups. The lambda adsorption efficiency for DNA and protein was preferred to the higher number of amine groups such as tri-amino functionalized magnosilicate nanocaptor. The use of functionalized self-assembled magnosilicate nanocaptor for the in-situ separation process of human DNA and protein give a lot of advantages rather than the conventional silica based process.

### 6416-40, Poster Session

#### **Functional bone-mimetic scaffolds of bicontinuous, thermo-responsive L3-phase silica/hydroxyapatite nanocomposites**

J. H. Chang, K. J. Kim, Korea Institute of Ceramic Engineering and Technology (South Korea)

This work presented the highly controlled drug delivery system to achieve the suppression of the burst release at initial time and long term release of drug with cancellous bone mimetic nanoporous structures. The materials were prepared by the integration of synthesized inorganic hydroxyapatite (HA) and the hybrid gels of bicontinuous sponge-phased L3 silicate and thermo-responsive poly(N-isopropylacrylamide) (L3-PNIPAm gels). The materials were designed to have the three dimensionally interconnected heterogeneous porosity of macro- and mesoporosity, in which the HA has the macroporosity of 150  $\mu\text{m}$  to be impregnated the drug into the pores and the L3-PNIPAm gels have mesoporosity of 5 nm to regulate the temperature sensitive drug-release through the pore channels and polymeric network, respectively. Consequently, these bone-mimetic system gave the highly long term drug release over the 60 days with suppressing the burst release and was able to control the releasing rate per time by the change of the HA and PNIPAm composition ratios. The structural characterization was achieved by TEM, SEM, XRD, Micro-Raman spectroscopy, BET, and the direct contact cytotoxicity test was described. In vitro analysis carried out with prepared material did not show any cytotoxicity, and the cells were found to well grow on surface of the matrix. The L3-PNIPAm/HA nanocomposites could be applied to highly long term drug release materials in the regeneration of damaged bones.

### 6416-41, Poster Session

#### **Electrical detection of biomolecules in a PDMS microfluidic channel using a MOSFET-type biosensor**

J. Shin, D. Kim, Kyungpook National Univ. (South Korea); G. Lim, Pohang Univ. of Science and Technology (South Korea); S. Shoji, Waseda Univ. (Japan)

Recently, biotechnology and medical diagnostics are constantly developing in the field of determination of specific biomolecules for identifying certain infectious or inherited diseases. Therefore, there has been considerable attention for the detection of biomolecules including DNA, proteins and single cells. Even though several techniques for biological detection such as mass spectrometry, optical measurement and electrochemical measurement exist, MOSFET-type biosensors, which are fabricated by semiconductor integrated circuit technology, have lately attracted considerable attention because of numerous advantages in terms of miniaturization, standardization, mass-production, and especially suitable configuration for on-chip integration of both the sensor and measurement system. However, they are still limited by several drawbacks related to interferences due to light, temperature and noisy drift and need a stable reference electrode for proper functioning. In addition, conventional reference electrodes like Ag/AgCl electrode cause limitations in miniaturization of the whole sensor system and increase its cost. Furthermore, in recent years, numerous reports have continuously suggested that biosensors should be integrated with a micro-fluidic system for sample volume reduction, less contamination, fast response time, high accuracy and realization of portable and disposable device. On that account, in this research, we describe a MOSFET-type biosensor using a Pt quasi-reference electrode assembled in a polydimethylsiloxane (PDMS) micro-fluidic channel for electrical detection of biomolecules. Differential measurement system is used to avoid the interferences due to light, temperature and drift.

## 6416-42, Poster Session

### **Encapsulation of cell into monodispersed hydrogels on microfluidic device**

C. Choi, J. Lee, H. Shim, N. Lee, J. Jung, T. Yoon, D. Kim, C. Lee, Chungnam National Univ. (South Korea)

The technology of cell encapsulation provides a physical or biological barrier for cells against a host immune response, as the capsules prevents infiltration by immune cells and antibodies. The application of monodispersed hydrogels for drug delivery and biosensor could provides distinctive advantages compared to polydispersed ones with respect to detecting, monitoring, predicting, and modeling of their behavior as they show expecting signal to external stimuli.

The goal of this study is to create microbeads that will contain viable cells for a long time. The utilization of microfluidics is helpful to synthesize monodispersed alginate hydrogels and in situ encapsulate cell into the generating hydrogels in microfluidic device. First, the condition of formation of hydrogels in multiphase flows including soybean oil, water, CaCl<sub>2</sub>, and alginate was optimized. Based on the preliminary survey, microfluidic device could easily manipulate the size of alginate beads having narrow size distribution and in situ encapsulate cell into the generating hydrogels.

In conclusion, a microfluidic based approach provides convenient synthetic route to generate monodispersed alginate hydrogel particles and simultaneous encapsulation of cells in microfluidic channel. The modulation of flow rate, viscosity, concentration of crosslinking agent and geometrical design of microfluidic channels could provide the high production rate of beads.

## 6416-43, Poster Session

### **Rapid bio-patterning method based on the fabrication of PEG microstructures and layer-by-layer polymeric thin film**

H. Shim, J. Lee, C. Choi, B. Kim, N. Lee, J. Jung, D. Kim, C. Lee, Chungnam National Univ. (South Korea)

The patterning of biomolecules in well-defined microstructures is critical issue for the development of biosensors and biochips. However, the fabrication of microstructures with well-ordered and spatially discrete forms to provide the patterned surface for the immobilization of biomolecules is difficult because of the lack of distinct physical and chemical barriers separating patterns.

This study present rapid biomolecule patterning using micromolding in capillaries (MIMIC), soft-lithographic fabrication of PEG microstructures for prevention of nonspecific binding as a biological barrier, and self assembled polymeric thin film for efficient immobilization of proteins or cells. For the proof of concept, protein (FITC-BSA) and bacteria (*E.coli* BL21-pET23b-GFP) were used for biomolecules patterning on polyelectrolyte coated surface within PEG microstructures. The novel approach of MIMIC combined with LbL coating provides a general platform for patterning a broad range of materials because it can be easily applied to various substrates such as glass, silicon, silicon dioxide, and polymers.

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## 6417-01, Session 1

### Electric field detectors in a coupled ring configuration: preliminary results

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The possibility to exploit a ring of non-linear detectors, with a unidirectional coupling, to sense weak signals has been recently demonstrated [1-4]. Actually, the presence of a weak external dc perturbation interacting with the system state (having small amplitude compared to the energy barrier height of a single element) can be detected and quantified via its effect on the oscillation frequency and asymmetry of the system output signals.

In this paper, a coupled ring of ferroelectric devices is proposed as a convenient way to sense weak electric fields. The dynamic behaviour of the ferroelectric ring can be described by using the equations of the "quartic double well" potential that model the ferroelectric capacitors where the target electric field is considered as a perturbation in the polarization status of each ferroelectric element.

Simulation results have been obtained where it can be observed the change in the harmonic content of the permanent oscillation that the coupled system generates, for a coupling factor greater than the critical one, as related to the external field amplitude (the system is conceived for electro static fields detection).

Work is currently in progress for the experimental confirmation of the simulation results presented. The real device uses an suitable dual electrode configuration (a large top electrode exposed to the electric target field and a small bottom electrode immersed in the ferroelectric core) which implements a charge density gain between the top and the bottom electrodes, thus amplifying the effect of the weak target field on the device polarization.

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## 6417-03, Session 1

### Wearing process simulation between 2 polymer materials

H. Lin, H. Lin, L. Kong, Univ. of South Australia (Australia)

One vital and persistent goal in engineering discipline is to develop explicit relationships between the variables and the parameters of a system, in mathematical form. So too in tribology, to reduce the length of the product development cycle and achieve good production quality control, engineers and designers should have equations to predict wear rates. Unfortunately, it is difficult to describe the whole complicated wear process by a relative simple equation which has enough precision. On the other hand, in order to predict wear and eventually the life-span of a mechanical system, several hundred thousand operating cycles have to be tested on samples. Therefore, a computer simulation model based on powerful finite element analysis and a suitable theoretical wear law is an optimum choice. In recent years, research has been done along this line of thinking. However, these studies usu-

ally focus on metal material or metal to polymer friction system. One possible reason is polymer materials have diversiform microcosmic structure and various proportions of additives which cause the tribological properties of polymers much more complicated than metals. Thus, many classical wear laws are not appropriate any more. To simulate the wear process between two polymer materials some new wear theories should be applied.

In the present paper a finite element model to predict the wear process of two different polymer materials has been developed. Some theoretical wear analyses have also been involved. Two widely used materials of SVSA were discussed. Assembling condition for this study is a sliding friction system with two different polymer materials, one is 45% glass reinforced polyethylene terephthalate the other is 33% glass reinforced black nylon copolymer resin. Both friction surfaces have significant sharp changing with wear. All physical test and computer simulation have been used in this study.

A series of tribological tests between the two polymer materials have been conducted. Each test was set different lubrication conditions and normal pressure. The curves of wear rate with time are measured. The results showed that under appropriate lubrication conditions and with a certain range of pressure, the wear process performed similarly. It can be divided into two stages. The first stage which represents a small proportion of the total time of operation of the junction has a "running-in" characteristic. The second stage presents almost a constant wear rate.

In FEA simulation procedure, the commercial FEA code ANSYS version 9 has been used. Both sides of friction surface have been considered as flexible surface and nonlinear analysis has been conducted. Local wear was computed and then integrated over the sliding distance using theoretical wear calculation equations (in each wear stage, various wear calculation equations were used). The FEA simulation worked in a loop and performed a series of static simulations with updated surface geometries. After every wear step the geometry is re-meshed to correct the deformation from wear.

The result from FEA simulation is in good agreement with physical testing result. Therefore, it can be used to improve the product design.

## 6417-04, Session 1

### Nonlinear dynamics that appears in the dynamical model of drying process of a polymer solution coated on a flat substrate

H. Kagami, Nagoya College (Japan)

We have proposed and modified the dynamical model of drying process of polymer solution coated on a flat substrate for flat polymer film fabrication and have presented the fruits through Photomask Japan 2002, 2003, 2004 and so on. And for example numerical simulation of the model qualitatively reappears a typical thickness profile of the polymer film formed after drying, that is, the profile that the edge of the film is thicker and just the region next to the edge's bump is thinner. Then we have clarified dependence of distribution of polymer molecules on a flat substrate on a various parameters based on analysis of many numerical simulations.

On the other hand, the dynamical model has characteristic nonlinearity. That is, since drying process is nonlinear process, the number of molecules of solvent or solute per a volume depends on a position in a polymer solution coated on a flat substrate and consequently the number of molecules of solute and a quantity of solvent interact each other through each evolution equation.

In this presentation, at first, we derive nonlinear equations from the dynamical model of drying process of polymer solution. Then we introduce results of numerical simulations of the nonlinear equations and consider an role of a parameter  $\gamma$  which is indirectly concerned in strength of non-equilibriumity.

Through this study, we want to approach essential qualities of nonlinearity in drying process.

## 6417-06, Session 2

### Optical tweezers demonstrations of new concepts in nonequilibrium statistical mechanics

E. M. Sevick, D. J. Evans, G. Wang, The Australian National Univ. (Australia)

Thermodynamics is the study of the flow of heat between states and its transformation into work. Our understanding of thermodynamics is largely confined to equilibrium states. The field of nonequilibrium thermodynamics represents a simple-minded extension of the 19th century concepts of equilibrium thermodynamics to systems that are close to, or near equilibrium.

Moreover, these traditional concepts are limited in application to large systems, referred to as the thermodynamic limit.

However, in the last decade, two new theorems have been proposed to revolutionise the field of thermodynamics and its application to modern systems. These new theorems, referred to as fluctuation theorems, firstly lift the restriction of the thermodynamic limit, allowing thermodynamic concepts to be applied to small systems, and secondly, characterise systems that may be far-from-equilibrium.

The first of these theorems, the Evans-Sealres Fluctuation Theorem (ESFT), generalises the Second Law of Thermodynamics so that it applies to small systems, including those that evolve far from equilibrium. The second, the Crooks Fluctuation Theorem, provides a method of predicting equilibrium free energy differences from the experimental trajectories of systems, including those that traverse far-from-equilibrium states. Both of these theorems are at odds with a traditional understanding of 19th century thermodynamics where equilibrium is central and the Second Law inviolate. However these theorems are critical to the application of thermodynamic concepts to systems of interest to scientists and engineers in the 21st century.

Fluctuation theorems have been studied mostly by theoreticians and simulationist; however the practicality of the theorems or how they can be used to answer questions in science has yet to be demonstrated. In this talk we will describe the theorems in practitioners' language, along with our optical tweezers experiments that irrefutably demonstrate the theorems.

## 6417-08, Session 2

### High-resolution optimal quantization for stochastic pooling networks

M. D. McDonnell, The Univ. of Adelaide (Australia); P. Amblard, Ctr. National de la Recherche Scientifique (France); N. G. Stocks, The Univ. of Warwick (United Kingdom); S. Zozor, École Nationale Supérieure d'Ingénieurs Electriciens de Grenoble (France); D. Abbott, The Univ. of Adelaide (Australia)

Pooling networks of noisy threshold devices are good models for natural networks (e.g. neural networks in some parts of sensory pathways in vertebrates, networks of mossy fibers in the hippocampus, ...) as well as for artificial networks (e.g. digital beamformers for sonar arrays, flash analog-to-digital converters, rate-constrained distributed sensor networks, ...).

Such pooling networks exhibit the curious effect of suprathreshold stochastic resonance, which means that optimal control of the network is stochastic, for a given task.

Recently, some progress has been made in the understanding of pooling networks of identical—but independently noisy—threshold devices. One aspect concerns the behavior of information processing in the asymptotic limit of large networks, which is a limit of high relevance for neuroscience applications.

The mutual information between the input and the output of the network has been evaluated, and its extremization has been performed.

The aim of the present work is to extend these asymptotic results

to study the more general case when the threshold values are no longer identical. In this situation, the values of thresholds can be described by a density, rather than by exact locations.

We present a derivation of Shannon's mutual information between the input and output of these networks. The result is an approximation that relies on the use of a weak version of the law of large numbers, and a version of the central limit theorem. Optimization of the mutual information is then discussed, and some particular cases are studied in some depth. In particular, links with previous recent results are made.

## 6417-09, Session 2

### Relaxation in complex systems and fractional calculus

V. E. Arkhincheev, Buryat Institute of Natural Sciences (Russia) and Federal Urdu Univ. (Pakistan); A. B. Bainova, Buryat State Univ. (Russia)

The relaxation in complex systems is studied. Relaxation behavior in these systems differ from usual exponential Maxwell one. NonMaxwell relaxation occurs on two types of systems: regular fractals and heterogeneous multi-phase media and it is caused by two different reasons. The physical mechanisms of new relaxation laws in complex disordered systems are obtained. Correspondingly two different types of generalized relaxation equations of temporal derivatives of fractional order will be arise.

## 6417-10, Session 3

### Brownian motion in titled periodic potential driven by green impulse noise

M. V. Sviridov, S. A. Guz, M. G. Nikulin, Moscow Institute of Physics and Technology (Russia)

We study a Brownian overdamped motion driven by the sequence of non-Gaussian correlated rectangular impulses when following impulse has strong opposed sign (of alternating-sign quasi-delta-functions). The noise is generated by a time derivative of stationary jump random function (similar to a random telegraphic signal). Therefore, this is green by definition [Phys. Lett. A 240 (1998) 43]. We consider two variants of noise. In the first variant probability densities of time intervals between the quasi-delta-functions are exponential and in the second variant - uniform. To find a response function we use two methods: an averaging method and a numerical simulation. We consider two models of the jump function. One of these good coincides with a Poisson process. We show that a locking effect (or a synchronization) exists even if a mean frequency of impulses is large. With a high accuracy this effect remains even if a noise is large. According to the theory an effective locking band is equal to the cosine of the amplitude of the original jump function. In particular, if the amplitude is  $\pi$ , the band is zero, however, if it is equal to  $\pi/2$ , the band is unity as well as in the ideal case of zero noise. This effect weakly depends on an impulse form. The theory good coincide with the numerical simulation.

## 6417-11, Session 3

### Brownian ratchets in the simulated annealing algorithm

A. G. Allison, D. Abbott, The Univ. of Adelaide (Australia)

The "Monte Carlo" algorithm was developed, by Ulam et al. [1] in 1947, to study the diffusion of neutrons. This was soon modified to include a Boltzman distribution function, by Metropolis et al. [2], to create an importance sampling technique for evaluating path integrals. The Boltzman factor was applied to more general problems and given the name "Simulated Annealing" by Kirkpatrick et al. [3] in 1983. The Simulated Annealing algorithm was applied to time-varying problems and given a Fokker-Planck and Langevin formalism by Gelfand [4]. A full Hamiltonian formulation, called "Hybrid MonteCarlo," was created by Duane et al. [5]. This was further developed by Salazar and Toral [6], under the name "Hybrid Simulated Annealing". The authors [7], and Amengual and Toral [8], have used a Fokker-Planck formulation

to show that Parrondo's games are a discrete version of a Brownian ratchet. In this paper we use a Fokker-Plank formalism to show that some time-varying versions of Simulated Annealing can exhibit the counter-intuitive probability flow, exhibited by Parrondo's games. This has implications for the necessary and sufficient conditions for convergence of time-varying versions of Simulated Annealing.

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### 6417-12, Session 3

#### On the fractal properties of Parrondo's games

A. G. Allison, D. Abbott, The Univ. of Adelaide (Australia)

Parrondo's games are a set of discrete games of chance, which have the counter-intuitive property that random combinations of "losing" games can be winning. The work of Allison et al. [1] has shown that the state-space visualization of all the recurrent states, of the randomized game, is a fractal. The explanation of this phenomenon can be clearly understood in terms of inhomogeneous sequences of affine transformations, Barnsley [2] or in terms of non-homogeneous matrix products, Hartfiel [3]. Unpublished work by the authors revealed that some periodic sequences give better rates of return than others. The completely optimal sequence is not known. Behrends [4] has postulated that the amount of effort required to search for an optimal sequence within a fractal set, depends on the dimension of the fractal. This is essentially a coverage argument. In this paper we examine the evidence in favour of Behrend's hypothesis, using a mixture of theoretical and experimental techniques.

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### 6417-16, Session 3

#### Simulation and measurement of a two-stage complex network model

H. H. L. Luo, K. Horadam, Royal Melbourne Institute of Technology (Australia)

Real-world complex networks such the Internet, social networks and biological networks have increasingly attracted the interest of researchers from many areas. Accurate modelling of the statistical regularities of these large-scale networks is critical to understand their global evolving structures and local dynamical patterns. Two main families of models have been widely studied:

those based on the Erdos and Renyi random graph model and those on the Barabasi-Albert scale-free model. In this paper we develop a new model: the Hybrid model, which incorporates two stages of growth. The aim of this model is to simulate the transition process between a static randomly connected network and a growing scale-free network through a tuning parameter. We measure the Hybrid model by extensive numerical simulations, focusing on the critical transition point from Poisson to Power-law degree distribution.

### 6417-13, Session 4

#### Transformations between fractals

M. F. Barnsley, The Australian National Univ. (Australia)

This paper will describe the construction, theory and some applications of very recently discovered transformations between attractors of hyperbolic iterated function systems (IFSs). These transformations can be computed using a chaotic iteration algorithm (M.C.M.C.). The central result is that two IFS attractors are homeomorphic if and only if they have equivalent code space structures; this enables complex pictures to be compared topologically using symbol manipulation and suggests numerous applications, especially in digital imaging and the biological sciences.

### 6417-14, Session 4

#### Marital infidelity and its effect on pathogen diversity

M. J. Berryman, The Univ. of Adelaide (Australia)

Marital infidelity is usually examined solely in terms of strategies of men and women, with an emphasis on the enhanced payoff for male infidelity (provided he can get away with it). What are not clear are the payoffs for women who cheat, and the strategies used, both in terms of how often to engage in extra-marital affairs and also in short term mate selection. It has been proposed that these female strategies are governed by a "decision" to maximise the genetic diversity of her offspring, in order to better guarantee that at least some will survive against a common pathogen. This strategy would then impact on the strategies and diversity of pathogens. We make a number of predictions about both strategies and the genetic diversity of humans and pathogens, couched in game-theoretic terms. These predictions are then compared with the existing evidence on the strategies used by women and also in terms of the genetic diversity of human populations.

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### 6417-19, Session 5

#### Quantitative modeling of multiscale neural activity

P. A. Robinson, The Univ. of Sydney (Australia)

The electrical activity of the brain has been observed for over a century and is widely used to probe brain function and disorders, chiefly through the electroencephalogram (EEG) recorded by electrodes on the scalp. However, the connections between physiology and EEGs have been chiefly qualitative until recently, and most uses of the EEG have been based on phenomenological correlations.

A quantitative mean-field model of brain electrical activity is described that spans the range of physiological and anatomical scales from microscopic synapses to the whole brain.

Its parameters measure quantities such as synaptic strengths, signal delays, cellular time constants, and neural ranges, and are all constrained by independent physiological measurements.

Application of techniques from wave physics allows successful predictions to be made of a wide range of EEG phenomena.

Fitting to experimental data also enables physiological parameters to be inferred, giving a new noninvasive window into brain function.

Modifications of the core model to treat mm-scale patchy interconnections in the visual cortex are also described, and it is shown that resulting waves obey the Schroedinger equation. This opens the possibility of classical cortical analogs of quantum phenomena.

### 6417-20, Session 5

#### **Rate coding by noise-induced attractor selection in multistable neuronal networks**

L. A. Safonov, Y. Yamamoto, The Univ. of Tokyo (Japan)

The brain combines long-term continuity with the ability to adapt to environmental changes. This is possibly achieved by switches between multistable states. In this study we consider systems of coupled neurons with combined excitation and inhibition. Both FitzHugh-Nagumo equations and realistic hippocampal network model equations are studied.

For certain parameter values multistability of several firing regimes with different firing rates is observed. In presence of noise, there is noise-driven switching between these states (chaotic itinerancy) and the resulting firing pattern is long-range correlated.

The selection between higher- and lower-frequency oscillations depends on the input, which results in coherence between the periodic input and the system's firing rate. The system is therefore able to perform rate coding by selecting multistable attractors.

### 6417-21, Session 5

#### **Analyses of heart-rate dynamics before the onset of ventricular tachycardia using scaling characteristics and compression entropy**

M. Baumert, The Univ. of Adelaide (Australia)

Ventricular tachycardia (VT) provoke sudden cardiac death (SCD), which is a major cause of mortality in developed countries with an incidence of 3 million cases per year worldwide. Implantable cardioverter-defibrillators (ICDs) are an efficient therapy for SCD prevention. In this study we analyze heart rate dynamics (HRD) in data stored by ICDs for the short-term forecasting of VT. In 29 patients exhibiting VT episodes, the last 1000 normal beat-to-beat intervals are analyzed and compared to an individually acquired control time series (CON). HRD analysis is performed with standard parameters in the time and frequency domains as suggested by the HRD Task Force. In addition, we analyze the scaling characteristics of heart rate time series, applying Higuchi's fractal dimension algorithm (HFD) and detrended fluctuation analysis (DFA). Therefore, scaling exponents are computed adaptively for the high frequency (HF), low frequency (LF), and very low frequency (VLF) range of HRV. For the assessment of HRD complexity, we further estimate the entropy by means of the time series' compressibility, applying a modified LZ77 algorithm for lossless data compression. None of the standard HRD parameters show significant differences between CON and VT. The scaling analyses, however, reveal significant changes in the fractal characteristics of HRD. HFD and DFA reveal decreased fractal dimension and increased correlation in short-term HRD (HF and LF range) before the onset of VT. Moreover, data compression shows a significantly reduced HRD entropy before the onset of VT. In conclusion, the analysis of HRD scaling characteristics, as well as the compression entropy, provide additional information about autonomic control and might be suited in ICDs for the short-term forecasting of life-threatening tachycardia.

### 6417-22, Session 5

#### **Is the fractal geometry of nature a coincidence?**

J. D. Halley, Commonwealth Scientific and Industrial Research Organisation (Australia)

No abstract available

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## Registration and Information Desk

Foyer Area, Napier Bldg, Univ. of Adelaide

Sunday ..... 18.00 to 20.00  
 Monday through Wednesday ..... 08.00 to 17.00

## Poster Session

Foyer Area, Napier Bldg, Univ. of Adelaide

Monday 11 December ..... 18.00 to 19.30  
 Poster authors can post their papers at 08.00 on Monday. Posters must be up no later than 16.00. Authors must remain in the vicinity of their posters to answer questions and provide in-depth discussion regarding their papers.

## Tea and Lunch Breaks

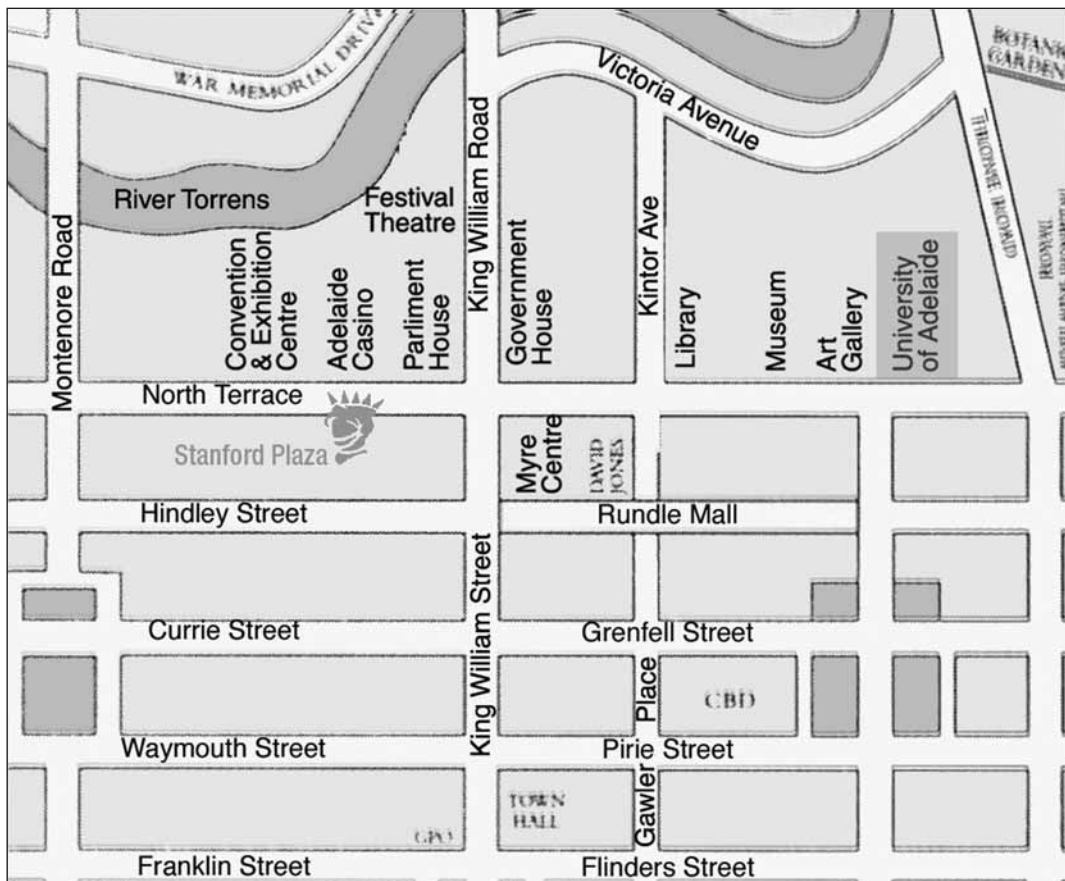
All morning and afternoon tea breaks and lunches will be served in the Foyer Area, Napier Bldg, Univ. of Adelaide.

## Standard Audiovisual Equipment

Meeting rooms will contain data projectors. A standard PC for Power Point presentation will be available. Please bring your Power Point on a CD or Memory Stick (with a backup!), or otherwise, you may use your own laptop computer.

A speaker preparation area will be provided in Foyer Area, Napier Bldg, Univ. of Adelaide and presentations will be loaded onto the presentation computers when possible.

## City Map



# General Information

## The University of Adelaide

Since its establishment in 1874 the University of Adelaide has been amongst Australia's leading universities. North Terrace is the earliest permanent home of the University. Development of the campus began when the South Australian Parliament granted five acres (2 hectares) to the University of Adelaide. It remains as the University's main campus and is the site of the most teaching and research facilities. Three Nobel prize winners: Bragg, Florey, and Warren were all educated at the University of Adelaide.

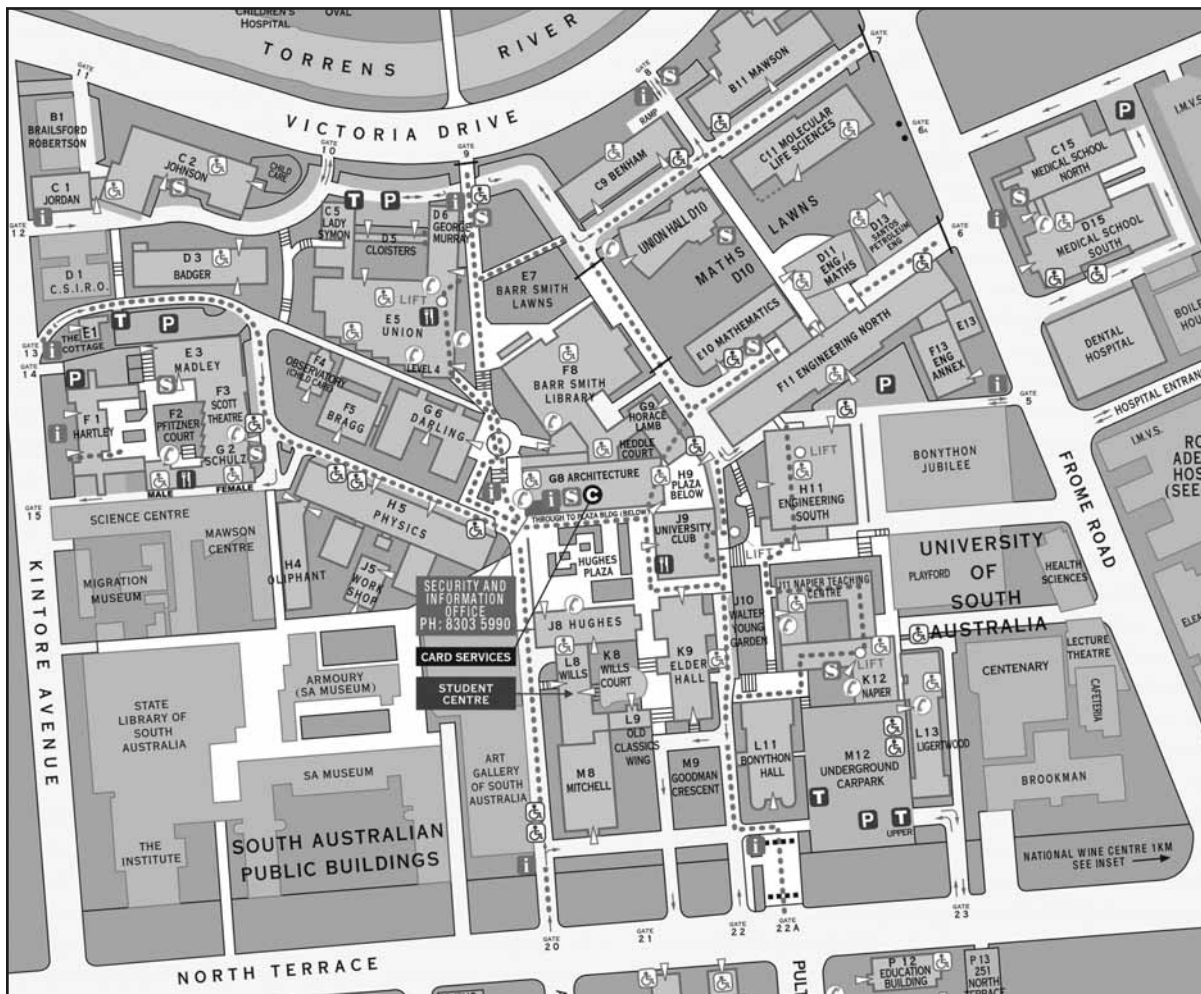
The University's contribution to the wealth and well being of South Australia and Australia as a whole-across all fields of endeavor-has been enormous. Adelaide has a fine tradition of exemplary scholarship and ground-breaking research, and its unique relationship with industry and other organisations ensures that their research expertise is translated into tangible benefits for the global community.

Adelaide's research is at the leading edge of knowledge, with research earnings consistently the highest per capita of any university in Australia. Analysis of the impact of publications and citations shows that the University of Adelaide is ranked in the top 1% in the world in 11 research fields. An innovative and forward-looking University, Adelaide has major strengths in wine and food, health sciences, biological sciences, physical sciences, information technology and telecommunications, environmental sciences and social sciences.

Located on Adelaide's cultural boulevard of North Terrace, the main campus contains many of the University's original buildings. Recent years have seen the rise of new buildings to accommodate world class schools. The modern, well-equipped lecture theatres and seminar rooms, central city location, and access to the River Torrens parklands make it a popular venue for national and international conferences.

You can reproduce the campus map from: <http://www.adelaide.edu.au/campuses/maps2006/northtce.pdf>

## University of Adelaide



## Adelaide

Founded in 1836, Adelaide is the state capital of South Australia. It is an attractive well-planned city of wide streets, gardens, squares, parklands and a mixture of historic and modern buildings. About one million people live in Adelaide, renowned for its rich cultural life. The city is small enough to be friendly and welcoming, yet large enough to provide plenty of attractions and entertainment.

The Adelaide Fringe celebrates the city's love of music and the performing arts with artists coming from around the world.

The University manages the landmark National Wine Centre of Australia, one of the city's true icons which caters to special events and conferences. There are also splendid wineries, food producers, villages and natural attractions nearby in the Mount Lofty Ranges, Barossa Valley and Southern Vales.

Set between the hills and the sea, Adelaide enjoys a Mediterranean climate with a 15°C average maximum in winter and 29°C average maximum during summer. Beaches, outdoor sports, theatres and shopping are popular pastimes. Adelaide offers a good quality of life, low cost of living and clean environment which make it ideal for an academically and personally rewarding study experience.

## Electricity

The electrical current in Australia is 240/250 volts AC 50Hz. The Australian 3-pin power outlet is different from many countries including Asia, so some visitors may need an adaptor socket. If your appliances are 100V, check if there is a 110/240V switch: if not, you will also need a voltage converter. Universal outlets for 240V or 100V shavers are found in most leading hotels.

## Transportation

Airport code for Adelaide is ADL. Information on the airport is at: <http://www.aal.com.au/>

Taxis are the recommended method and are easily obtainable at the airport or at your hotel. The approximate city-airport fare to expect is around \$A18.

Skylink Airport Shuttle specializes in providing a regular scheduled bus service between Adelaide Airport, Keswick Interstate Railway Terminal and the Adelaide CBD. Set downs and pick ups from most major city hotels. For further information see [www.skylinkadelaide.com](http://www.skylinkadelaide.com) or email [sales@skylinkadelaide.com](mailto:sales@skylinkadelaide.com)

A public transport bus service is also available. The direct 7 day a week JetBus services link the Airport and City through to the North Eastern suburbs and Elizabeth with a limited stop route that allow connections to most services in the City.

## City Bus Information

Adelaide is serviced by a very good public transit system. The web site is very good with detailed routes and timetables. <http://www.adelaidemetro.com.au>. In addition, there is an info centre at the corner of King William and Currie Street in the City, which is very close to both the conference venue and hotel. The Info Centre is open from 8am - 6pm Monday, Friday, 9am - 5pm Saturday and 11am - 4pm Sunday.

Visitors may also note that there is a tram from the city to the Glenelg, which is a quaint beachside town.

Further information about local transportation can be found on the web at:

<http://www.aal.com.au>

## Tipping in Australia

Please note that there is no tipping in Australia. You are not expected to tip in taxis, hotels, or restaurants.

## Restaurants

There are many excellent restaurants on Rundle Street, which is walking distance, only one block away from the conference venue. If you use transportation, other recommended restaurant areas are Melbourne Street, O'Connell St, The Parade, Unley Road, Henley Square, and their sounding areas.

## Tourist Information on South Australia

Please visit <http://www.aal.com.au> to find the secrets of Adelaide. If you have time to explore farther a field in South Australia, the Naracoorte Caves, Great Ocean Road, McClaren Vale, Barossa Valley, Clare Valley, Kangaroo Island, and the Flinders Ranges are recommended.

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