Grandior Prague Hotel, Czech Republic
Conference Venue
ICSS 2016
June 25th - June 29th
Prague, Czech Republic
MEETING PROGRAM

Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Information</td>
<td>1</td>
</tr>
<tr>
<td>Program-at-a-glance</td>
<td>5</td>
</tr>
<tr>
<td>Program Schedule</td>
<td>8</td>
</tr>
<tr>
<td>Sunday, June 26th</td>
<td>8</td>
</tr>
<tr>
<td>Monday, June 27th</td>
<td>10</td>
</tr>
<tr>
<td>Thursday, June 28th</td>
<td>14</td>
</tr>
<tr>
<td>Abstract Session</td>
<td>1</td>
</tr>
<tr>
<td>Author Index</td>
<td>67</td>
</tr>
</tbody>
</table>
General Information

The International Conference on Small Science (ICSS 2016) will take place at Grandior Prague Hotel, Prague, Czech Republic. The conference will be held from June 25th to June 29th, 2016.

Workshops on selected focus topics will include invited and contributed oral presentations from Sunday to Tuesday, and the poster sessions will be presented on the afternoon of Monday (June 27th).

REGISTRATION DESK HOURS

The ICSS registration desk, located in the Grandior Prague Hotel, Czech Republic, will be open during the following hours:

Saturday, June 25th .......................... 14:00-18:00
Sunday, June 26th ........................... 08:00-18:00
Monday, June 27th ........................... 08:00-18:00
Tuesday, June 28th ........................... 08:30-18:00

PUBLICATION INFORMATION

Authors of accepted presentations are encouraged but not required to submit their full manuscripts for publication reviewing as journal articles or book chapters. The following are possible publishing titles:

- Nanoscale Research Letters (Springer)
- Journal of Semiconductors (IOP)
- Lecture Notes in Nanoscale Science and Technology (Springer)
- Springer Series in Materials Science (Springer)
COMMITTEES

Advisory Committee

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Mohamed ANSARI, Universiti Tenaga Nasional (UNITEN), Malaysia

Paolo SAMORI, Univ. Strasbourg, France

Shu-Shen LI, CAS, China

Stephen PEARTON, University of Florida, USA

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Mahmoud MERIBOUT, The Petroleum Institute, United Arab Emirates

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Bin YU, State University of New York, USA

Ivan BOZOVIC, Brookhaven National Laboratory, USA

Jang Myoun KO, Hanbat National University, South Korea

Nico DE ROOIJ, EPFL and CSEM, Switzerland

Po-Wen CHIU, National Tsing Hua University, Taiwan

Shuyan XU, Nanyang Technological University, Singapore

Supriyo BANDYOPADHYAY, Virginia Commonwealth University, USA

Tomonobu NAKAYAMA, NIMS, Japan

Local Organizing Committee

Jan M. MACAK, University of Pardubice, Czech Republic
General Chair

Zhiming Wang

Institute of Fundamental and Frontier Sciences, UESTC, China

Co-Chair

Ercan Balikci

Bogazici University, Turkey
Program at-a-glance

Sunday Morning, June 26th

Keynote Lecture & Biochemical Sensors and Detection Technologies I 8:30-10:50 Room A

Biochemical Sensors and Detection Technologies II 11:05-12:40 Room A

Sunday Afternoon, June 26th

Energy Materials I 14:00-15:40 Room A

Micro and Nano Engineering I 17:55-19:35 Room A

Monday Morning, June 27th

General I 8:30-10:10 Room B

General II 10:25-12:30 Room B

MEMS I 8:30-10:10 Room C

Micro-Nano Photonics 10:25-13:05 Room C
<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>General III</td>
<td>14:00-15:40</td>
<td>Room B</td>
</tr>
<tr>
<td>General IV</td>
<td>16:10-17:50</td>
<td>Room B</td>
</tr>
<tr>
<td>Poster Session</td>
<td>15:40-16:10</td>
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<tr>
<td>Energy Materials II</td>
<td>14:00-15:40</td>
<td>Room C</td>
</tr>
<tr>
<td>Micro and Nano Engineering II</td>
<td>16:10-17:50</td>
<td>Room C</td>
</tr>
<tr>
<td>Optical and Luminescent Materials</td>
<td>9:00-9:50</td>
<td>Room B</td>
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<tr>
<td>MEMS II</td>
<td>10:30-12:35</td>
<td>Room B</td>
</tr>
<tr>
<td>Optical and Luminescent Materials</td>
<td>9:00-10:15</td>
<td>Room C</td>
</tr>
<tr>
<td>Biochemical Sensors and Detection Technologies III</td>
<td>10:30-12:55</td>
<td>Room C</td>
</tr>
<tr>
<td>Event</td>
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<tr>
<td>General V</td>
<td>14:00-15:40</td>
<td>Room B</td>
</tr>
<tr>
<td>General VI</td>
<td>15:55-17:10</td>
<td>Room B</td>
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<tr>
<td>Micro and Nano Engineering III</td>
<td>14:00-15:15</td>
<td>Room C</td>
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<tr>
<td>Energy Materials III</td>
<td>15:55-17:30</td>
<td>Room C</td>
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</table>
# Program for ICSS 2016

**Saturday June 25th**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker</th>
<th>Institution</th>
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<tbody>
<tr>
<td>14:00-18:00</td>
<td>Onsite registration &amp; Sign up</td>
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**Sunday June 26th**

## Room A

**Session: Keynote Lecture & Biochemical Sensors and Detection Technologies I**

**Chair: Agnese Sonato**

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30-9:00</td>
<td>A01: Straintronics: An extremely energy-efficient hardware platform for information technology</td>
<td>Supriyo Bandyopadhyay</td>
<td>Virginia Commonwealth University (VCU), USA</td>
</tr>
<tr>
<td>9:00-9:30</td>
<td>A02: Ultrafast Dynamics Within Silica-based Materials: Relevance to Nanophotonics and Nanocatalysis</td>
<td>Abderrazzak Douhal</td>
<td>Universidad de Castilla La Mancha (UCLM), Spain</td>
</tr>
<tr>
<td>9:30-10:00</td>
<td>A03: High speed 3D imaging microscopy, profilometry and vibrometry at the nanoscale</td>
<td>Ibrahim Abdulhalim</td>
<td>Ben Gurion University, Israel</td>
</tr>
<tr>
<td>10:00-10:25</td>
<td>A04: Coherent Diffractive Imaging of Single Layer Nano-Microspheres with Extreme Ultraviolet Radiation</td>
<td>Lap Van Dao</td>
<td>Swinburne University of Technology, Australia</td>
</tr>
<tr>
<td>10:25-10:50</td>
<td>A05: Raman Scattering for chemicals detection at trace levels</td>
<td>Zhengjun Zhang</td>
<td>Tsinghua University, China</td>
</tr>
<tr>
<td>10:50-11:05</td>
<td>Session Break</td>
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</tbody>
</table>

**Session: Biochemical Sensors and Detection Technologies II**

**Chair: Lap Van Dao**

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
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</thead>
<tbody>
<tr>
<td>11:05-11:30</td>
<td>A06: Novel detection concept in forensic analysis</td>
<td>Jan Halamek</td>
<td>University at Albany-SUNY, USA</td>
</tr>
<tr>
<td>11:30-11:55</td>
<td>A07: Compact plasmonic lab-on-chip for enhanced biosensing efficiency: fabrication and sensing strategies</td>
<td>Agnese Sonato</td>
<td>Laboratorio Nazionale IOM-CNR, Italy</td>
</tr>
<tr>
<td>11:55-12:15</td>
<td>A08: Gas sensing using recyclable Ag NRs@HfO2 SERS substrate</td>
<td>Ma Lingwei</td>
<td>Tsinghua University, China</td>
</tr>
<tr>
<td>12:15-12:40</td>
<td>A09: Nanostructured Plasmonic Chips for Chemical and Biological Sensing</td>
<td>Anuj Dhawan</td>
<td>Indian Institute of Technology Delhi, India</td>
</tr>
</tbody>
</table>

12:40-14:00 Lunch Break
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
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</thead>
<tbody>
<tr>
<td>14:00</td>
<td><strong>Session: Energy Materials I Chair: Huaiyu Shao</strong></td>
<td>A10: Graphene-based 3D frameworks for energy storage</td>
<td>Hirotomo Nishihara</td>
<td>Tohoku University, Japan</td>
</tr>
<tr>
<td>14:25</td>
<td>A11: Fine-controlled sub nano particles in Dendrimer</td>
<td></td>
<td>Kimihisa Yamamoto</td>
<td>Tokyo Institute of Technology, Japan</td>
</tr>
<tr>
<td>14:50</td>
<td>A12: Applications of Computational Chemistry to Functional Material Systems</td>
<td></td>
<td>Michihisa Koyama</td>
<td>Kyushu University, Japan</td>
</tr>
<tr>
<td>15:40</td>
<td>Session Break</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15:55</td>
<td><strong>Session: Micro and Nano Engineering I Chair: Kimihisa Yamamoto</strong></td>
<td>A14: Strained Ge-On-Insulator Substrates toward Optoelectronic Integrated Circuits</td>
<td>Kentarou Sawano</td>
<td>Tokyo City University, Japan</td>
</tr>
<tr>
<td>16:20</td>
<td>A15: Laser direct-write methods for inks microprinting</td>
<td></td>
<td>J. Marcos Fernández-Pradas</td>
<td>Universitat de Barcelona, Spain</td>
</tr>
<tr>
<td>16:45</td>
<td>A16: Nanotribology of thin functional coatings</td>
<td></td>
<td>Dae-Eun Kim</td>
<td>Yonsei University, South Korea</td>
</tr>
<tr>
<td>17:10</td>
<td>A17: Energy harvesting from random vibration</td>
<td></td>
<td>Fei Wang</td>
<td>South University of Science and Technology of China, China</td>
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<tr>
<td>18:00</td>
<td>Dinner Social</td>
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<tr>
<td>Time</td>
<td>Session/Abstract</td>
<td>Speaker</td>
<td>Affiliation</td>
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<tr>
<td>8:30-8:55</td>
<td>B01: Compact photonic devices based on graphene</td>
<td>Sangin Kim</td>
<td>Ajou University, Korea</td>
<td></td>
</tr>
<tr>
<td>8:55-9:20</td>
<td>B02: Wavelength conversion enhancements by double resonances of photonic/plamonic structures</td>
<td>Soon-Hong Kwon</td>
<td>Chung-Ang University, Korea</td>
<td></td>
</tr>
<tr>
<td>9:20-9:45</td>
<td>B03: Biomedical application of chitin nanofibers for cosmetic, wound healing, skin inflammation and biological adhesive</td>
<td>Kazuo Azuma</td>
<td>Tottori University, Japan</td>
<td></td>
</tr>
<tr>
<td>9:45-10:10</td>
<td>B04: Pleiotropic effects of chitosan and chitosan-nanofibers on oxidative stress related diseases</td>
<td>Makoto Anraku</td>
<td>Sojo University, Japan</td>
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<tr>
<td>10:10-10:25</td>
<td>Session Break</td>
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<tr>
<td>10:25-10:50</td>
<td>B05: High Throughput Fabrication of Metal Nanoparticle Related Materials by Liquid-Solid Reaction Systems by Organic Precursor Painting Reduction Method</td>
<td>Yamato Hayashi</td>
<td>Tohoku University, Japan</td>
<td></td>
</tr>
<tr>
<td>10:50-11:15</td>
<td>B06: Deformation and Fracture Processes in Graphene Materials with Lattice Defects</td>
<td>Boris Semenov</td>
<td>Peter the Great St. Petersburg Polytechnic University, Russian</td>
<td></td>
</tr>
<tr>
<td>11:15-11:40</td>
<td>B07: Mechanoresponsive Gold Complexes with Tunable Luminescent Properties</td>
<td>Tomohiro Seki</td>
<td>Hokkaido University, Japan</td>
<td></td>
</tr>
<tr>
<td>11:40-12:05</td>
<td>B08: A biosensor to detect inter-protein interaction and domain-domain interaction</td>
<td>Masahide Terazima</td>
<td>Kyoto University, Japan</td>
<td></td>
</tr>
<tr>
<td>12:05-12:30</td>
<td>B09: Approaching the Resolution Limit of Nano-gap by Using Focused Ion Beam Chemical Vapour Deposition</td>
<td>Jun Dai</td>
<td>Beijing Institute of Technology, China</td>
<td></td>
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<tr>
<td>12:30-14:00</td>
<td>Lunch Break</td>
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<tr>
<td>Time</td>
<td>Session</td>
<td>Title</td>
<td>Speaker</td>
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<tr>
<td>14:00-14:25</td>
<td>B10</td>
<td>Direct molecular alignment induced by masked photopolymerization with no alignment layer and non-polarized light</td>
<td>Kyohei Hisano, Tokyo Institute of Technology, Japan</td>
<td></td>
</tr>
<tr>
<td>14:25-14:50</td>
<td>B11</td>
<td>Preparation of a protein-chitin nanofiber complex from crab shells and its application as a reinforcement filler or substrate for biomineralization</td>
<td>Shinsuke Ifuku, Tottori University, Japan</td>
<td></td>
</tr>
<tr>
<td>14:50-15:15</td>
<td>B12</td>
<td>On-chip picosecond pulses in 2D systems</td>
<td>Alexander S. Mayorov, National University of Singapore, Singapore</td>
<td></td>
</tr>
<tr>
<td>15:15-15:40</td>
<td>B13</td>
<td>Printed manufacture ultra-integrated multi-analysis devices</td>
<td>Fengyu Li, CAS, China</td>
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<td><strong>Poster Session</strong></td>
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<td><strong>Session: General IV Chair: Kyohei Hisano</strong></td>
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<tr>
<td>16:10-16:35</td>
<td>B14</td>
<td>New Photofunctional Materials Based on Pyrene Chromophore</td>
<td>Gen-ichi Konishi, Tokyo Institute of Technology, Japan</td>
<td></td>
</tr>
<tr>
<td>16:35-17:00</td>
<td>B15</td>
<td>Energy-level structure and correlated electron dynamics in quasi-one-dimensional artificial atoms</td>
<td>Tokuei Sako, Nihon University, Japan</td>
<td></td>
</tr>
<tr>
<td>17:00-17:25</td>
<td>B16</td>
<td>Self-assembly of adenine-silver nanoparticles forms rings resembling the size of cells</td>
<td>Junhua Yu, Seoul National University, Korea</td>
<td></td>
</tr>
<tr>
<td>17:25-17:50</td>
<td>B17</td>
<td>Ultrasmall far-red emitting polymer dots: structures and photophysics</td>
<td>Satoshi Habuchi, King Abdullah University of Science and Technology, Kingdom of Saudi Arabia</td>
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<td>18:30</td>
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<td><strong>Dinner Social</strong></td>
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</table>
**Monday June 27th**  
**Room C**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session: MEMS I</th>
<th>Chair: Liantuan Xiao</th>
</tr>
</thead>
</table>
| 8:30-8:55  | C01: High Q Piezoelectric Micro-Resonators for Microwave filters | Matthieu Chatras  
XLIM Research Institute, France |
| 8:55-9:20  | C02: Cantilever MEMS devices - measurement tools and measurement objects | Grzegorz Jóźwiak  
Wroclaw University of Technology, Poland |
| 9:20-9:45  | C03: Optical MEMS sensors such as Micro Doppler sensor, Micro Blood flow sensor, Micro Shear Force Sensor, and their applications | Renshi Sawada  
KYUSHU University, Japan |
| 9:45-10:10 | C04: MEMS based tuneable filters for IR spectroscopy | Jarek Antoszewski  
The University of Western Australia, Australia |
| 10:10-10:25 | Session Break | |

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<thead>
<tr>
<th>Time</th>
<th>Session: Micro-Nano Photonics</th>
<th>Chair: Matthieu Chatras</th>
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</thead>
</table>
| 10:25-10:50| C05: Laser Induced Fluorescence Modification of Monolaye MoS2 and Its Potential Application | Liantuan Xiao  
Shanxi University, China |
| 10:50-11:15| C06: 3-dimension nano-structure of trap split based on nonlinear polarization | Yuqiang Jiang  
CAS, China |
| 11:15-11:40| C07: Infrared near-field microscopy on semi-conductor multilayers and quantum cascade lasers | Yannick De Wilde  
ESPCI ParisTech-CNRS, France |
| 11:40-12:05| C08: Silicon Photonic Grating-Assisted Vernier Resonators for 3-Port Filter Applications | Robert Boeck  
University of British Columbia, Canada |
| 12:05-14:00| Lunch Break | |
### Session: Energy Materials II  Chair: Arife Yurdakul

<table>
<thead>
<tr>
<th>Time</th>
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<th>Affiliation</th>
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<tbody>
<tr>
<td>14:00-14:25</td>
<td>C09: Onboard and Stationary Hydrogen Energy Storage in Nanostructured Mg-based Materials</td>
<td>Huaiyu Shao</td>
<td>Kyushu University, Japan</td>
</tr>
<tr>
<td>14:25-14:50</td>
<td>C10: Chiral Polymer-based Nanofiber Webs for Nanoenergy Harvesting and Dynamic Pressure Sensing</td>
<td>Kap Jin Kim</td>
<td>Kyung Hee University, Korea</td>
</tr>
<tr>
<td>14:50-15:15</td>
<td>C11: ZnO-based Nanoelectrodes for Dye-sensitized Solar Cell Application</td>
<td>Chaoyang Li</td>
<td>Kochi University of Technology, Japan</td>
</tr>
<tr>
<td>15:15-15:40</td>
<td>C12: Cu2ZnSnS4-based photocatalysts for hydrogen generation from water</td>
<td>Lawrence YoonSuk Lee</td>
<td>The Hong Kong Polytechnic University, Hong Kong</td>
</tr>
<tr>
<td>15:40-16:10</td>
<td>Poster Session</td>
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### Session: Micro and Nano Engineering II  Chair: Lawrence YoonSuk Lee

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<th>Time</th>
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<tbody>
<tr>
<td>16:10-16:35</td>
<td>C13: Nano-Scale Engineering of Hard and Tough Zirconia Based Ceramics</td>
<td>Arife Yurdakul</td>
<td>Dumlupinar University, Turkey</td>
</tr>
<tr>
<td>16:35-17:00</td>
<td>C14: Mesenchymal stem cell differentiation on nano pattern fabricated by femtosecond laser</td>
<td>Takao Hanawa</td>
<td>Tokyo Medical and Dental University, Japan</td>
</tr>
<tr>
<td>17:00-17:25</td>
<td>C15: Femtosecond laser micro- and nanoengineering of 3D environments for cancer cell study</td>
<td>Felix Sima</td>
<td>Romania/RIKEN-SIOM Joint Research Unit, Japan</td>
</tr>
<tr>
<td>17:25-17:50</td>
<td>C16: Modification of functional surface for wetting behavior in solid and liquid interface</td>
<td>Young-Rae Cho</td>
<td>Pusan National University, Korea</td>
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<tr>
<td>18:30</td>
<td>Dinner Social</td>
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### Tuesday June 28th
**Room B**

#### Session: Optical and Luminescent Materials  Chair: Francis Malit

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<tr>
<th>Time</th>
<th>Session</th>
<th>Speaker</th>
<th>Institution</th>
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<tbody>
<tr>
<td>9:00-9:25</td>
<td>B18: Classical and Quantum Light Generation with Nitride-based</td>
<td>Yong-Hoon Cho</td>
<td>Korea Advanced Institute of Science and Technology (KAIST), Korea</td>
</tr>
<tr>
<td></td>
<td>Semiconductor Nanostructures</td>
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<tr>
<td>9:25-9:50</td>
<td>B19: Direct imaging and chemistry of defect structures within SiAlON</td>
<td>Hilmi Yurdakul</td>
<td>Dumlupinar University (DPU), Turkey</td>
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<td>lattices and their effects on luminescence properties</td>
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<tr>
<td>10:15-10:30</td>
<td>Session Break</td>
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#### Session: MEMS II  Chair: Yong-Hoon Cho

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<tr>
<th>Time</th>
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<th>Institution</th>
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<tbody>
<tr>
<td>10:30-10:55</td>
<td>B20: Thick film permanent magnets for MEMS</td>
<td>Masaki Nakano</td>
<td>Nagasaki University, Japan</td>
</tr>
<tr>
<td>10:55-11:20</td>
<td>B21: Design and Characterization of Electrically-Sensitive Capacitance</td>
<td>Francis Malit</td>
<td>Technological Institute of the Philippines, Quezon City, Philippines</td>
</tr>
<tr>
<td></td>
<td>to Voltage Converter (CVC) for Parameter Extraction of Microelectromechanical Systems (MEMS) Capacitive Accelerometer</td>
<td></td>
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</tr>
<tr>
<td>11:20-11:45</td>
<td>B22: High Power RF MEMS Switches</td>
<td>Hosein Zareie</td>
<td>Urmia University of Medical Sciences, Iran</td>
</tr>
<tr>
<td>11:45-12:10</td>
<td>B23: Biomimetic MEMS/NEMS sensors inspired by marine life</td>
<td>Ajay Giri Prakash Kottapalli</td>
<td>Nanyang Technological University, Singapore</td>
</tr>
<tr>
<td>12:10-12:35</td>
<td>B24: Resonant MEMS mirrors for optical and laser scanning applications</td>
<td>Thomas Von Wantoch</td>
<td>Fraunhofer Institute for Silicon Technology ISIT, Germany</td>
</tr>
<tr>
<td>12:35-14:00</td>
<td>Lunch Break</td>
<td></td>
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</tbody>
</table>
## Session: General V  Chair: Toshihiro Hirai

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:00-14:25</td>
<td>B25: Accelerating inkjet towards immediate 3D printing</td>
<td>Moshe Einat</td>
<td>Ariel University, Israel</td>
</tr>
<tr>
<td>14:25-14:50</td>
<td>B26: ENVIRONMENTAL BARRIER COATINGS (EBC) FOR SILICON-BASED CERAMIC COMPOSITES</td>
<td>Nasrin Al Nasiri</td>
<td>Imperial College London, UK</td>
</tr>
<tr>
<td>15:15-15:40</td>
<td>B28: Characterization of nanomaterials using filed-flow fractionation</td>
<td>Haruhisa Kato</td>
<td>National Institute of Advanced Industrial Science and Technology (AIST), Japan</td>
</tr>
<tr>
<td>15:40-15:55</td>
<td>Session Break</td>
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## Session: General VI  Chair: Moshe Einat

<table>
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<th>Time</th>
<th>Title</th>
<th>Speaker</th>
<th>Affiliation</th>
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<tbody>
<tr>
<td>15:55-16:20</td>
<td>B29: Soft dielectric gels as electro active materials</td>
<td>Toshihiro Hirai</td>
<td>Shinshu University, Japan</td>
</tr>
<tr>
<td>16:20-16:45</td>
<td>B30: Construction of luminescent silver nanodots for probing and imaging</td>
<td>Sungmoon Choi</td>
<td>Seoul National University, Korea</td>
</tr>
<tr>
<td>16:45-17:10</td>
<td>B31: Construction of porous molecular materials via designed hydrogen bonding network</td>
<td>Ichiro Hisaki</td>
<td>Osaka University, Japan</td>
</tr>
<tr>
<td>18:00</td>
<td>Dinner Social</td>
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<td>Time</td>
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<tr>
<td>9:00-9:25</td>
<td>C17: Physics and applications of ballistic graphene Josephson junctions</td>
<td>Jonathan Prance</td>
<td>Lancaster University, UK</td>
</tr>
<tr>
<td>9:25-9:50</td>
<td>C18: Interface effects on acceptor silicon spin qubits</td>
<td>José Carlos Gª Abadillo-Uriel</td>
<td>Instituto de Ciencia de Materiales de Madrid (ICMM), Spain</td>
</tr>
<tr>
<td>9:50-10:15</td>
<td>C19: Two-dimensional Molybdenum Trioxide for Applications in Electronics</td>
<td>Sivacarendran Balendhran</td>
<td>RMIT University, Australia</td>
</tr>
<tr>
<td>10:15-10:30</td>
<td>Session Break</td>
<td></td>
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</tr>
<tr>
<td>10:30-10:55</td>
<td>C20: Signal and Information Processing with Biomolecules: Enzyme-Catalyzed Reactions and Their Cascades for Multi-Input Biosensing and Biocomputing</td>
<td>Vladimir Privman</td>
<td>Clarkson University, USA</td>
</tr>
<tr>
<td>10:55-11:20</td>
<td>C21: Electrochemical and optical biosensing based on nanobiomaterials</td>
<td>Ilia Kurochkin</td>
<td>M.V. Lomonosov Moscow State University, Russia</td>
</tr>
<tr>
<td>11:20-11:45</td>
<td>C22: A Microfluidic Chip for Detecting Protein Phosphorylation in Cells</td>
<td>Iuliana Lazar</td>
<td>Virginia Tech, USA</td>
</tr>
<tr>
<td>11:45-12:05</td>
<td>C23: Near- and far-field optical response of zig-zag silver nanorods for SERS</td>
<td>Jianghao Li</td>
<td>Tsinghua University, China</td>
</tr>
<tr>
<td>12:05-12:30</td>
<td>C24: DNA-based high multiplex detection methods</td>
<td>Barisic Ivan</td>
<td>AIT Austrian Institute of Technology GmbH, Austria</td>
</tr>
<tr>
<td>12:30-12:55</td>
<td>C25: DNA electrochemical sensor Obtained by &quot;layer by layer&quot; deposition of &quot;viologen&quot; -thymine derivatives and oligo-adenines on mesoporous TIO2 films</td>
<td>Carmen-Simona Asaftei</td>
<td>University of Applied Sciences, Germany</td>
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<td>12:55-14:00</td>
<td>Lunch Break</td>
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<td>14:00-14:25</td>
<td>Micro and Nano Engineering III</td>
<td>C26: Digital X-ray sources based on carbon nanotube electron emitters</td>
<td>Yoon-Ho Song</td>
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<td>14:25-14:50</td>
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<td>C27: Fabrication of Gold Nanoparticles into 1D and 2D Structures with Amyloidogenic Protein of Alpha-Synuclein and Their Applications</td>
<td>Seung R. Paik</td>
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<td>14:50-15:15</td>
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<td>C28: Photo-design of metal nanoparticles and metal/polymers nanoassemblies</td>
<td>Lavinia Balan</td>
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<td>15:40-15:55</td>
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<td>Session Break</td>
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<td>16:15-16:40</td>
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<td>C30: Electrochemical property of binary metal oxide conversion anode synthesized from Layered double hydroxides and its reaction mechanism</td>
<td>Noriyuki Sonoyama</td>
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<tr>
<td>16:40-17:05</td>
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<td>C31: Optimization of Li4Ti5O12 based material as high performance electrode for energy storage devices</td>
<td>Jae Hyun Kim</td>
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<tr>
<td>17:05-17:30</td>
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<td>C32: Redox reactions in lithium ion battery positive electrode materials by X-ray Compton scattering</td>
<td>Kosuke Suzuki</td>
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<tr>
<td>18:00</td>
<td></td>
<td>Dinner Social</td>
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<td>Poster Session</td>
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<td><strong>Poster Session</strong></td>
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</tbody>
</table>
| P1: Novel nickel iron phosphide (NIP) nanoparticles for photocatalytic hydrogen generation | **Chui-Shan Tsang**  
The Hong Kong Polytechnic University, Hong Kong |
| P2: Hierarchical spherical activated carbon with high performance for ultracapacitors | **Kwang Chul Roh**  
The Korea Institute of Ceramic Engineering and Technology, Republic of Korea |
| P3: The Magnetic Levitated Loading of the Dipole Trap for Cesium Atom         | **Jie Ma**  
Shanxi University, China |
| P4: Flexible and Controllable Photoluminescence Enhancement of Monolayer MoS2 through Continuous-wave Laser Irradiation | **Chengbing Qin**  
Shanxi University, China |
| P5: Solution-Processed Flexible Transparent Electrodes for Organic Solar Cell Applications | **Jae-Wook Kang**  
Chonbuk National University, Korea |
| P6: Thermal drift optimization technique for silicon microgyroscope           | **Jian Zhou**  
Nanjing University of Science and Technology, China |
| P7: Cross-linked Thermoplastic Polyurethane Electrospun Nanoweb with Improved Piezocapacitive Sensor Performance | **Mi Kyong Yoo**  
Kyung Hee University, Republic of Korea |
| P8: Electrospun Poly (lactic acid) Nanofiber Web Based Piezoelectric Sensors for Vital Signal Monitoring | **Yu Jin Ahn**  
Kyung Hee University, Korea |
| P9: Optical and lasing properties of micrometer-sized simple oxides: MgO and ZnO | **Uchino Takashi**  
Kobe University, Japan |
Invited Talk Session

A01: Straintronics: An extremely energy-efficient hardware platform for information technology
Supriyo Bandyopadhyay¹, Jayasimha Atulasimha²

¹Department of Electrical and Computer Engineering, Virginia Commonwealth University, Richmond, VA 23284, USA
Email: sbandy@vcu.edu, web site: http://www.people.vcu.edu/~sbandy

²Department of Mechanical and Nuclear Engineering, Virginia Commonwealth University, Richmond, VA 23284, USA

Information technology hardware (computer processors and memory) is faced with an ever-increasing demand for computing machinery that is energy-efficient. Toward this end, we have introduced the field of "straintronics" that deals with switching the magnetizations of multiferroic nanomagnets with bistable magnetization states using electrically generated mechanical strain. Such strain-switched nanomagnets can be interconnected using dipole interaction, or embedded in magneto-tunnelling junction devices (MTJ), to implement Boolean logic1-3, non-volatile memory4-6 and non-Boolean computing architectures such as spin neurons7 and Bayesian inference engines8. Theoretical simulations have shown that the energy dissipated in a bit operation can be less than 1 aJ making it, arguably, the most energy-efficient computing paradigm extant. The energy dissipation in a low density processor (108 switches/cm²) operating at ~ 1 GHz clock speed can be so low (~ 1 mW/cm²) that it can be powered by harvesting energy from the surroundings9 (4G networks, cable TV, even wind and vibrations) and not require a battery! They are obviously very attractive for implanted medical devices (brain wave monitors in epileptic patients, pacemakers), wearable electronics (Fitbit, Apple Watch, Google glass) and personal communicators.

Straintronic operation of both straintronic nanomagnetic memory and logic have been demonstrated by us10, utilizing 200-300 nm feature sized magnetostrictive Co and FeGa nanomagnets delineated on piezoelectric PMN-PT substrates to form 2-phase multiferroics. Repeatable read/write operations for memory, and NOT gates for logic, as well as Bennett clocking in logic chains, have been demonstrated. From the experimental data10, 11, we have extrapolated that in ~100 nm scaled structures, the energy dissipation per bit is a mere 2-3 aJ, making the energy cost per bit operation exceedingly low - low enough to extend the Moore's law of electronics well beyond the year 2020.
Abstract

2

Fig. 2: Three ~100 nm sized Co nanomagnets of progressively decreasing shape anisotropy on a PMN-PT substrate are close enough to be dipole coupled. The magnetizations are initialized with a magnetic field in the same direction. Stress generated by applying a global electric field across the substrate makes the magnetic ordering in some of the trios (shown with yellow arrows) anti-ferromagnetic encoding the bit string 101 or 010 where the first bit is replicated in the third, resulting in successful Bennett clocking. From ref. [11].

References:
2. M. Salehi-Fashami, et al., Nanotechnology, 22, 155201 (2011);
7. A. K. Biswas, et al., Nanotechnology, 26, 285201 (2015);

A02: Ultrafast Dynamics Within Silica-based Materials: Relevance to Nanophotonics and Nanocatalysis

Abderrazzak Douhal

Departamento de Química Física, Facultad de Ciencias Ambientales y Bioquímica, and INAMOL, Universidad de Castilla-La Mancha, Avenida Carlos III, S.N., 45071 Toledo, Spain.

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Silica-based materials are being used in several fields of science and technology, including catalysis, photonics, and drug delivery, to cite few applications. Understanding the interactions of dyes, particles and drugs with these materials is paramount for a better understanding of the formed hybrid complexes, and for the development of the related fields. During the last years, we have reported on the fast and ultrafast dynamics of several dyes trapped within silica-based mesoporous and zeolite materials. [1-9] We have also used single molecule/particle fluorescence microscopy to map the interaction of guest molecules with mesoporous materials. In this lecture, I will show and discuss our advances in this area by using femtosecond emission spectroscopy to interrogate the confined dynamics of selected guests undergoing proton-, charge- and electron-transfer reactions in addition to possible twisting motion within the used silica materials. Some of the guests show caged monomers, J- and H-aggregates within the hosts. Others can interact with the surrounding medium of the hybrid materials. We will examine the effect of the cage/pore size, nature and amount of the metal doping the silica materials on the populations and dynamics of these trapped species. We will also show how intramolecular reactions/events can compete with the interactions between the guest and the host material giving rise to a possible tuning of the photobehavior and photocatalysis of these hybrid nanomaterials.

Acknowledgments: This work was supported by the MINECO and JCCM through projects: Consolider Ingenio 2010 (CSD2009-0050, MULTICAT), MAT2014-57646-P and PEII-2014-003-P.

References:
7. C. Martin et al., PCCP, 18, 2152 (2015).

A03: High speed 3D imaging microscopy, profilometry and vibrometry at the nanoscale

Ibrahim Abdulhalim and Avner Safrani
Department of Electro-Optic Engineering and The Ilse Katz Institute for Nanoscale Science and Technology, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
Email: abdulhlm@bgu.ac.il

A fast phase shift 3D microscopy system is presented using a polarization based Linnik interferometer operating with three synchronized, phase masked, parallel detectors. Using this method, several important applications which require high speed and accuracy are demonstrated in 50 volumes per seconds and 2 nm height repeatability, fast sub-nm vibrometry, tilt measurement, nanoscale roughness measurement, 3D profiling of fine structures and height uniformity in an integrated semiconductor chip. Using multiple wavelengths approach phase unwrapped imaging is demonstrated with topography exceeding few microns. The figure below shows different examples of images of Cu micro-pillar arrays.

References:


A04: Coherent Diffractive Imaging of Single Layer Nano- Microspheres with Extreme Ultraviolet Radiation

Lap Van Dao and Peter Hannaford
Centre for Quantum and Optical Science, Swinburne University of Technology, Melbourne, VIC-3122, Australia
Email: dvlap@win.edu.au

Because optical components for X-ray and Extreme Ultraviolet (XUV) radiation are difficult to produce coherent diffraction imaging (CDI), or “lens-less imaging” has been developed as an alternative approach to capture high resolution images in this region. In CDI the sample is illuminated with a coherent x-ray source then the far-field diffraction pattern is recorded. The image of the object can be reconstructed by diffraction picture using iterative phase retrieval algorithms. The resolution of the CDI technique basically depends on the wavelength of the incident radiation and the largest recorded order of diffraction. CDI has now been successfully implemented using a variety of coherent sources including synchrotrons, free electron x-ray lasers, and high harmonic generation (HHG) sources [1]. High order harmonic generation, which occurs following interaction between an intense laser pulse and an atomic or molecular medium, can provide soft X-Ray and extreme ultraviolet radiation with high degree of spatial coherence. The size of the HHG beam at the sample spot was usually > 1 mm and therefore the effective photon flux for illumination of a micron-scale sample was also low. By using XUV focusing mirrors, a single harmonic beam can be confined.
to a smaller area (< 50μm) that is comparable to the size of the sample. As a result the total photon flux through the sample is increased and hence the exposure time needed to capture a full dynamic range diffraction pattern can be significantly reduced.

In this paper we have demonstrated coherent diffractive imaging for the absorption samples using a table-top soft x-ray source at a wavelength around 30 nm based on the harmonic emission from argon gas. By using focusing mirrors, a single harmonic can be selected and converged to illuminate the sample [2]. As a result, the quality of the diffraction pattern is improved and the required exposure time is significantly reduced. This experimental scheme is highly promising for imaging sub-10 nm objects using a shorter wavelength source. In addition, our successful reconstructed image for the absorption sample opens up the possibility to develop a table-top soft x-ray microscope to image other non-binary absorbing samples.

Fig1. (a,d) Scanning electron microscope image, (b,e) diffraction pattern, and (c,f) reconstructed image of the sample with single layer nano- and microspheres.

References:

A05: Raman Scattering for chemicals detection at trace levels

Z.J. Zhang¹, L.W. Ma¹, M.J. Hou¹ and Y. Huang¹

¹Key Laboratory of Advanced Materials, School of Materials Science and Engineering, Tsinghua University, Beijing 100084, China.
E-mail: zjzhang@tsinghua.edu.cn

It is of importance to realize trace level analysis of chemicals qualitatively and quantitatively. Surface-enhanced Raman scattering (SERS) has been proven a powerful means for trace level detection of molecules at a fast speed, with the fingerprints advantage, when using nanostructures of noble metals like Cu, Ag and Au as the substrates, among which Ag nanostructures are the most promising one. For practical usages of Ag nanostructures, however, one need to solve several problems, e.g. its morphology changes at relative low temperatures inducing fluctuation in SERS sensitivity, oxidized/sulphurized in air easily and corroded in harsh environments and chemical thus losing the SERS sensitivity. In addition, there is a lack of methods to realize compositional and quantitative analysis of chemicals at trace levels using SERS technique. We report that chemicals at trace levels can be detected by using surface-enhanced Raman scattering with silver nanorods as the substrate. Based on the principal component analysis method of the Raman spectra of chemical mixtures, by using the triangle and balanced rules, one could get the compositional information of the chemical components forming the mixtures at trace levels. In addition, using the partial linear square root method to analyze the Raman spectra, one could get quantitative information of the chemicals at trace levels. For the practical applications of the silver nanorods as the substrate, we developed several ways to protect the silver nanorods from oxidation and sulphurization in the air, with long-term stability in sensitivity, structure and morphology, and could be reused by the photocatalytically active surface to degrade the molecules attached on it.

A06: Novel detection concept in forensic analysis

J. Agudelo, E. Brunelle, C. Huynh, L. McGoldrick and J. Halánek

Abstract 4
In the past century, fingerprinting has become a universally accepted and reliable method for identification. Fingerprint analysis, however, still consists only of pictorial/visual comparisons and ignores the importance of sebum residue left with latent prints. There has been no effort to overcome the discipline’s dependence on the existence of a prerecorded matching fingerprint for comparison. Due to this limitation, an information-rich latent print may not be used to its full potential. Our lab has developed a bioaffinity-driven cascade for the determination of gender from those components. We have further created a ninhydrin-based chemical assay that is capable of this. Further assays are being developed for other physical traits.

The analysis of blood samples for drug and DNA testing is now routinely used in crime laboratories for criminal investigations. These tests are able to provide a multitude of useful information about the respective sample originators that can serve as both investigative leads and incriminating evidence. There is, however, a weakness in these methods that need to be addressed: time. Currently, most blood analysis techniques are time consuming and must be performed in laboratories, meaning there is a time lag in evidence processing that could prove fatal to an investigation. Our lab experiments with a new methodology for quick, on-site blood analysis for the determination of both the age of the individual and the time since deposition of a blood sample. Further research is being done on this topic as well.
reactions using a sensing substrate able to detect up to 100 biological events onto a single 1cm²-sensor chip (Figure 1 (b)). The sensing architectures here proposed represents a new promising SPR technology satisfying the major requirements of recent SPR technologies: scalability and high throughput. Moreover, in general, the technologies reported in this study can be applied to a great variety of biological systems and sensing geometries.

**Fig1.** (a) SAW-SPR microfluidic biosensor chip. (b) Multiple detection SPR sensor chip.

**References:**
Presentation

A08: Gas sensing using recyclable Ag NRs@HfO₂ SERS substrate

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As an influential method for trace molecule detection, surface-enhanced Raman scattering (SERS) technique is a promising analytical tool in fields of chemistry, biology, medicine and life science, with the advantages of high sensitivity, rapid response speed and non-destructive determination. [1] In general, noble metal materials like Au, Ag, and Cu of multiple nanostructures can render excellent SERS performance. However, from practical application viewpoint, not only strong enhancement but also stability, recyclability as well as cost-effective preparation methods are necessary for satisfactory SERS sensors. To this end, herein we reported the preparation of Ag nanorods coated with an ultrathin HfO₂ layer (Ag NRs@HfO₂), for the synthesis of stable and recyclable SERS sensor.

Figure 1a shows the schematic for SERS detection of 2-naphthalenethiol (2-NAT) gas molecules using Ag NRs@HfO₂ substrate. N₂ was utilized as the carrier gas to transport 2-NAT from its ethanol solution to the SERS substrate, and Raman spectra were obtained in situ. Figure 1b shows the Raman spectra of 600 ppb 2-NAT and its Raman intensity changes at 1064 cm⁻¹ obtained within 100 minutes. The Raman signals increased gradually and reached saturation afterwards, demonstrating the feasibility of the SERS platform for trace molecule sensing. Meanwhile, it is known that Ag nanostructures coated with oxide layers exhibited much better thermal stability compared with bare silver.[2] Therefore, after Raman detection, the Ag NRs@HfO₂ substrate could be annealed on a hot plate at 200-300 °C.
for a few seconds, without damaging the morphology or sensitivity of SERS substrate. The adsorbed molecules were gradually decomposed at high temperatures, so this substrate could be reused as a new and clean SERS sensor (see Figure 1c).

Fig1. (a) The schematic for SERS detection of 2-NAT gas molecules using Ag NRs@HfO2 substrate. (b) Raman spectra of 600 ppb 2-NAT and its Raman intensity changes at 1064 cm$^{-1}$ obtained within 100 minutes. (c) Raman signals at 1064 cm$^{-1}$ obtained in 40 minutes and after heating the substrate at 250 $^\circ$C for 30 seconds, and this detection cycle was repeated for 3 times.

References:

A09: Nanostructured Plasmonic Chips for Chemical and Biological Sensing

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Email: adhawan@ee.iitd.ac.in
Web site: http://ee.iitd.ac.in/people/adhawan.html

Plasmonic nanostructured chips — more specifically Surface enhanced Raman scattering (SERS) substrate chips — were fabricated by employing different techniques such as electron beam lithography (EBL) and focused ion beam (FIB) milling, such that sub-15 nm gaps were present between neighboring plasmonic nanostructures. Along with having a large SERS enhancement factor, it is important that the SERS substrate chips can be fabricated in a controllable and repeatable manner. Silver and gold nanostructures of different geometries such as nanopillar arrays, nano-donut arrays, nanolines, as well as nanopillars in a checkboard pattern were fabricated using EBL and FIB milling. Moreover, complex plasmonic nanoantenna structures were also fabricated using FIB milling and EBL. Plasmonic chips were also developed on a wafer scale by employing a combination of deep UV lithography, atomic layer deposition, and electron beam evaporation [1]. We fabricated SERS substrate chips consisting of plasmonic nanofingers on nanowires by first fabricating triangular shaped nanowire (TSNW) arrays, followed by the development of angled triangular shaped Au nano-fingers on the surface of these nanowires using electron-beam evaporation. Finite Difference Time Domain (FDTD) simulations were also carried out to obtain EM (electromagnetic fields) in the vicinity of the different types of plasmonic nanostructured chips. Commercial FDTD software FullWave 9 was employed for the FDTD simulations, and nanostructures having different sizes and shapes were evaluated [2-3]. The spacings between the plasmonic nanostructures were varied such that the effect of nanostructure spacings on the EM fields (and therefore on the SERS enhancement factor) in the regions between the plasmonic nanostructures could be studied.

References:
2. Y. Sharma and A. Dhawan, Optics letters 41, 2085-2088 (2016).
A10: Graphene-based 3D frameworks for energy storage

Hirotomo Nishihara1,2, Takashi Kyotani1

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2PRESTO, the Japan Science and Technology Agency (JST), 4-1-8 Honcho, Kawaguchi 332-0012, Japan

Graphene-based materials are expected as electrode materials for electrochemical capacitors, and a huge number of reports have been published in this field over recent years [1]. One of the reasons why many people are motivated to use graphene is its large geometric surface area (2630 m²/g). However, in most cases, the actual specific surface areas of the materials produced so far are much lower (ca. 1/10–1/4) than the ideal value, because 2D graphene is inevitably stacked and loses most surfaces. To fully utilize its potential surface, it is necessary to avoid stacking by modifying 2D graphene into a self-standing 3D porous framework. In this talk, two types of graphene-based porous frameworks are introduced: zeolite-templated carbon (ZTC) [2, 3] and graphene mesosponge (GMS), and their unique features as electrodes of electrochemical capacitors are mentioned. Both of them are comprised mainly of single-layer graphenes and have large surface areas, but they have very different amount of edge sites and thereby possess different advantages, respectively.

ZTC is an ordered microporous carbon obtained as a negative replica of zeolite [2, 3]. The framework of ZTC consists of a cross-linked bucky-bowl-like nanographene. Due to its huge gravimetric (2000–4000 m²/g) and volumetric (1400–1700 m³/cm³) surface areas, ZTC exhibits remarkably high gravimetric/volumetric capacitance [4]. In addition, its three-dimensionally arrayed and mutually connected 1.2-nm nanopores greatly reduce the ion-transfer resistance, and ZTC therefore shows very high rate performance despite its small pore size. ZTC contains a lot of highly reactive edge sites, which are easily electrooxidized in aqueous electrolytes [5,6]. Such electrochemical oxidation introduces a large number of quinone groups into the edge sites of ZTC, with keeping the framework structure intact [5]. The quinone groups thus introduced give rise to the occurrence of a very large pseudocapacitance in acidic electrolytes, and the resulting capacitance reaches 335–511 F/g [6]. Recently, it has been demonstrated that ZTC could be electrooxidized to form redox reactive functional groups also in an organic electrolyte (1 M Et₄N-BF₄ in propylene carbonate). Such polarization behavior has never been observed in general activated carbons. The available potential window of ZTC in this electrolyte is –2.0 – 1.0 V (vs. Ag/Ag⁺), and ZTC shows high specific capacitance ranging from 230 to 330 F/g, with good rate performance as well as cyclability [7].

By using commercial alumina nanoparticles as a hard template, GMS can be prepared through chemical vapor deposition (CVD) using methane as a carbon source [8]. With an appropriate CVD condition, the carbon layer can be tuned mostly to single-layer graphene. The mesoporous carbon obtained by removing the template can retain its porosity very well even upon a high-temperature treatment at 1800 °C. GMS thus obtained possesses a high surface area (1700–2000 m²/g), but has a very little amount of edge sites, unlike conventional high-surface carbon materials. With its sufficient capacitance and remarkably wide potential window (up to 4 V), GMS exhibits a double higher energy density in a two-electrode cell than conventional activated carbons used in commercial ECs.

References:
A11: Fine-controlled sub nano particles in Dendrimers

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Keywords: Dendrimer, Subnano metal particle

We show that tin chlorides, SnCl₂ and FeCl₃ complexes to the imines groups of a spherical polyphenyl-azomethine dendrimer in a stepwise fashion according to an electron gradient, with complexation in a more peripheral generation proceeding only after complexation in generations closer to the core has been completed. The metal assembly in a discrete molecule can be converted to a size-regulated metal cluster with a size smaller than 1 nm as a molecular reactor. Due to the well-defined number of metal clusters in the subnanometer size region, its property is much different from that of bulk or general metal nanoparticles.

Dendrimers are highly branched organic macromolecules with successive layers or “generations” of branch units surrounding a central core. Organic inorganic hybrid versions have also been produced, by trapping metal ions or metal clusters within the voids of the dendrimers. Their unusual, tree-like topology endows these nanometre-sized macromolecules with a gradient in branch density from the interior to the exterior, which can be exploited to direct the transfer of charge and energy from the dendrimer periphery to its core.

Here we show that tin ions, Sn²⁺, complex to the imines groups of a spherical polyphenylazomethine dendrimer in a stepwise fashion according to an electron gradient, with complexation in a more peripheral generation proceeding only after complexation in generations closer to the core has been completed. By attaching an electron-withdrawing group to the dendrimer core, we are able to change the complexation pattern, so that the core imines are complexed last. By further extending this strategy, it should be possible to control the number and location of metal ions incorporated into dendrimer structures, which might and uses as tailored catalysts, building blocks, or fine-controlled clusters for advanced materials (Figure 1).

Figure 1. Fine-controlled Metal Assembly in Dendrimers

A12: Applications of Computational Chemistry to Functional Material Systems

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Properties of functional materials are determined by a variety of factors including materials, interface, morphology, and operation...
To design the materials with properties best fit with the required function, it is important to effectively use the simulation methods. Figure 1 shows a schematic illustration of three design approaches for porous electrode systems. Recent development of theoretical chemistry as well as computer science, one can expect that properties of bulk and ideal surfaces of materials are theoretically investigated with a reasonable computational cost. Thus, much effort should be devoted to the interface, microstructure, and bridging those three approaches. In the author’s research group, multi-scale, multi-physics simulation of porous electrode systems is challenged. In such simulation, important aspect is the incorporation of complicated structures at both m \[1-2\] and atomistic [3] scales into the simulation. In this work, the state-of-the-art results of computational simulation taking into account the microscopy observations for functional materials used in energy devices will be introduced.

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The relaxor-ferroelectric materials based on lanthanum-doped Pb (Zr, Ti) O\textsubscript{3} are consider to be one of the potential candidates for use in pulse power applications. In this study, the epitaxial lead zirconate titanate Pb(Zr\textsubscript{0.52}Ti\textsubscript{0.48}) O\textsubscript{3} (undoped, PZT) ferroelectric thin films and Pb\textsubscript{0.9}La\textsubscript{0.1}(Zr\textsubscript{0.52}Ti\textsubscript{0.48}) O\textsubscript{3} (La-doped, PL10ZT) relaxor-ferroelectric thin films were grown on SrRuO\textsubscript{3}/SrTiO\textsubscript{3}/Si substrates by pulsed laser deposition. A 300-nm-thick epitaxial PL10ZT thin film exhibited a large recoverable storage density \(U_{reco}\) of 13.7 J/cm\textsuperscript{3} with a high energy efficiency \(\eta\) of 88.2\% under an applied electric field of 1000 kV/cm and at 1 kHz frequency. These high values are due to the slim and asymmetric hysteresis loop, compared to the values in the undoped epitaxial PZT film (\(U_{reco} = 9.2\) J/cm\textsuperscript{3} and \(\eta = 56.4\%\)) with a higher remnant polarization and a small shift in the hysteresis loop, under the same electric field. These properties demonstrate that the epitaxial PL10ZT relaxor-ferroelectric thin films have the promising for application in high power energy storage devices.

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Fig. 1. Bipolar ferroelectric P-E hysteresis loops and switching currents (inset) of the PL10ZT and PZT thin films performed at an electric field of ±200
kV/cm and 1 kHz frequency. (b) Dielectric constant-electric field loops of the PL10ZT and PZT thin films.

Fig. 2. (a) Recoverable energy storage density (Ureco) and (b) energy efficiency (η), of PL10ZT and (b) PZT thin films, as a function of applied electric field and at 1 kHz frequency.

A14: Strained Ge-On-Insulator Substrates toward Optoelectronic Integrated Circuits
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Today’s highly advanced electronics has been established by continual developments of the silicon (Si) large scaled integrated circuit (LSI) based on miniaturization (scaling) of physical sizes of metal-oxide-semiconductor field-effect-transistors (MOSFETs), the most elementary devices in the LSI. However, serious problems have been imposed recently, such as the scaling limit and immense power consumptions due to very dense electric interconnections. Overcoming these problems is indispensable for the sustainable growth of electronics in the future.

For this purpose, germanium (Ge) has emerged as a promising material for both CMOS channels and photonic devices owing to its high carrier mobilities and band gap corresponding to telecommunication wavelength. Particularly, the introduction of tensile strain into Ge is known to decrease direct bandgap, leading to enhancement of light emission via direct transition. Furthermore, Ge-on-insulator (GOI) structures can add many benefits to both electronic and photonic devices, and performance improvements are attainable based on GOI. Therefore, we have been developing tensile-strained GOI by means of Ge epitaxial growth on Si and wafer transfer technique. We have shown that the tensile strain of 0.2% is introduced into a Ge grown on a Si with a two-step growth manner and the strain is well maintained after the GOI fabrication. It is known that undoped Ge epitaxial films show p-type conduction due to acceptor-like defects. Especially, more defects exist around the interface between Ge and Si due to the strain relaxation and low growth temperature for a first Ge layer. In this study, the GOI is finally thinned and polished by CMP, and the defective region was completely eliminated. Moreover, selective etching technique was developed using SiGe etching stop layers to form thinner GOIs. As a result, we obtained defect-free GOIs (Fig.1), from which the hole mobility over 1500 cm2/Vs and enhanced room-temperature photoluminescence were demonstrated. This indicates that the strained GOI is a promising template for high-performance Ge-based optoelectronic integrated circuits.

Fig. 1 Cross-sectional TEM images of the fabricated GOI substrate.

A15: Laser direct-write methods for inks microprinting
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Lasers can be used for the direct-write of materials in subtractive and additive configurations. The printing of inks with lasers is based on the laser-induced forward transfer (LIFT) technique. [1] LIFT is an additive technique that was first developed for printing inorganic materials from thin solid films donors with micrometric resolution. However, the extension of the LIFT concept on thin liquid films donors allowed to extend the range of printable materials. This nozzle-free approach...
has been demonstrated feasible for printing complex and delicate materials such as nanoparticle inks, polymers, and biological materials as DNA, proteins or living cells.

In this work we review the different approaches for printing inks with lasers, paying special attention to the analysis of the liquid transfer dynamics and to the most recent developments towards the optimization of the performance of the technique.

The principle of operation of LIFT is based on the localized absorption of a laser beam which is focused through a transparent substrate in the thin film of the ink containing the material to be printed (donor film). As a result of the laser absorption, a cavitation bubble is generated. The expansion of the bubble displaces a fraction of the liquid around it, leading to the formation of a jet which propagates away the donor film and towards the acceptor substrate placed in front. The contact of the jet with the acceptor substrate results in the deposition of the liquid (Figure 1). The generation of micropatterns is achieved through the motion of the laser beam and/or the receiving substrate.

More recently, it has been demonstrated that weakly absorbing inks can also be printed directly from a reservoir containing the ink by using ultrashort laser pulses. In this case, the cavitation bubble is generated through nonlinear absorption mechanisms below the free surface of the ink.

References:

A16: Nanotribology of thin functional coatings

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As mechanical devices get miniaturized and more precise, issues related to reliability and durability of the comprising parts continue to emerge. Particularly in systems where conventional liquid lubrication methods cannot be applied, there is a profound need to develop effective techniques to mitigate the tribological problems. One way to tackle this problem is through development of coatings that may be applied on the surface of the mechanical component to reduce friction and wear. For this purpose, numerous types of coatings have been proposed. [1-3] In design of such coatings, there are several parameters that need to be considered including material type, thickness, uniformity, number of layers and deposition technique. In this regard, it is expected that novel functional coatings with superior tribological properties will continue to be proposed.

In this work, the basic concept exploited to reduce wear was to control the stiffness of the coating rather than to increase its hardness. The feasibility of this concept has been demonstrated using coatings composed of nanowires and surface structures. [4-5] In addition to the need to control the mechanical properties of the coating, adhesion that depends on the surface energy of the coating needs to be minimized. It has been well documented that thin organic films are effective for this purpose. The potential use of such films has also been confirmed in micro-ball bearing application. [6] It is expected that the tribological properties may be improved further by combination of both functional coatings and low surface energy organic films.
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References:

A17: Energy harvesting from random vibration
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Vibration based energy harvesting device with a linear spring-mass system can generate maximum power output at a specific resonant frequency, but typically with a narrow bandwidth. This limit the practical use since the ambient vibrations exhibit random frequency spectrum. One approach is to use a broadband energy harvester with multiple beams [1]. The harvester is basically a series of separate linear devices with different resonant frequencies. The efficiency of the overall devices is in doubt [2], although it is able to harvest energy at multiple resonant frequencies. Another approach is to design a double well potential with a bi-stable resonant system which can be realized by adding external magnets or by buckling a beam with preload. [3-4]. In this talk, I will introduce a new piezoelectric energy harvester (PEH) device (shown in Fig.1a) with dual resonant structure, which consists of two cantilever-mass systems to achieve two different resonant frequencies. For each beam-mass system, there is one specific resonant frequency. By tuning the separate resonant frequencies of the two subsystems, we can regulate the bandwidth of the PEH device due to their vibration coupling effect. The PEH-top (PEH-T) and PEH-bottom (PEH-B) devices are connected in series during the test, which provides a complimentary voltage output according to the external vibration. In an optimal design, the PEH with dual resonant structure can outperform the sum of the two subsystems in terms of the energy harvested from random vibration sources.

References:

B01: Compact photonic devices based on graphene
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Abstract 13
Electrically tunable permittivity of graphene provides an excellent tool in photonic device design. Many previous works on graphene-based photonic devices relied on variable absorption in graphene, which is naturally small in the optical region and thus, required resonant structures to enhance it. Recently, we have proposed several novel schemes to control the property of guided modes in graphene-based plasmonic waveguide structures exploiting the feature that the permittivity of graphene can be controlled to be close to zero.\cite{1,2,3} Especially, in the structure composed of two layers of graphene, the mode property can be varied greatly: the propagation loss of the guided mode can be varied from 0.4 dB/m to 63 dB/m with just 0.03 eV change of Fermi-level of graphene, and the mode can be even turned from a guide mode to a leaky mode via electrical doping change in graphene if surrounding dielectric materials are properly chosen. Based on the widely controllable mode property, compact optical devices such as modulators and switches have been designed and their performances have been theoretically investigated.

Fig. 1 shows an example of designed optical modulator composed of two graphene layers. Depending on Fermi-level of graphene, the existence of the guided mode in the top slab waveguide in Fig. 1(a) can be manipulated. For $E_F = 0.9$ eV, the slab waveguide supports a low-loss guided mode (Fig. 1(b)), whereas, no guided mode exists for $E_F = 0.97$ eV (Fig. 1(c)). This device can work as a waveguide-type optical modulator. Here, it should be noted that the transmission modulation depends on the electrically controlled existence of a guided mode of the waveguide, not the variation of the ohmic loss of graphene, resulting in a low insertion loss and a small device footprint (approximately 4 m long with 20 dB extinction ratio).

Fig1. A slab waveguide-type modulator based on the GA-FTIR. (a) Schematic diagram of the modulator in which one of the semi-infinite high-index (Si) media in the GA-FTIR structure is replaced by a 400-nm-thick single-mode slab waveguide, the two graphene layers are separated by a 10-nm-thick SiO2 layer, and a semi-infinite Si layer at the bottom serves as a leaky channel. The red arrow indicates the light input. (b, c) Electric field distributions obtained from 2D FEM simulation of the device in the on-state ($E_F = 0.9$ eV) and the off-state ($E_F = 0.97$ eV), respectively, at $\lambda = 951$ nm.

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B02: Wavelength conversion enhancements by double resonances of photonic/plamonic structures

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Recently wavelength conversion technology which converts near infrared (NIR)/ultraviolet (UV) light into visible light has been widely studied for various applications in solar cells, imaging sensor, and bio imaging, etc. In particular, the efficiency of upconversion
process which converts NIR light into visible light is greatly improved by developments of materials. However, since the conversion efficiency is still very low because of low NIR absorption efficiency and inefficient energy transfer processes, realizations of practical photonic devices are still challenging. On the other hand, nanoparticles or nanostructure made by dielectric or metal can interact strongly with light due to resonant properties. When the resonance is matched to absorption wavelength, the incident light intensity is amplified to increase the absorption efficiency. If the resonance corresponds to the emission wavelength, the enhancement of the spontaneous emission rate results in total amount of the emission light. In this talk, we present simultaneous enhancement of the absorption/emission efficiency in the upconversion process by using double resonant photonic/plasmonic structures [1].

References:

B03: Biomedical application of chitin nanofibers for cosmetic, wound healing, skin inflammation and biological adhesive
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Previously, many evidences indicate the efficiency of chitin nanofibers (CNF) for the skin. The application of CNF to skin improved the epithelial granular layer and increased granular density in a three-dimensional skin culture model [1]. Superficially deacetylated CNFs (SDACNFs) induced re-epithelium and proliferation of the fibroblasts and collagen tissue in wound healing process [2]. More recently, we evaluated the effect of CNF application via skin swabs on an experimental atopic dermatitis (AD) model. AD scores were lower, and hypertrophy and hyperkeratosis of the epidermis were suppressed after CNF treatment [3]. The suppressive effects of CNFs were equal to those of corticosteroid application; however, chitin did not show these effects. CNF application might have anti-inflammatory effects via suppression of the activation of nuclear factor-kappa B, cyclooxygenase-2, and inducible nitric oxide synthase. Now, we are evaluating the biological activities to the films made by CNF and gelatins.

Moreover, CNF and SADCNF also apply for biological adhesives [4]. Chitin derivatives with acrylic groups, such as 2-hydroxy-3-methacryloyloxypropylated carboxymethyl chitin (HMA-CM-chitin), were synthesized and cured by the addition of an aqueous hydrogen peroxide solution as a radical initiator. The adhesive strength of HMA-CM-chitin was increased when it was blended with CNF or SDACNF. HMA-CM-chitin/CNF or HMA-CM-chitin/S-DACNF have almost equal adhesive strength compared to that of a commercial cyanoacrylate adhesive. Moreover, a quick adhesion and induction of inflammatory cell migration were observed in HMA-CM-chitin/CNF and HMA-CM-chitin/SDACNF.

These data strongly indicate the efficiency of CNF for skin application, including cosmetic, drug (drug carrier) and biological adhesives.

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B04: Pleiotropic effects of chitosan and chitosan-nanofibers on oxidative stress related diseases
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Chitosan has been proposed as a suitable functional material for treating oxidative stress-related diseases, because of its biocompatibility, biodegradability, non-toxicity, adsorption properties and antioxidant activities. The antioxidant properties of chitosan derivatives are subjects of considerable interest. Therefore, the antioxidant properties of chitosan, as evidenced by both in vivo and in vitro studies, were studied. In in vitro studies, low molecular weight (Mw) chitosans (< 30kDa) have impressive antioxidant properties. We also suggest that low Mw chitosan preparations, which have a high antioxidant activity in an extended release formulation, can be safely administered in the form of a non-toxic gel. In patients or model rats with the metabolic syndrome, chitosan has a high antioxidant activity as well as antilipidemic effects. Furthermore, in patients or model rats with chronic renal failure (CRF), chitosan has a high antioxidant activity as well as renoprotective effects. From these results, we hypothesize that chitosan reduces the levels of lipids and/or uremic toxins that induce the production of reactive oxygen species in the intestinal tract, and, in the case of the metabolic syndrome or CRF, inhibits the subsequent development of oxidative stress in the systemic circulation. Thus, the pleiotropic effects of chitosan might lead to the development of new, more effective methods for the treatment of lifestyle diseases such as the metabolic syndrome or CRF.

We recently prepared surface-deacetylated chitin nanofibers (SDAC-NFs) by mechanically treating the exoskeletons of crabs, followed by partial deacetylation of the amide groups that were located on the surface of the resulting chitin nanofibers. SDAC-NFs have attracted considerable interest in medical fields, because of their various bioactivities. In fact, SDAC-NFs are attractive, because their surface properties, as well as the macroscopic properties, of the fiber can be altered by chemically modifying the amino groups on the surface or by electrostatic interactions between the cationic amino groups on the surface and secondary components that carry an anionic charge, thus endowing the fibers with a variety of physicochemical and biological functions. By using these properties, in the case of the CRF rats, the ingestion of SDACNFs over a 4 week period resulted in a significant decrease in the levels of uremic toxins and oxidative stress, compared with the levels of surface-deacetylated chitin (SDAC). Further, we prepared a gel starting from SDACNFs by taking advantage of electrostatic interactions with sulfobutyl ether β-cycloexetrin (SBE-β-CD)8). Among the various CDs and the derivatives tested, SBE-β-CD formed a stiff, non-fluid elastic gel, whereas other gels prepared from neutral CDs formed weak, rather fluid gels. SBE-β-CD is known to form inclusion complexes with various drug molecules and its ability to solubilize poorly water-soluble drugs is higher than that of the parent compound, β-CD, due to the presence of a hydrophobic butyl moiety. It therefore appears that a SDACNFs/SBE-β-CD elastic gel would be useful for preparing homogeneous high-content gels that contain drugs that are poorly water soluble. Therefore, we report on an evaluation of the effect of a SDACNFs/SBE-β-CD elastic gel on wound healing in an experimental model, and a comparison of the results for those for SDACNFs gel without SBE-β-CD. In addition, we report on the effect of a SDACNFs/SBE-β-CD elastic gel including prednisolone (PD) on ulcerous colitis in an experimental model as another oxidative stress related disease. From these results, we suggest an efficient strategy against oxidative stress related diseases by using chitosan and chitosan derivatives such as SDACNFs. The pleiotropic effect of chitosan or SDC-NF has the potential for future applications in a wide variety of pharmaceutical fields.

References:
B055: High Throughput Fabrication of Metal Nanoparticle Related Materials by Liquid-Solid Reaction Sytems by Organic Precursor Painting Reduction Method

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Recently, a variety of high-value-added technologies as nanotechnology and the high value-added products as nano metal particle related materials using it can be requested various fields. Nanoparticles is one of the most important nano metal related materials because nanoparticle manufacturing is an essential component of nanotechnology. Also assembling of nanoparticles and related structures is the most generic route to generate nanostructured materials and build-up bulk materials. Nanoparticle were fabricated by various processing. Sonochemical processing and microwave processing are chemical process. In general, the properties of a specific energy source determine the course of the chemical reaction. The ultrasonic and microwave irradiation differs from traditional energy sources in duration, pressure, and energy per molecule. The chemical effects of ultrasound do not come from a direct interaction with molecular species. Instead, they are derived principally from acoustic cavitation, which can produce temperatures as high as those on the surface of the sun and pressures as great as those at the bottom of the ocean[1]. However, ultrasound generation uses a wide range of energy sources that can be used from cleaning to reducing applications. We developed a new nano metal particle related materials synthesis method that achieved by sonochemical solid-liquid processing. This new synthesis method is with the ultrasonic as nonequilibrium reactor and the metal oxide and alcohol based solvent are used for the raw material. We have synthesized nano metal related materials by ultrasound in liquid-solid (alcohol - metal oxide) slurry and controlled morphology of products. Microwave irradiation in liquid-solid process can be expected as chemical non-equilibrium and nonlinear reactors for metal nanoparticle related materials synthesis too. The alcohol based solvent and the metal oxide powder are put in the beaker and only irradiated by ultrasound or microwave. The metal oxide simply was reduced into metal and morphology of metal nanoparticles was changed by various conditions [2,3]. Fig.1 shows FE-SEM image Ag/CNT nanocomposite. Ag nanoparticle was highly dispersed CNT surface. This nanocomposite have high thermal and electric conductivity. Fig.2 shows image of Ag/Peanuts nanocomposite. This fabrication method is extremely clean and safety processing, so it can also be applied to food and medicines, etc.

![Fig1. SEM images of precursor and Ag/CNT nanocomposite](image)
B06: Deformation and Fracture Processes in Graphene Materials with Lattice Defects

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Pristine graphene exhibits the unique mechanical properties – superior strength, ultra-high elastic straining and huge Young modulus – that are of crucial interest from both fundamental and applied viewpoints; see, e.g., [1]. At the same time, real graphene materials typically contain crystal lattice defects capable of dramatically influencing their mechanical and other properties [2]. This talk presents a short overview of molecular simulations (based on the AIREBO potential) addressing deformation and fracture processes in graphene materials with defects. A particular attention is devoted to strength, elasticity and plasticity characteristics demonstrated by free-standing graphene sheets containing divacancies (5-8-5 defects and 555-777 defects) and graphene nanoribbons containing disclinations (5- and 7-defects).

The simulations have shown multistage character of deformation and fracture processes occurring in defected graphene materials under tensile load [3-5]. So, after elastic deformation stage, initial stages of plastic deformation and fracture concurrently occur through re-arrangements and breaks of interatomic bonds, respectively. In doing so, re-arrangements of interatomic bonds are described as transformations of disclination dipoles serving as carriers of plastic flow in graphene (as with disclination dipoles in 3D nanomaterials [6]). Breaks of interatomic bonds lead to generation and growth of nanoscale voids mediating fracture in graphene. The final stage of plastic deformation of graphene sheets is realized through formation of monatomic carbon chains that join separate parts of these sheets. The final fracture event - separation of a graphene sheet into two isolated pieces – occurs through break of an interatomic bond at a chain.

Deformation and fracture processes in graphene sheets containing 5-8-5 defects and their high-density ensembles are revealed to be significantly sensitive to temperature [3,4]. So, in these sheets, the fracture stage occurring through simultaneous generation and growth of many separated nanoscale voids tends to be shorter with rising temperature. For comparatively high temperatures (400 K and more), an ensemble of 5-8-5 defects in a graphene sheet under tensile load behaves as a single "large" defect triggering fast formation of a large elongated void without apparent plastic deformation [4].

In computer simulations of deformation and fracture processes in graphene sheets containing 555-777 defects (divacancies) [7], it was found that the presence of these divacancies in graphene leads to a dramatic reduction of its strength as compared to strengths specifying pristine graphene and graphene sheets with divacancies of the 5-8-5 type. Besides, graphene sheets containing 555-777 divacancies show a rather unusual sequence of deformation/fracture stages, namely "elastic deformation-incomplete fracture (occurring through generation and growth of nanoscale voids)-plastic deformation.

References:
(occurring through formation and elongation of monatomic carbon chains)-final fracture”.

Deformation and fracture processes in graphene nanoribbons containing line disclination quadrupoles exhibit specific peculiarities due to the combined effects of graphene edges and disclination-produced curvature [5]. In particular, graphene nanoribbons under consideration demonstrate both highly non-linear elasticity and enhanced plasticity characterized by plastic strain degree of around 13.4%. Also, the strength of these nanoribbons significantly degrades (by factor of ≈2), as compared to that of pristine graphene.

References:

B07: Mechnoresponsive Gold Complexes with Tunable Luminescent Properties

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Phase transitions of organic crystalline materials have attracted considerable attention. Generally, molecules capable of forming different crystalline structures show phase-dependent various properties, such as solubility, melting temperature, size, color, and photoluminescence, and these properties can be switched upon phase transitions. Various types of external stimuli, such as heating/cooling, photoirradiation, solvent vapor, and the application of mechanical stimulation, can induce the phase transitions in molecular crystals followed by the changes in various properties of the material. Among them, mechanical stimulation is facile to employ, but still can induce phase transition of these materials. Mechanical stimulation exerts random stimuli and thus mechano-induced phase transition often affords amorphous powder materials. We recently found mechanically triggered single-crystal-to-single-crystal phase transition of luminescent gold complexes, which has never been reported so far.

We showed that a mechanical stimulus in a local area of a seed crystal of phenyl (phenyl isocyanide) gold (I) 1 (Figure 1a) can trigger a single-crystal-to-single-crystal (SCSC) phase transition (Figure 1b). [1] The phase transition, which starts in a local area subjected to mechanical stimulation, develops over entire crystals within hours, and is observed by an emission color change from blue to yellow (Figure 1c). This is the first example of the SCSC phase transition triggered by mechanical stimuli. Thus, single crystal X-ray analysis gives the precise crystal structures before and after the phase transition. We conclude that the red-shifted emission of 1 is attributed to the formation of aurophilic interactions. [1] Recently we found dimethylated analogue 2 (Figure 1a) also showed a mechano-triggered SCSC phase transition. This time, a blue-shifted emission occurs because of the disconnection of aurophilic bonds (Figure 1d). [2] Contrasting crystal structures, emission properties, and related properties of 1 and 2 will be discussed. [3,4]
B08: A biosensor to detect inter-protein interaction and domain-domain interaction

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Detections of protein association as well as conformational change induced by other molecules or proteins are important for studying biological reactions or biological functions of proteins. Nevertheless, detection of such association or conformational change by conventional spectroscopy has been very difficult. Several techniques that can detect protein binding have been developed as a biosensor, and some of them are commercially available now, such as surface plasmon resonance (SPR) method. However, there are some inherent shortcomings for this method. For example, the target protein should be fixed on metal surface and it usually takes several tens minutes to accumulate proteins on the surface for detection. If one can detect the protein binding in solution phase with much shorter time, it could be complementary to the SPR method. Here, I will show that the diffusion detection of proteins by the laser induced transient grating (TG) method can be a suitable way for detecting not only protein-protein binding but also domain-domain interaction.

One of the samples we will demonstrate here is a photosensor protein. PixD are ones of blue light photosensors containing the BLUF domain, and identified in cyanobacteria. They include Slr1694 of the mesophilic Synechocystis sp. PCC6803 (SyPixD) and Tll0078 of the thermophilic Thermosynechococcus elongatus BP-1 (TePixD). SyPixD regulates phototaxis of cyanobacterium. Crystallographic analyses showed that these homologous PixD proteins have a unique oligomeric structure: a decamer comprised of two stacked pentameric rings. By using the TG technique, we discovered that the light irradiation changes the inter-protein interaction; e.g., changing the oligomeric structure. For example, the decamer of TePixD dissociates into the pentamer, and the decamer of SyPixD dissociates into the dimer. We discovered very peculiar reaction of this protein; strange dependences of the conformational change of the TePixD and SyPixD decamer on the concentration, on the intensity of the excitation light, and on the pressure. In particular, by using the excitation light intensity dependence, we found that the multiphoton excitation of this protein is important for the reaction.

The driving force of this reaction was studied by the time-resolved thermodynamics. It was found that the isothermal compressibility is increased during the reaction. This result showed that the structural fluctuation of the intermediates is enhanced. To clarify the relationship between the fluctuation and the reaction, the compressibilities of multiply excited SyPixD and TePixD were also measured. The isothermal compressibility of the first and the second intermediates of TePixD showed a monotonic decrease with increasing excitation laser power, and this tendency correlated with the reactivity of the protein. This result indicates
that the TePixD decamer cannot react when its structural fluctuation is small. We concluded that the enhanced compressibility is an important factor for driving the reaction of TePixD.

We will also show an example of another photosensor protein.

**B09: Approaching the Resolution Limit of Nano-gap by Using Focused Ion Beam Chemical Vapour Deposition**

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Nano-gaps are the fundamental building blocks for nanochannels, plasmonic nanostructures and Josephson junctions. We present a systematical study on the resolution limit of nano-gap fabricated by using focused-ion-beam chemical vapour deposition (FIB-CVD). First, dot array with average dot size of 32 nm at FWHM and average height of 0.9 nm has been grown up. Then, lines and spaces with the smallest spacing of 5 nm have been fabricated. Finally, nano-gap having a width of 5 nm and a height difference of 50 nm has been synthesized. To date it is the narrowest nano-gap fabricated by using FIB-CVD. FIB-CVD opens avenues for novel functional nanodevices that can be potentially used for lab-on-chip experiments.

**B10: Direct molecular alignment induced by masked photopolymerization with no alignment layer and non-polarized light**

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Polymer films having high functionality are taking an important role in various applications such as electronics, photonics and medical devices. For the manifestation of the functionality, the precise control of molecular alignment in films is crucial, and is achieved mainly with the assistance of an alignment layer, over which photopolymerizable molecules are aligned and the alignment is fixed by subsequent photopolymerization. Recently, a photoalignment layer demonstrated the impressive success of alignment control from unidirectional (1D) to complex (2D) pattern. However, this method requires complicated procedures and is activated only by the combination of irradiation of specific photoreactive compounds with linearly polarized light. [1] We propose a simple method for the alignment control where we carried out masked photopolymerization of a mixture including a photochemically inert monomer and crosslinker. Although masked photopolymerization enabling to generate molecular diffusion due to chemical potential, no one has reported the direct induction of molecular alignment owing to the diffusion. [2] In this study, we revealed that the masked photopolymerization directed uniform 1D or 2D molecular alignment with no alignment layer and non-polarized light.

As shown in Figure 1a and 1b, we prepared a glass cell where the mixture composed of mesogenic monomer was injected, and subsequently irradiated of the cell with UV light vertically through a 500 µm line-space photomask. Polarized optical micrographs of the resultant film revealed that the film has optical anisotropy at every boundary between irradiated and unirradiated regions. Detailed observation and evaluation of the optical anisotropy indicated that the appearance of the anisotropy was due to uniform 1D alignment of mesogens. In addition, we found that the alignment direction was ruled by the normal vector direction to the boundary and resultant molecular diffusion. Therefore, only by changing the spatial design of a photomask, we successfully fabricated the 2D molecular alignment.

**References:**

B11: Preparation of a protein-chitin nanofiber complex from crab shells and its application as a reinforcement filler or substrate for biomineralization

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Chitin is a highly abundant carbohydrate polymer existing mainly in the exoskeletons of crabs. Crab shells have a strictly hierarchical organization (Fig. 1). The chitin molecules are aligned in an antiparallel manner to form chitin nanofibers (NFs). The NFs are wrapped with a protein layer. The next level consists of a cluster of a number of protein–chitin NFs. Crystalline calcium carbonate is embedded within the space of the helicoidally shaped structure. Commercial chitin is generally prepared by treating crab shells with NaOH and HCl solutions to remove proteins and calcium carbonate, followed by drying in an oven. The production of commercial chitin is quite expensive (3000–5000 JPY/kg), and the major effluent purification treatments required to remove the abundant protein residue contribute the most to the costs. Indeed, the protein removal process accounts for approximately half of the production cost of commercial chitin. Moreover, the removal process with NaOH solution causes deacetylation and depolymerization of chitin molecules by alkaline hydrolysis. Recently, we developed a method of isolating chitin NFs existing in crab shell [1]. Chitin NFs have a characteristic morphology, high surface-to-volume ratio, high mechanical strength, and strong biological functions. We expect that the addition of NFs will promote the use of chitin as a novel biomacromolecule. Chitin NFs from crab shells were prepared by a simple mechanical treatment after the removal of proteins and minerals. The chitin is easily disintegrated into NFs by mechanical treatment after removal of the embedding matrices. Protein layer on the NF surface are considered to play important roles in the biomineralization of calcium carbonate in crab shells. In other words, proteins themselves basically do not provide as a solid support for the rigid exoskeleton of the crabs. Thus, it may be possible to skip the protein removal process during the preparation of chitin NFs. This simplification of the procedure would bring down the production cost of NFs. In this study, we report on the production of NFs from crab shells without the protein removal step [2].

A protein–chitin NF complex was successfully prepared from crab shells by a mechanical treatment after the removal of CaCO3. One step in the conventional series of treatments—i.e., the removal of proteins—was omitted to bring down the production cost of the nanofibers. The obtained protein–chitin nanofibers had uniform width of approximately 20 nm and a high aspect ratio (Fig. 2). These characteristics were similar to conventional chitin nanofibers. The optically transparent protein–chitin nanofiber composite was fabricated with acrylic resin. The nanofibers reinforced the acrylic resin film and thereby increased its mechanical properties. Proteins on the chitin nanofiber surface affected the biomineralization of CaCO3 in the crab shell. Mineralization of CaCO3 on the protein–chitin nanofiber was carried out by the gas-diffusion method. Protein molecules on the chitin NFs increased the chances for biomineralization to occur. The protein molecules stabilized the formation of vaterite and inhibited the transformation of vaterite to calcite.

Fig. 1. Hierarchical structure of crab shell. Reprinted from Ref. 2.
B12: On-chip picosecond pulses in 2D systems  
Alexander S. Mayorov

B13: Printed manufacture ultra-integrated multi-analysis devices  
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Inspired by human olfactory system, cross-reactive sensor array has emerged as a valid approach to multi-analyte recognition and has been widely used in food industry, environmental detection, biological screening, etc. To achieve complete multi-analyte recognition, it need obtain as abundant as possible sensing response information. [1] Generally, the array sensing needs large numbers of serial compounds as sensors to perform the correlative differential analysing. It involves complicated chemical synthesis and valid compound screening. Focusing on toilless and high-performed multi-recognition, we design novel detection methods and sensor materials including facile fabrication processes.

We investigated the correlative multi-states properties of a photochromic sensor, which is capable of a selective and cross-reactive sensor array for discriminated multi-analyses detection by just one sensing compound. The multi-testing sensor array performed in dark, ultraviolet or visual stimulation, corresponding to different molecular states of spirooxazine metal ions coordination. [2] The facile photochromic microchip contributes a multi-states array sensing method, and will open new opportunities for the development of advanced discriminant analysis for complex analytes.

We designed and fabricated a multi-stopband PCs microchip based on hydrophilic-hydrophobic patterned substrate. The microchip can selectively amplify the sensing fluorescence in different channels, and perform a high-efficient multi-analyte discriminant testing. It is remarkably that just one simple sensor, 8-HQ, actualizes 12 various metal ions recognition and analysis. [3] The facile fabrication of high-performance PCs microchip and the insight of sensing efficiency evaluation will be of great importance for the development of advanced discriminant analysis for complex analytes in luminescence sensing systems and devices.

Printed flexible electronics are drawing enthusiastic attention, because of their features and promising applications in flexible displays, artificial skins, sensors, etc. Curve is the effective design to endow durable stretchability. However, the fabrication of elastomeric matrices is limited by the arbitrary curve patterns or tunable tortuosity morphologies and large scale produce with high resolution. We demonstrated a feasible strategy to assembly nanoparticles into micro or nano curves. The curves with various tortuosity morphologies have differential resistive strain sensitivity, which can be integrated to multi-analysis flexible sensor. The facile strategy could rapidly and accurately produce nanoparticle based curve arrays. [4] The printable curves sensor performed sensitive and stable resistance response on deformations, which could run complicated facial expression recognition, and contribute the remarkable application on skin micromotion manipulation auxiliary apparatuses for paraplegics.
References:

B14: New Photofunctional Materials Based on Pyrene Chromophore
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Pyrene is a well-known chromophore, and it has been a typical candidate organic fluorescent material, e.g., as a probe in multimolecular systems or as a metal ion sensor, because of its environment-responsive vibrational fluorescence structures, long excited singlet lifetime, ability to form excimers. Since pyrene and most of its derivatives have high absorption coefficients and fluorescence quantum yields, many investigations have been carried out on their use as highly emitting materials for organic electronic devices.

We have investigated new materials chemistry of pyrene chromophore. [1-11] In this lecture, some examples are presented. For example, (1) We synthesized new pyrene and anthracene derivatives that have both high luminous efficiency and high solubility to cholesteric liquid crystals (CLC). The use of such highly efficient dyes enables us to attain lower lasing thresholds in dye-doped distributed feedback (DFB)-CLC lasers. [4] (2) Novel pyrene analogs of Prodan exhibit outstanding photophysical properties, i.e., remarkably high fluorescence quantum yield (QY) in solvents ranging from apolar hexane to polar methanol (QY > 0.85), that are accompanied by strong solvatochromism and large Stokes shifts. (3) Imaging lipid organization in cell membranes requires development of advanced fluorescent probes. We have successfully designed ideal dye for its imaging. [10] (4) We synthesized A-π-A type pyrene dyes that can be excited and fluoresce efficiently in the ‘tissue optical window’ (650–1100 nm) the two-photon fluorescence microscope (TPFM). [11]
A confined quantum system in which a small number of electrons are bound in a low-dimensional nanoscale potential well, called an artificial atom or semiconductor quantum dot, has attracted great attention over the last two decades owing to its unique electronic properties as a solid-state object, such as a discrete energy-level structure and its controllability by changing the shape and strength of confinement [1]. It has been also known that the oscillator strengths of such artificial atoms can be very large as compared with natural atoms [2], that makes them a promising candidate for future nanoscale optical devices. Since the electron correlation energy increases rapidly as its increasing size, or its decreasing strength of confinement, to the extent as large as more than 10 percent of the total energy [3], the electronic structure in this weak limit of confinement does not allow a single-reference description based on an independent particle model such as the Hartree-Fock method but requires intrinsically a multi-configuration treatment. In order that these attracting nanoscale objects to be used in future quantum devices a relation between this complicated electronic structure and the underlying electron dynamics needs to be established. In the present study we have focused on a few-electron quasi-one-dimensional artificial atoms so that their wave functions can be visualized allowing us clear understanding of the intrinsic many-body nature of the complicated wave functions and its relation to the energy-level pattern.

The energy spectrum and the wave function of a few electrons confined in a quasi-one-dimensional nanoscale potential well has been studied relying on the full configuration interaction method supplemented by anisotropic Gaussian-type basis functions [3]. The confining potential in the lateral direction is of an attractive Gaussian function form that is characterized by a harmonic frequency $\omega$ and the depth of the potential well $D$. The energy spectrum depends strongly on $\omega$ and is categorized into three regimes of the strength of confinement, namely, large, medium, and small, whose typical $\omega$ values are 10, 1, 0.1, respectively. In the large regime, the spectrum shows a band structure characterized by the so-called polyad quantum number $\nu_P$ [4-6]. In this

![Fig1. New pyrene dyes for materials chemistry.](image)

**References:**


**B15: Energy-level structure and correlated electron dynamics in quasi-one-dimensional artificial atoms**

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omega regime the corresponding electron dynamics is basically that of an independent particle model based on a set of normal-modes of electrons. In the medium regime the energy-levels belonging to different polyad manifolds overlap with each other and the spectrum shows a complicated level pattern. The electron dynamics is, however, still dominated by an independent particle model. A significant change occurs both in the energy spectrum and in the electron dynamics in the small regime of the strength of confinement. The energy-level pattern recovers the band structure characterized by vp but each energy level has a definite number of nearly-degenerate states with different spin multiplicities. The correlation energy becomes very large and the electronic structure and the associated electron dynamics have changed qualitatively. The transition from the normal-modes to novel electronic modes will be discussed in detail in the presentation focusing particularly on the cases with large anharmonicity in the confining potential.

References:

B16: Self-assembly of adenine-silver nanoparticles forms rings resembling the size of cells
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Supramolecular chemistry may have played critical roles in the origin of life. Mineral surface adsorption and catalysis of molecules leads to their evolution and the accumulation of prebiotic materials. While researchers focus on the contribution from light metal derivatives to prebiotic chemistry, heavy metals are rarely considered. The heavy metals have been existed on primitive Earth and we cannot exclude the possible contribution of heavy metals to the origin of life on primitive Earth. But why are they not reflected in modern life? Here we show that, with the interactions between silver and nucleobases as a model, ssDNA oligomer-stabilized silver nanoparticles and adenine self-assemble to form ring-like compartments similar to the size of modern cells, especially when the aqueous solution of such a mixture undergoes drying on a glass surface. However, the silver ions only dismantle the self-assembly of adenine. The membrane-like edge of the ring is composed of adenine filaments glued together by silver nanoparticles. Interestingly, chemicals are confined and accumulated inside the ring, suggesting that this might be an alternative to the compartmentalization of bioactive molecules by the lipid bilayer in the origin of life. (1-6)
fluorescent proteins, and inorganic semiconductor quantum dots. Among others, conjugated polymer nanoparticles (Pdots) are an emerging class of fluorescent nanoparticle as their fluorescence properties could be fine-tuned by an appropriate molecular design. Due to the relatively flexible molecular design, Pdots have been used in a wide range of application from imaging to sensors. Unlike other fluorescent probes, the fluorescence properties of Pdots are governed largely by intraparticle excited-state interactions between the emitting sites rather than the fluorescence properties of each emitting site. This makes it difficult to predict their fluorescence properties based on the chemical structures. Especially, the development of bright far-red- and near-infrared-fluorescent Pdots with small sizes has been challenging due to an efficient quenching of the excited state through chain-chain interactions. We have been investigating the excited-state photophysics occurring within single conjugated polymer molecules by means of single-molecule fluorescence imaging techniques, such as super-resolution localization microscopy [1,2] and defocused imaging. [3] They provide a unique opportunity to characterize the relation between the chain configuration and photophysical properties of conjugated polymers.

Here we report a new strategy for the development of ultrasmall Pdots with high fluorescence quantum yield. Unlike conventional approach that focuses solely on the molecular design, we will develop new Pdots based on a combination of appropriate molecular design and proper control of the chain interactions through a new fabrication method, modified reprecipitation method, which is backed by detailed photophysical and structural characterization. The Pdots were fabricated by the modified reprecipitation method using donor-acceptor-type poly(1,8-carbazole)-benzothiadiazole and poly(1,8-carbazole)-dithienylbenzothiadiazole copolymers. The obtained Pdots have diameters of approximately 3 nm and exhibit a far-red fluorescence (600 – 800 nm) with high fluorescence quantum yield (ϕf1 ~ 0.20). The fabricated Pdots are one of the smallest and brightest Pdots with highest photostability reported so far, which proves the effectiveness of our approach to develop new

References:

B17: Ultrasmall far-red emitting polymer dots: structures and photophysics
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The development of fluorescent probes is becoming increasingly important with the development of advanced fluorescent imaging and microscopy techniques. Especially, far-red/near-infrared emitting fluorophores attract great attention due to their wide applications in bioimaging, including deep tissue imaging. Various types of far-red fluorescent probes have been developed, including organic fluorophores, photon source of the fluorescence images were from the photoluminescence of silver nanodots that were doped homogeneously into silver nanoparticles. c, d. Same as a, except that the samples were diluted 10-fold (c) and 100-fold (d). Images having the same scale bar in d.
Pdots. We found that small differences in the preparation method significantly affect the brightness of the Pdots. Single-molecule imaging together with electron microscopy and NMR spectroscopy demonstrate that the packing of the polymer chains within the particle affect significantly the fluorescence properties of the Pdots. Our results suggest that both emitting sites and side chains of the polymers have well-ordered structure within the brighter Pdots in which the efficient energy transfer between the emitting sites occurs. Our results demonstrate that the development of Pdots requires not only appropriate molecular designs but also proper control of the physical interaction between the chains and relative orientations of the emitting sites.

References:

C01: High Q Piezoelectric Micro-Resonators for Microwave filters
Matthieu Chatras
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This paper deals with the design, simulations, fabrication and test results of piezoelectric MEMS resonators integrating piezoelectric zinc oxide (ZnO) layers. Pulsed Laser Deposition has been used to achieve thin films of ZnO. These micro-resonators are built on top of a 2μm thick silicon membranes of SOI wafers. We demonstrate that the reduction of the ZnO thickness from 800 nm to 200 nm increases the quality factor from 430 to 1600 respectively around 700 MHz. To improve the quality factor Q and the electromechanical coupling coefficient kt2 of the proposed devices different numbers and different lengths of inter-digitated (IDTs) electrodes have been tested.

C02: Cantilever MEMS devices-measurement tools and measurement objects
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Cantilever MEMS devices are used for ultra sensitive force and mass measurements. For this reason, they are also suitable for various scanning probe microscopy (SPM) applications. Constantly increasing requirements for measurements sensitivity, speed and convenience cause decrease of size and increase of complexity of cantilever MEMS. This trend increases significance of procedures used for calibration of the response of these sensors.

The main factors being subjected to calibration are: the sensitivity to a cantilever’s deflection, the efficiency of an excitation to a cantilever’s vibrations, a cantilever’s effective mass and spring constant [1,2]. If cantilever MEMS devices are used as a probe in SPM experiments, the shape and the properties of the tip are important factors [3]. Especially, if the area of tip-sample contact is a significant issue. Such a situation appears for instance in scanning thermal microscopy (SThM) [4] or chemical force microscopy (CFM) [5].

The methods of calibration of these factors and signal processing techniques that were proposed for these methods will be presented. Among them the application of parametric and nonparametric estimation of stochastic process parameters, precisely calibrated high gain amplifiers, morphological image processing in blind tip reconstruction task and optimization routines used in SThM for tip-sample thermal flux modeling will be presented.

These methods were applied to various kinds of microcantilevers (see Fig. 1). These MEMS differ in the method of deflection measurements (optical beam, piezoresistive) and excitation to vibrations (thermal, electromagnetic). They are applied as mass sensors, massively parallel arrays of AFM probes and SThM and CFM probes.
Abstract

Fig. 1. Various types of cantilever MEMS devices investigated and calibrated by Nanometrology Group.

References:

C03: Optical MEMS sensors such as Micro Doppler sensor, Micro Blood flow sensor, Micro Shear Force Sensor, and their applications
Renshi Sawada, Hirofumi Nogami, Nobutomo Morita, Fumiya Nakashima, and Ryo Inoue.

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Optical MEMS sensors with extremely simple structure including a laser diode chip and a photo diode chip are described: 1) MEMS encoder consisting of encoder itself and external traveling grating scale, 2) Micro laser Doppler sensor using scattering objects instead of the grating scale of the encoder, 3) Micro blood flow sensor, based on mathematical application of probability (Stochastic means) instead of obtaining Doppler shift, and shear force sensor (a combination of deformable frame and laser displacement sensor consisting of VCSEL chip bonded on the center of Si square chip in whose periphery, photo diodes are monolithically integrated). Next I’ll touch on applications of these optical MEMS sensors to a robot hand and healthcare.

C04: MEMS based tuneable filters for IR spectroscopy
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The research efforts in the field of miniature tunable infrared (IR) detectors have been intensified after 9/11 New York attacks due to potential applications in defense and security. Today, other applications may benefit from this research such as mineral exploration, environment monitoring, chemical sensing, agriculture, food processing, medicine, and many more. The development of tunable IR detectors, so called IR micro-spectrometers, evolved in two directions: tunable matrices for IR hyperspectral imaging, and single detector devices for spectral analysis. Development of tunable IR matrices represents very ambitious and complex task due to high density of pixels uniformity requirements. Although significant progress has been made the final goal has not been achieved yet. On the other hand, the single micro-spectrometers operating in different IR bands have been successfully demonstrated.

In this presentation the results of the micro-spectrometer program carried out at The University of Western Australia will be presented. This will include brief description of the concept of IR tunable detector (Fig.1a), its mechanical structure (Fig.1b), requirements for MEMS structural materials and for optical materials. The performance of micro-spectrometers will be discussed in terms of the tuning range, optical transmission (Fig1.c), effect of stress in mechanical and optical materials, tuning speed, and finally potential applications.
Fig 1. a) Principle of operation, b) SEM of micro-spectrometer, and c) Experimental spectra of micro-spectrometer in 1.5µm–2.5µm range for actuator’s bias changing from 0V (right peak) to 27V (left peak).

References:

C05: Laser Induced Fluorescence Modification of Monolaye MoS2 and Its Potential Application
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Optical data storage, with green features of extremely low energy consumption, ultra-long lifetime and ultra-high security compared with magnetization-based storage technologies, has been heralded as the promising solution for the next generation of big data storage[1]. The major hurdle for the large scale impact is the relatively low storage capacity which is limited to a few hundreds of gigabytes per disc. Tremendous research and development efforts have been focusing on improving the volume of recording media for volumetric or multilayer memories facilitated on three-dimensional (3D) fused quartz[2], 1D DNA chain[3] and 0D nanoplasmonics[4]. Here, we report a new class media for data storage based on the defect engineering of 2D atomically thin semiconductor (molybdenum disulfide, MoS2). It is demonstrated the fluorescence of MoS2 can be enhanced by at least two orders of magnitude through femtosecond laser irradiation. Both peak position and intensity of the fluorescence can be conveniently controlled via the changing of either laser power or irradiated time. Moreover, this giant fluorescence enhancement is retained for longer than one year. The mechanisms of the enhanced optical response are not only attributed to the defect engineering on the monolayer surface, but also linked to the switching between excitations and trions in MoS2. Our scheme is compatible with device fabrication for big data storage.

References:
[4] Zijlstra P., Chon J. W. & Gu M. "Five-dimensional optical recording mediated by surface

**C06: 3-dimension nano-structure of trap split based on nonlinear polarization**

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**Abstract**—A phenomenon called “trap split” had been found when gold nanoparticles were trapped by femtosecond laser pulses, and the trap split was demonstrated strongly dependent on the polarization, energy and wavelength of the laser pulses. The 3-dimension distribution of trap split and its mechanism were systemically investigated in this work.

**Keywords**—femtosecond laser; trap split; nonlinear polarization; gold nanoparticles

I. INTRODUCTION

A novel phenomenon called “trap split” has been discovered when the gold nanoparticles are trapped by a femtosecond laser, where the nonlinear polarization plays an essential role. Compared to the CW laser trapping, the stable trap site is split into two equivalent positions when the gold particles are trapped by a linearly polarized, near-infrared Gaussian femtosecond laser beam \([1, 2]\). The trap split is found strongly dependent on the polarization, energy and wavelength of trapping laser pulses. In this work, it was further studied that distribution of trap split under various power femtosecond laser illumination. Besides the 2-D distribution of trap split in transversal direction, the results reveal the distribution of traps in axial direction.

II. EXPERIMENTAL

A femtosecond laser trapping system with an orthogonal illumination-imaging system combined with a confocal microscope was built, and the 3-dimension structures of trap split was investigated. When gold nanoparticles are trapped by femtosecond laser, the trapping site will split into two or more positions depending on the trapping laser power, despite the laser is a single Gaussian beam which normally generates only one trapping position at CW trapping condition. Besides the 2-dimension distribution of trap split in lateral direction (XOY), axial direction structures of trap split were also found, as shown in Fig. 1. These novel phenomena have never been reported, to our best knowledge.

![Fig. 1 The 3-D distribution of trap split: (a), (b) the distribution of trap split in XOY and XOZ planes under relative low power trapping; (c), (d) and (e), the distribution of trap split under relative high power trapping.](image)

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**References:**


**C07: Infrared near-field microscopy on semiconductor multilayers and quantum cascade lasers**

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The metal tip of a scanning probe constitutes a sub-wavelength scatterer, which can be used to map the electromagnetic near-field and measure its spectrum with a spatial resolution of tens of nanometers at mid-infrared wavelengths. In this presentation, we will firstly demonstrate the use of a mid-infrared scattering near-field microscope to investigate semiconductor stacks made of doped/undoped InAs multilayers. Heavily doped semi-conductor layers behave as metals in the infrared. They can therefore support plasmonic modes confined at the interface which they exhibit with air or with the undoped semi-conductor layers. The surface plasmons modify the electromagnetic local density of states (EM-LDOS) [1], which we have probed via measurements of the near-field thermal emission on the cleaved edge of a semiconductor stack in a mode called thermal radiation scanning tunneling microscopy [2], in order to access the 300 nm semi-conductor layers individually.

Secondly, we will present the near-field investigation of mid-infrared quantum cascade (QC) lasers. The implementation of an array of linear metallic nano-antennas on the top surface of the ridge of a QC laser is sufficient to result in a single mode emission of the laser. Scanning near-field investigations on the top surface of the device in operation have been performed to find out how the mode inside the laser cavity couples with the array of antennas.

This work has been performed in collaboration with Institut Langevin at ESPCI Paris (F. Peragut), Laboratoire Charles Fabry-IOGS (J.-J. Greffet, J.-P. Hugonin), Institut d’Electronique du Sud (T. Taliereio, V. Ntsame Guilengui), Institut d’Electronique Fondamentale (R. Colombelli, A. Bousseksou, T. Ongarello). The work was supported by LABEX WIFI (Laboratory of Excellence within the French Program “Investments for the Future”) under references ANR-10-LABX-24 and ANR-10-IDEX-0001-02 PSL*.

References:

C08: Silicon Photonic Grating-Assisted Vernier Resonators for 3-Port Filter Applications

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Blending the desirable characteristics of contra-directional grating couplers (contra-DCs) and ring resonators has been previously demonstrated [1-4]. The main design goals for creating a grating-assisted ring resonator filter consist of (1) ensuring that the filter’s spectra have only one resonant peak and one resonant notch that are not suppressed, (2) ensuring large suppression of minor resonant peaks and minor resonant notches, (3) ensuring low drop port passband dispersion and low through port dispersion.
passband dispersion, and (4) ensuring that the filter meets its specifications. Here, we present a design of a 3-port grating-assisted Vernier filter, as shown in Fig. 1. The design of the grating-assisted resonator is similar to the designs presented in [1-4]. As compared to previous results [1-4], this Vernier filter has improved performance and meets commercial 3-port filter specifications (values can be found in [5-7] and definitions can be found in [3, 8-11]) for a clear window of 15 GHz and a channel spacing of 200 GHz.

![Diagram of the 3-port grating-assisted Vernier racetrack resonator filter.](image1)

The design method used for this filter can be found in [3]. Here, silicon strip waveguides (oxide cladding, heights = 220 nm, and loss = 3 dB/cm) were used for the co-directional couplers (widths = 550 nm and gaps = 280 nm) and for the contra-DCs (bus widths = 450 nm, racetrack widths = 550 nm, and coupling coefficients = 13000 m-1); for additional parameter values see Fig. 1. Figure 2(a) shows the theoretical filter spectra and Fig. 2(b) shows the spectra near the main resonance. The drop port passband dispersion is shown in Fig. 2(c) and the through port passband dispersion, to the left of the main resonance, is shown in Fig. 2(d).

![Filter spectra, (b) spectra near the main resonance (clear window = 15 GHz, channel spacing = 200 GHz), (c) drop port dispersion (at main resonance), and (d) through port dispersion (to the left of the main resonance).](image2)

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C09: Onboard and Stationary Hydrogen Energy Storage in Nanostructured Mg-based Materials

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Hydrogen storage combined with fuel cell technology is thought to be one of the future ultimate carbon-free energy storage solutions, for both onboard and stationary applications. People have tried to research on Mg-based materials for onboard hydrogen storage for decades. Based on the author’s study of downsizing effect on thermodynamics, it was
found that desorption thermodynamics in nanostructured system does not change with downsizing and catalysis in the size range of 5-300 nm. This implies that nanostructured MgH2-Mg materials cannot be used for onboard hydrogen storage with a working temperature below 100 degree C at this size. However, the Mg-based materials show promising properties for stationary energy storage due to the advantages of Mg, such as low cost, high energy density and no need for low working temperature. Some recent results on Mg-based materials with focus on kinetics enhancement, thermodynamics tailor and capacity improvement will be discussed in this work. If one may use Mg-based materials to directly store hydrogen produced from renewable energy and release this hydrogen for later electricity generation, the energy density is very high. It is 9.2 MJ/kg, 2600 Wh/kg, 13.3 MJ/L, 3700 Wh/L (calculated from LHV of hydrogen). Our team reported the idea of connection of MgH2 system with Solid oxide fuel cell (SOFC) to use exhaust heat from SOFC for desorption reaction in the MgH2 tank [1]. In 2013 Patricia Rango and her team published both simulation and experimental work [2].

References:

C10: Chiral Polymer-based Nanofiber Webs for Nanoenergy Harvesting and Dynamic Pressure Sensing
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Recently, due to unique helical structure formed by chiral molecules, the shear piezoelectric property of poly (lactic acid) (PLA) has attracted many attentions.[1,2] Moreover, it has been well documented that electrospinning is a powerful and useful method for the fabrication of piezoelectric materials.[3,4] Hence, we prepared poly(L-lactic acid) (PLLA) nanofiber web through electrospinning and demonstrated that electro-spun PLLA nanofiber web could be used as a power source to operate LEDs in our previous study.[3] Considering the shear piezoelectricity of uniaxially drawn PLLA film or fiber, the piezoelectric signal cannot be generated from a conventional capacitor structure through exerting normal pressure, because D1=d14T4 for PLLA film, i.e., piezoelectric charge (D1) can be induced only by shear stress (T4). Therefore, it is impossible to detect any sort of shear piezoelectric signal using the experimental setup shown in Fig. 1(e). Nevertheless, we could obtain a very high piezoelectric current from electrospun PLLA nanofiber web as in case of poled PVDF film or electrospun P(VDF-TrFE) nanofiber web. This suggests that the electrospun PLLA nanofiber web can have preferentially oriented C=O dipoles, which induced piezoelectric charge as seen from poled PVDF film. However, poled PVDF loses piezoelectricity completely after annealing above 80 oC, since oriented CF2 dipoles are randomized during annealing.[4,5] Therefore, to identify the origin of piezoelectric charge induced by normal pressure exerted on electrospun PLA nanofiber web, we annealed electrospun PLLA and poly(D-lactic acid) (PDLA) nanofiber web sensors at the temperature of 120 oC, which is high enough to randomize preferentially oriented C=O dipoles, for 12 h in vacuo, and then their piezoelectricity was measured. Surprisingly, both PLLA and PDLA nanofiber web sensors still generate stable piezoelectricity even after annealing at 120 oC for 12 h. Taking all of these findings into consideration, it is certain that the signals detected from both annealed PLLA and PDLA nanofiber web sensors are obviously from neither shear piezoelectricity nor conventional piezoelectricity based on induced dipoles; presumably it should be analyzed with a new piezoelectric mechanism.
In this work we present a new piezoelectric mechanism of PLA to show excellent thermally stable piezoelectricity resulting from the deformation of oriented 31 helical conformations and demonstrate that electrospun chiral polymer-based nanofiber webs can be used for nanoenergy harvesting and dynamic pressure sensing. More details are discussed in the presentation.

Fig. 2. (a) The equivalent circuit diagram to operate LED diodes; charging voltage vs. time when LEDs were (b) not connected and (c) connected for more than 3000 s for capacitors having different capacitances; and (d) photograph of LEDs operated using a 100 F capacitor.; (e) custom-made device for piezoelectricity measurement.

References:

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Recently, more and more attention has been paid to the ZnO nanostructures for its potential application in dye-sensitized solar cell (DSSC) [1]. Comparing to traditional photoelectrode material TiO2, ZnO has not only wide bandgap energy of 3.37eV, but also much higher electron mobility [2]. In addition, ZnO was much easily to be nanostructured which is considered as one of reasons limited the energy conversion efficiency for the DSSC using TiO2 as photoanode. In order to achieve the high absorption ratio to the dye, in this research, we developed a novel method to fabricate ZnO nanostructures with the large area surface. ZnO nanorods were firstly synthesized by recrystallizing the reduced ZnO film with a multiple-annealing process which included the reducing annealing process and oxidization process [3]. Then surface of ZnO nanorods were modified in the mist CVD process to achieve the surface regrowth, as shown in Fig. 1. The parameters of thin film deposition, annealing process and mist CVD process were compared to investigate their influence on the properties of obtained ZnO nanostructures. As the result, the well-aligned ZnO nanostructures with large surface area were achieved. The structural and the optical properties of the obtained ZnO nanostructures were investigated. Finally the DSSC using obtained ZnO nanostructures as photoanodes was demonstrated with the highest conversion efficiency of 3.19%.

C11: ZnO-based Nanoelectrodes for Dye-sensitized Solar Cell Application

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With the depletion of fossil-based resources and increasing concerns about environmental problems, the demand for renewable energy and high-efficiency energy conversion devices has continued to grow rapidly. A direct conversion of solar energy into versatile chemical fuels, such as photon-driven electrolysis of water to produce hydrogen gas for energy storage, is both clean and renewable path thus very attractive. Quaternary semiconductor complexes Cu2ZnSnS4 (CZTS) is one of the promising candidates for thin film absorber material in solar energy conversion applications due to its low cost and high performance. Their optimum band gap energies and high absorption coefficients are comparable to the widely studied chalcopyrite semiconductors, CuIn(1-x)GaSe2 (CIGS), while they are composed of only earth-abundant and non-toxic elements.1

Although it is now possible to prepare CZTS nanocrystals in high purity,2 the delicate tailoring of the size, shape, and crystallinity of nanocrystals with a high degree of monodispersity still remains a challenge. A simple wet chemical method was employed to synthesize different shapes of CZTS and its analogue Cu2FeSnS4 (CITS) nanostructures of near-monodispersity. We demonstrate that the anisotropic growth of CZTS and CITS nanocrystal could be modulated. Another attractive chalcogenide. Furthermore, gold nanoparticle (AuNP) was placed inside to yield core/shell configurations for both CZTS and CITS. TEM, XRD, UV/Vis and X-ray photoelectron spectroscopy (XPS) were used to confirm their core/shell structures.

The photocatalytic reduction of water to hydrogen gas using various CZTS and CITS-based nanostructures as photocatalysts was compared.
C13: Nano-Scale Engineering of Hard and Tough Zirconia Based Ceramics

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Zirconia (ZrO2) ceramics are one of the best alternative materials to combine extremely hard and tough characteristics of final product. These features also enable to use ZrO2 in wear resistant applications. Therefore, locator pins from ZrO2 ceramics are successfully produced with the aim of welding sheet metals in automotive industry. To synthesize in low agglomeration degree and high purity of ceramic powders, the hydrothermal synthesis was carried out to prepare nano-sized ZrO2 powders stabilized with 3 mol % yttrium (3Y-ZrO2). The reaction occurred in urea media, and zirconium acetate in dilute acetic acid was used as a beginning precursor. Darvan-7 ammonium based dispersant was also added to deagglomerate the suspension. Afterwards, bulk ceramics were prepared with synthesized nano-size (5-10 nm) tetragonal ZrO2 powders (TZP). Based on the Vickers indentation method for bulk ceramics, the fracture toughness (KIC: 15.17 MPa.m1/2) and hardness (H: 9.5 GPa) values were determined.

Furthermore, high mechanical performance of zirconia ceramic was proved with the detailed observation of tetragonal to monoclinic martensitic transformation by TEM combined FIB sample preparation and electron diffraction patterns at nano-scale ranges as well as the SEM images. Figure 1 (STEM image) indicates the phase transformation regions in nano-scale from the sintered ZrO2 samples by using of synthesized TZP in present research.

Keywords: Y-TZP, mechanical properties, SEM, TEM.

References:
Many techniques to control cell alignment have been developed. Microscale technologies are successful applied to tissue engineering to enhance the control of cell behavior and functions. A variety of surface patterns including a wide range of size and shape on different kinds of substrat materials and a wide range of cell types have been investigated. Cell alignment and extension (elongation, circularity, and area) have been implicated in the induction of human mesenchymal stem cell (hMSC) differentiation in vitro. To clarify the effects of micron/submicron hybrid topography on cell behavior and morphology, we investigated the adhesion of hMSCs to titanium (Ti) surfaces with three different topographies; namely, Micron, Nano, and Hybrid grooves which created using a femtosecond laser. In addition, immune-fluorescent detection of the differentiation of hMSC cultured on specimens after differentiation was conducted.

The surface topography of specimens was characterized (Fig. 1). Mirror had a smooth surface before femtosecond laser processing. After 6 h of culture on submicron groove of hybrid surfaces, hMSCs were highly aligned and elongated. Adhesion plaque (vinculin) localization indicated that micron and submicron grooves affected cell orientation and extension, respectively. Importantly, a highly aligned and elongated morphology was observed in hMSCs cultured on the hybrid surface. Four cell types, neurocytes (nerve cell), adipocytes (fat cells), osteocytes (bone cells), and chondrocytes (cartilage cells), were differentiated from hMSC. The different surface features had different effects on the differentiation of hMSC. In particular, the Hybrid surface topography promoted the osteogenic differentiation and chondrogenic differentiation. This micron/nano hybrid topography of Ti surfaces is likely to modulate cell differentiation.

Our findings provide a basis for designing novel biomaterial-cell interfaces to control specific cellular functions.

I would like to thank Dr. Chen, Tokyo Medical and Dental University and Drs. Aso and Sasakit, Aisin Seiki Co., Ltd.to conduct this research.
analyzing sub-cellular content at the single-cell level.

Lasers with pulse durations of hundreds of femtoseconds, which are termed femtosecond lasers, are excellent tools for three-dimensional (3D) processing of transparent material. Specifically, due to the high peak intensity which can induce multiphoton absorption only at the focal volume even inside the transparent materials, they are able to induce local modification at micro- to nanoscale regions with high precision. Rapid prototyping technologies using femtosecond lasers for glass and polymer 3D processing have been progressively developed for microfluidic biochip applications [1].

We propose herein the “ship-in-a-bottle” integration of 3D polymeric patterns inside 3D glass microchannels by a hybrid subtractive - additive femtosecond laser processing method [2]. It consists of Femtosecond Laser Assisted Wet Etching (FLAE) of a photosensitive glass for fabrication of the glass microchannels followed by Two Photon Polymerization (TPP) of a negative epoxy-resin for integration of the polymeric patterns. The method allows lowering the structure size inside microfluidic channels to smaller details, below dimension of a cell. A closed environment is thus achievable to the prospective of mimicking in vivo conditions. A biochip is thus fabricated and consists of 3D nano- and microstructures in an embedded 3D glass microfluidic channel. A scheme of the “ship-in-a-bottle” integration by TPP additive process inside glass microchannels is shown in Figure 1.

The fabricated biochip is proposed for study of cancer cell invasiveness and migration at single cell dimension [3]. The spatial control of resin solidification by photo-polymerization permitted the design of sub-micrometric channels which can be used for single cell trapping, live monitoring and analysis. The adjustable channel geometries and sizes enabling flexible control of diffusible chemo-attractant gradients is helping in understanding single cell-type specific mechanical properties as well as signaling aspects during migration.

References:

C16: Modification of functional surface for wetting behavior in solid and liquid interface

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Major concern in surface modification is focused on the change in the surface energy and the surface morphology. Superoleophobic surfaces are of immense scientific and technological interest for a broad range of applications. This work reports the fabrication of superoleophobic (super-repellent to oil) surface with a mushroom or overhang structure by thermal imprint lithography. Conventional methods for such surfaces are complex and cannot be applied to roll to roll process [1]. In this work, we demonstrate an array of micro asperities that are coated with nanoparticles. Figure 1 shows the scanning electron microscopic image of micro pillars fabricated on the PMMA (polymethyl methacrylate) substrate.
To obtain this array structure, we prepare a nickel (Ni) stamp that has a reverse feature in comparison to Figure 1. For the imprinting process, PMMA substrate is heated above the glass transition temperature (Tg) and we could get a patterned polymer sheet. On the surface of micropillars, nano-sized particles were formed uniformly. This hierarchical structure with micropillars with nanoparticles morphology is a key point for oil-repelling properties [2]. From this study, we demonstrated that the hierarchical structure comprising micropillars and nanoparticles was successfully fabricated by thermal imprint process and additional spraying process. Moreover, this oleophobic surface could be used for a variety of applications such as self-cleaning, antifouling and deicing.

Fig. 1. SEM images of micro pillars. (10 um in diameter): (a) tilted view, (b) cross-sectional view (15 um in height).

References:

B18: Classical and Quantum Light Generation with Nitride-based Semiconductor Nanostructures

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Group III-nitride semiconductor nano/micro structures have attracted plenty of attention owing to their unique optical characteristics and their versatile classical and quantum photonic applications. Here, we present various nitride-based quantum structures grown on various types of nano/micro structures as a template. First, we demonstrated multi-color and broadband visible light emitting diodes (LEDs) based on GaN hexagonal annular structures. [1]. Second, by using tapered GaN/InGaN core–shell QW semiconductor rods having a large gradient in their bandgap energy along their growth direction, highly asymmetric photonic diode behavior was observed with low scattering loss [2]. Third, ultrafast and high efficiency single photon generation was demonstrated by virtue of spontaneous formation of single QD on the apex of tapered GaN nanostructures. Moreover, a broad spectrum of the entire visible range was achieved by growing multiple QW structure with various QW thicknesses on the obelisk-shaped GaN nanostructures. [3]. Forth, we demonstrate an approach of the self-aligned deterministic coupling of single QDs to nanofocused plasmonic modes. Using this approach, we achieved strong spontaneous emission enhancement as high as ~ 22 of QDs over a wide spectral range [4]. Finally, we developed a novel polariton system resulting from strong coupling between a two-dimensional exciton and whispering gallery mode photon using a core–shell hexagonal wire with GaN/InGaN multiple QW [5].

References:

B19: Direct imaging and chemistry of defect structures within SiAlON lattices and their effects on luminescence properties

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Abstract 40
Keywords: Cs-corrected STEM, atomic-resolved EELS, SiAlON, Ceramics, Luminescence

SiAlONs are new generation solid-solution ceramics derived from the same crystal structures of α-β/Si3N4 [1]. Depending on the sintering dopants, the desired engineering properties of SiAlONs for many kind of applications from cutting tools to white light emitting diodes (LEDs) can be tailored by microstructure, primarily consisting of two distinct polymorphs (α and β), triple junction phases and grain boundaries [2-4]. Therefore, the atomic-scale characterization is a key step in further developing and designing the SiAlONs. However, over the past three decades, although many researches have been shed light on the micro- to atomic-scale observations of SiAlONs, the atomic-resolved STEM knowledge from α- and β-SiAlON unit-cells as well as grain boundaries has been lacking.

Here, we report the atomic-scale imaging and spectroscopy of gas pressure sintered Yb, Ce and Yb-Ce containing single and double rare-earth cation doped α/β-SiAlONs as well as TiN reinforced β-SiAlON ceramics using Z-contrast and EELS techniques in different type of state of the art aberration-corrected STEMs [5-6]. The results demonstrate that: (i) Yb and Ce dopants were preferentially incorporated into the β-SiAlON crystal structure at the atom-specific lattice locations, with higher solubility for Yb than Ce; (ii) this observation was also confirmed in the Yb-Ce co-doped system; (iii) Ce atoms without any co-doped cation were present in the triangular-like host sites of α-SiAlON unit-cell, accommodating much more atoms than Ce-doped β-SiAlON; (iv) Yb and Ce atoms were periodically and differently arranged in the grain boundaries, explaining that they are in semi-crystalline nature, not completely amorphous; and (v) Ti atoms were incorporated into the β-SiAlON unit-cell.

In conclusion, our atomic-resolved microscopy and spectroscopy results demonstrate direct visualization of the sites and solubility of rare-earth and transition metal atoms in α-β SiAlON unit-cells and grain boundaries. This capability offers new atomic-level engineering insights into how appropriate rare-earth types and SiAlON host polymorphs should be chosen for nanoscopic tailoring of both next-generation SiAlON-based luminescent ceramics. We expect our observations of impurity sites and solubilities in SiAlON polymorphs and grain boundaries represents the first step towards a new paradigm for atomic-scale guidance in the production of rare-earth and transition metal atoms doped materials for a wide variety of applications.

References:

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B20: Thick film permanent magnets for MEMS

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Several researchers have reported Nd-Fe-B thick films on Si substrates with a metal buffer

Abstract 41
layer prepared by a sputtering method\textsuperscript{1,2}, and the thickness of each film was less than 100 μm. Recently, we demonstrated PLD (Pulsed Laser Deposition)-fabricated Nd-Fe-B films with the thickness up to approximately 160 μm on Si substrates without a buffer layer\textsuperscript{3}. In the study, the effect of the boundary between a Si substrate and a Nd-Fe-B film on various properties was investigated. This contribution reports the mechanical together with magnetic properties of the samples deposited on Si substrates with a thermal or a natural oxide film. Furthermore, a wet etching process of a Nd-Fe-B film was carried out.

Each rotated target with the composition of NdXFe\textsubscript{14}B (x=2.0, 2.6, 3.0, 3.5) was ablated by an Nd-YAG laser. All the as-deposited Nd-Fe-B thick films on SiO\textsubscript{2} (a thermal or a natural oxide film) /Si(100) substrates (5 mm × 5 mm : square) without a buffer layer had amorphous structure, therefore they were crystallized by a pulse annealing (PA) method in the vacuum atmosphere. Although the magnetic properties of films deposited on the both oxide films were almost the same, a peeling phenomenon occurred in a Nd-Fe-B film thicker than 20 μm from a Si substrate with a natural oxide film. The result was different phenomenon of a Nd-Fe-B film deposited on a Si substrate with a thermal oxide film\textsuperscript{3}. Namely, in the previous experiment, even if a Nd-Fe-B film deposited on a Si with a thermal oxide film was broken, the sample was destroyed from the inside of the substrate. The result suggests that the thermal oxide film is indispensable to obtain a strong adhesion between a Nd-Fe-B film and a Si substrate.

In addition, we confirmed no deterioration of magnetic properties after a chemical etching in a Nd-Fe-B film prepared on a thermal SiO\textsubscript{2}/Si substrate. For example, a dicing process for a 113 μm-thick sample which had the remanence of 0.5 T and coercivity of 1160 kA/m was carried out as shown in the Figure. It was clarified that the sample could be diced smoothly without destruction. We also confirmed that the magnetic properties didn’t degrade after the dicing.

References:

B21: Design and Characterization of Electrically-Sensitive Capacitance to Voltage Converter (CVC) for Parameter Extraction of Capacitive Microelectromechanical Systems (MEMS) Accelerometer

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Microelectromechanical System (MEMS) technology has been widely used in consumer electronics and mobile devices for the past decade. However, up to now fabricated MEMS components are not usually matched exactly with the target designed specifications due to inevitable technical errors in the manufacturing process and fabrication. \cite{1} Parameter characterization of these sensors is important to validate the design specifications. Since MEMS accelerometers have been commercialized at an
increasing rate, the present studies are not only focused on the accelerometer design but also on the testing methods as well. According to the MEMS Industry Group (MIG), between 20% to 50% of the total cost of the MEMS device goes to testing. Thus, there has been a growing interest for MEMS accelerometer characterization, and several methods were implemented for different kinds of accelerometers to measure and validate the parameters of the sensor. [2], [3] Conventional testing strategy for MEMS accelerometers requires mechanical stimulus, which leads to high cost of specified equipment and consumes a lot of time for testing procedure. A method of extracting the actual values of the nominal capacitance of a differential capacitive MEMS accelerometer using electrical method is presented. The Capacitance to Voltage Converter (CVC) is composed of an oscillator with an operating frequency of 1.4 MHz, which is used to excite the Device-Under-Test (DUT), connected to a frequency-to-voltage converter. The oscillator generates an electrical signal that causes the sensor to produce a change in capacitance. This nominal capacitance is converted into voltage through the use of frequency to voltage converter, and signal conditioning circuit implemented using two-pole Butterworth filter. From the output voltage, the actual value of the accelerometer’s nominal capacitance can be mapped, and the electrical sensitivity of the readout circuit is extracted. The design is capable of converting 90.91fF to 10pF nominal capacitance into voltage. An electrical sensitivity of 0.892V/pF from actual prototype testing is close to the theoretical target value of 0.816V/pF, offering less error of 9%. Discrete capacitors connected in series and parallel used as test capacitors does not always match the computed values, which may cause the obtained error. The error calculated from testing is also due to the presence of stray and parasitic capacitances caused by the connecting leads and PCB tracks, and the use of standard components available in the market. Overall, the demonstration of the project shows a very high linearity in the intended nominal capacitance values. The design project can be used as alternative testing equipment for differential capacitive MEMS accelerometer. It provides similar functions as the conventional mechanical testing machines, but with significantly lower cost and characterizes accelerometers in less time.

References:

B22: High Power RF MEMS Switches
Hosein Zareie

B23: Biomimetic MEMS/NEMS sensors inspired by marine life
Ajay Giri Prakash Kottapalli

B24: Resonant MEMS mirrors for optical and laser scanning applications
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Since the first publication of a single, silicon-based micromechanical scanning mirror in 1980 [1] various different one- and two-dimensional MEMS mirrors for diverse optical and laser scanning applications have been designed and fabricated [2]. Typical MEMS scanners feature mirror diameters up to a few Millimeters and address low optical power applications, e.g. laser beam scanning pico-projectors [3]. In contrast, recently introduced
resonant MEMS Scanners offer apertures up to 20 mm with integrated high reflectivity optical coatings and enable new applications for MEMS-based scanning in high power laser systems such as laser phosphor displays, automotive lighting and displays, 3D printing and general laser material processing [4].

In this work we discuss typical requirements for optical and laser scanning systems in different applications and present MEMS-based scanning solutions comprising resonantly actuated micromechanical mirrors as well as electronic hard- and software for driving, detecting the mirror angular deflection and controlling the MEMS scanner oscillation. In addition to the vacuum packaged electrostatically driven devices shown in Figure 1 we also present unpackaged and piezoelectrically actuated MEMS scanners.

Figure 1. A selection of vacuum packaged MEMS scanning mirrors with mirror diameters of 1 mm [5], 7 mm [6] and 20 mm [4].

References:

B25: Accelerating inkjet towards immediate 3D printing

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Three-dimensional (3D) printing is noted by many indicators as a revolutionary technology that has the potential to significantly change the consuming behavior and production as well as many other aspects of modern life [i, ii]. This technology with the current capabilities has already penetrated into many disciplines. A major limiting factor of the 3D technology is the printing speed, printing models takes long hours. It seems that a breakthrough enabling fast 3D printing will lead to further expansion of the 3D printers usage.

Inkjet is one of the several 3D printing developing techniques. This work presents a solution for fast 3D inkjet print head. The solution is based on enlargement of the print head to a large array of ejectors covering the entire printing area. The nozzles eject drops almost simultaneously and an entire layer is practically ejected at the same time without mechanical significant movement. Therefore, the printing time is reduced to the layer printing time (~100 layers/second) multiplied by the number of layers. Calculation shows that a short object can be printed within seconds and high object in ~1 minute. The print head is comprised
of small autonomous segments. Each segment is separated from the neighboring segments. The segments are comprised of an open micro reservoir feeding a chamber (or few chambers) with a MEMS produced resistor and nuzzle. The segments are manufactured on the same wafer enabling area coverage. The conceptual structure is seen in Fig. 1.

Models of the segmented print head were build and tested for functionality and for proof of concept. The fluid transport from the open micro reservoirs to the chambers was checked in one model of 12x12 cm² print head [iii], while in smaller models the lifetime was checked [iv] and printing was proven [v]. The segments were operated separately and drops were obtained. Various size and shapes were checked and various drop size were proven feasible.

The application of the 2D print head as a fast 3D printer will be presented as well as printing speed estimation. Also, the potential of extremely high speed inkjet digital printing, that may compete with traditional offset printing speed will be presented.

References:

B26: ENVIRONMENTAL BARRIER COATINGS (EBC) FOR SILICON-BASED CERAMIC COMPOSITES

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The need to increase the cycle efficiency and reduce noise and NOx emissions from jet engine turbine has promoted the development of ceramic matrix composites (CMC) such as silicon carbide fibre-reinforced silicon carbide (SiC-SiC). Use of CMCs will lead to a significant improvement in fuel consumption and thrust-to-weight ratio compared to metal alloys. In addition, the low density of CMCs allows weight savings of up to 30% compared to Ni-based super alloys equating to about 1000kg/engine thus leading to vastly improved fuel consumption. However, silicon (Si)-based ceramics such as SiC-SiC have poor environmental durability in high velocity combustion environments. Si-based ceramics have excellent oxidation resistance due to formation of a protective silica layer on reacting
with dry air making them stable at temperatures up to 1200°C for long-term application. On the other hand, the same silica layer will react with water vapour to form gaseous silicon hydroxide, leading to high recession and component failure. To avoid this behaviour, a prophylactic environmental barrier coating (EBC) is required. A variety of EBCs have been developed in the past, which consists of a minimum of 4 layers requiring a costly application method such as plasma spraying. In this work, five rare earth monosilicates are being examined as potential EBCs: Y₂SiO₅, Yb₂SiO₅, Lu₂SiO₅, Gd₂SiO₅ and Er₂SiO₅. Their performance in steam environments is being studied at 1200-1350°C for different times as a first step to determine which EBC candidate is most promising for protecting SiC-SiC CMCs in the jet engine environment. The main aim of this study is to develop a reliable single layer of EBC instead of multilayers and to develop a low cost method of applying the EBC.

B27: Skyrmion dynamics studied by time-resolved electron microscopy

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Skyrmions are rotationally symmetric nanoscale spin structures, observed in materials with chiral space-groups and possessing an intrinsic Dzyaloshinskii-Moriya interaction. Magnetic skyrmions are promising candidates as information carriers in logic or storage devices thanks to their robustness, guaranteed by the topological protection, and their nanometric size. Currently, little is known about the influence of parameters such as disorder, defects, or external stimuli on the long-range spatial distribution and temporal evolution of the skyrmion lattice. Utilising the Fresnel mode of a 200 keV cold field emission gun cryo-Lorentz transmission electron microscope, we image up to 70,000 skyrmions in a large (7.3 x 7.3 µm²) single-crystal nanoslice of Cu₂OSeO₃. Images were recorded as a function of the applied magnetic field. The emergence of the skyrmion lattice from the helimagnetic phase is monitored, revealing the existence of a glassy skyrmion phase at the phase transition field, where patches of an octagonally distorted skyrmion lattice are also discovered [1]. In the skyrmion phase, dislocations are shown to cause the emergence and switching between domains with different lattice orientations. The temporal fluctuation of these domains is filmed as a movie for 50 s, where each frame is exposed for 100 ms, and an image is acquired every 500 ms (Fig. 1). These results demonstrate the importance of direct-space and real-time imaging of skyrmion domains for addressing both their long-range topology and stability.

Fig. 1: Four frames of a skyrmions movie are displayed. Panels (a-d) depict the real-space images and panels (e-h) represent the corresponding Fourier Transforms. Fluctuations of the skyrmion lattice and formation of domains with different orientations as a function of time are evidenced by the splitting and
unsplitting of the Bragg peaks and their continuous change of position.

Reference:

B28: Characterization of nanomaterials using filed-flow fractionation
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“Size” and “size distribution” are significant physicochemical properties of functional materials since it determines many of the functional properties of these materials. Methods for the accurate determination of the size and the size distribution of materials are therefore one of the key to the development of nano- and biotechnologies. In the past few decades, dynamic light scattering (DLS) has been widely used for determining the sizes of Brownian nanoparticles in nano- and submicron-scale colloidal suspensions. Because of the convenience and usability of DLS, a large number of commercial instruments and analytical methods based on various principles underlying the DLS method are available. In this method, the diffusion coefficients of nanomaterials are determined first, after which the averaged diameters of the particles are calculated from the diffusion coefficients by using the Stokes–Einstein relationship. However, the apparent diameters of nanoparticles over a wide size distribution as determined using the DLS method depends on the particular analytical algorithm. Electric microscope is effective method to obtain the primary particle information visually, however; it requires counting a large number of materials for ensemble characterization. Additionally, the European Commission has declared that a “nanomaterial” is a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm–100 nm. According to this definition, not only the size but also the size distribution of nanomaterials in is an important factor for nanomaterial industrial fieled.

Fractionation methods such as field-flow fractionation (FFF) and microfluidic/nanofluidic technological separation have recently been focused upon as methods for the determination of accurate size distribution. FFF is elution techniques wherein nanoparticles, microparticles, and macromolecules are separated by their physicochemical properties. In nano- and micro-technology, various FFF methods are attractive techniques for separating materials in colloidal dispersions by means of flow, centrifugal, magnetic, and thermal field control. Different fields enable nanoparticle separation based on various criteria: diffusion coefficient (i.e., hydrodynamic size) by flow FFF, thermal diffusion coefficient, density, mass, and so forth. The most general applicable FFF methods are flow FFF and centrifugal FFF because of their practicality and the robust theoretical foundation established for separation of nano- and micro-materials in many areas. Herein, we performed FFF assessments of various materials combined with DLS and EM methods to characterize more accurate size and size distribution of materials than the results by single sizing method such as DLS. This study plays an important role in producing a new application of nano- and biotechnology in research of functional materials.

References:

B29: Soft dielectric gels as electro active materials
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Dielectric polymer materials softened with solvents and/or plasticizers can be a good electroactive materials. [1] Their performances are fairly nice, and can be applied for various type of actuators. The concept can also be applied for elastomers such as polyurethanes (PU).[2] In this presentation, polyvinyl alcohol (PVA) gel and plasticized polyvinyl chloride (PVC) will be introduced.

PVA gels swollen with DMSO can show deformations, such as, contraction, bending, and crawling with reaction time of ca. 40 ms. The mechanism has been considered “charge injection and solvent drag”. Fundamental phenomena is similar to “ion-drag”. [3] For practical use, depression of solvent content is required for the improvement of bleeding-out of solvent.

Plasticized PVC can also exhibit very good performance as electroactive actuator, and may be one of the closest for practical use. Their deformations and actuations are creeping, folding, contraction, laser deflection, piezoelectric function. Latter functions are useful for sensor devices. Durability is almost practical level for ambient use. Mechanism is charge injection and attractive force to the discharging electrode, the attractive force accompanies creep deformation.

In both cases, colossal dielectric constant in low frequency range (>1 kHz) plays an important parameter for evaluating the capability as actuator. [4]

These findings can be applied for the molecular design of electroactive actuator, and leads the concept of electroactive elastomers such as PUs and block copolymers, too. [5]

References:
phemonenon, we have demonstrated the advantage of the emitter as an imaging agent in oxidizing environments and designed ratiometric luminescence probes for the ultralow concentration detection. The in situ generation of silver nanodots in silver nanoparticle solutions enable the nanodots to reveal the interaction between silver nanoparticles and nucleobases in the concentration process of nucleobases. We are fabricating such functions into a unique, small size multifunctional nanoparticles. (1-5)

Figure 3: Reactive oxygen species selectively accelerated transitions between various silver nanodots. The blue was developed as an oxidant-resitant imaging agent and analyte reporter. In addition to the spectral response of nanodots to ROS, silver nanodots were formulated to detect analytes with excellent selectivity and picomolar detection limit when coupled to glucose oxidase.

References:


B31: Construction of porous molecular materials via designed hydrogen bonding network
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Porous molecular materials constructed by lamination of a two-dimensionally networked low density sheet composed of a π-conjugated molecule have attracted much attention because of application for selective absorbents of a certain chemical species, a catalyst, and photoelectronic materials. Particularly, hexagonal networks (HexNets) are expected to show their topology-generated physical properties, as well as provide spaces with well-predictable shape and size. In connection with this, we planned to fabricate novel layered assemblies of hydrogen-bonded HexNet (LA-H-HexNets) possessing multiple pores with different shape and size, based on a series of C3-symmetric planar π-conjugated molecules possessing alternate sides with different lengths and hydrogen bonding module (i.e. 4,4'-dicarboxy-o-terphenyl group).

We prepared a series of C3-symmetric molecules (C3Ps) Tp, T12, T18, and Ex1 and crystallized them with the optimized conditions to yield the corresponding multi-porous LA-H-HexNets, where all C3P were hexagonally networked by hydrogen-bonded PhT motif to form isostructural H-HexNets with dual or triple void spaces with systematically varied size and shape, while the HexNets were stacked in a different manner depending on the C3P. Furthermore, desolvated (activated) LA-H-HexNets of Tp and T12 are revealed to maintain
the layered HexNet structure and permanent porosity: SABET = 788 m2 g−1 and 557 m2 g−1, respectively, based on CO2 sorption at 195 K.

**Fig 1.** Formation of LA-HexNets: (a) C3Pis with six carboxyphenyl groups (Tp, T12, T18, and Ex1) form (b) hydrogen-bonded triangular motifs (b) to yield (c) the corresponding layered assemblies of hydrogen-bonded hexagonal networks (H-HexNets) with multi-pores.

References:

**C17: Physics and applications of ballistic graphene Josephson junctions**

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When high-quality graphene is placed in close proximity with a superconductor it is possible for dissipation-less current to pass through the graphene over length scales of several microns. The properties of graphene mean that the superconducting proximity effect can be studied in a material where the density of carriers can be controlled, where carrier transport is ballistic and coherent, and where contacts to the superconductor have high transmission. In this talk I will present measurements of niobium-graphene-niobium Josephson junctions and describe some of the unexpected behaviour seen in this system. In particular, we have found that super-current through the junctions, which should be suppressed in magnetic fields <10 mT, actually survives in magnetic fields as high as 1 T. We attribute the high-field supercurrent to mesoscopic states that exist near the edges of the graphene. The work reveals new regimes where super-current can be directed by quantum confinement and cyclotron motion, and points the way to new applications for graphene-based superconducting devices.

Reference:

**C18: Interface effects on acceptor silicon spin qubits**

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Recently, proposals of acceptor-based qubits have drawn considerable attention due to the long range strong dipolar inter-qubit coupling and the possibility of exploiting the spin-orbit interaction to couple spins to phonons or oscillating electric fields. Dopant-based quantum computing implementations often require the dopants to be situated close to an interface to facilitate qubit manipulation with local gates. Interfaces not only modify the energies of the bound states but also affect their symmetry.

Making use of the successful effective mass theory we study the energy spectra of acceptors in Si or Ge taking into account the quantum confinement, the dielectric mismatch and the central cell effects. The presence of an interface puts constraints to the allowed symmetries and leads to the splitting of the bulk four-fold degenerate ground state in two Kramers doublets. We show that, as the acceptor gets closer to the interface, the entire spectrum is compressed. Inversion symmetry breaking also implies parity mixing which affects the allowed
optical transitions. Consequences for acceptor qubits are discussed.

Fig 1. Effective mass prediction of the ground state splitting compared with experimental values.

References:

C19: Two-dimensional Molybdenum Trioxide for Applications in Electronics
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The discovery of graphene in 2004, [1] has drawn the interests of both industries and the scientific community on 2D materials. Although the enhanced carrier mobility observed in graphene is highly desirable for electronic applications, the lack of intrinsic bandgap leads to the exploration of alternative 2D materials with semiconducting properties.

This work explores the capabilities of two-dimensional molybdenum trioxide (MoO3), an intrinsic high-dielectric material as an alternative for achieving enhanced charge carrier mobilities. MoO3 is one of the transition metal oxides that has a relative dielectric constant of ~500 (where as MoS2 ~ 5) and can be exfoliated to minimum resolvable atomically thin layers. But stoichiometric MoO3 has a wide bandgap (>3 eV) which is not viable for transistor applications.[2] However the bandgap of MoO3 can be easily manipulated to desirable values by several techniques such as hydrogen ion (H+) intercalation, UV irradiation, electron beam bombardment etc. [3,4] Such techniques produce partially reduced, sub-stoichiometric MoO(3-x), which possesses an increased carrier concentration and a high dielectric value, thus favoring an enhancement in charge carrier mobility.

2D MoO3 crystals are obtained through a combination of chemical vapor deposition and mechanical/liquid exfoliation processes. Alternate top-down approach of a wet chemical etching process is developed, in order to controllably/sustainably obtain monolayers. The viability of 2D MoO3 based field effect transistors and thin film sensors are established. [2,5]

Reference:
C20: Signal and Information Processing with Biomolecules: Enzyme-Catalyzed Reactions and Their Cascades for Multi-Input Biosensing and Biocomputing

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Novel paradigms of signal and information processing have received significant attention based on their promise of new functionalities, new interfacing capabilities, and in some cases speed-up for sensor, diagnostic, and computational applications. Such “unconventional computing” realizations are in some cases contemplated as competitive, but in most situations will be complementary to the modern electronics technology.

An emerging research field of processing signals and information by using biomolecular processes will be surveyed in this talk, and specific examples and research results will be presented for enzyme-catalyzed biomolecular reactions [1].

Reference:
1. For additional information, see http://www.clarkson.edu/Privman

C21: Electrochemical and optical biosensing based on nanobiomaterials


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Keywords: enhanced Raman scattering, metamaterials, polyelectrolytes, layer by layer, biosensors, immunoassays, amperometric sensors.

The possibilities of nano-sized particles of manganese dioxide and the enzyme-polyelectrolyte complexes for the development of highly sensitive amperometric sensors for the detection of neurotoxins and blood esterases were considered in the presentation.

New dielectric SERS metamaterials were investigated also. The materials consist of dielectric and plasmonic resonators deposited on the metal substrate. Computer simulations as well as real experiment demonstrate the extraordinary enhancement of the Raman signal.

C22: A Microfluidic Chip for Detecting Protein Phosphorylation in Cells

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Genomic research has long benefitted from the unique capabilities of microfluidic devices. Proteomics, on the other hand, cannot claim yet the same success. In this presentation we will describe the lab-on-a-chip technology that we develop in our laboratory. Our main objective is to create miniaturized platforms for biological
sample analysis, as a front-end to mass spectrometry (MS) detection. We are interested in developing functional elements for fluidic propulsion, fast enzymatic reactions, sample separation and interfacing to mass spectrometry, and combine these elements into a stand-alone device. We fine-tune these devices for the analysis of biologically relevant molecules from cancer cell extracts. In particular, we are interested in the targeted detection of proteins that are markers of disease, and in profiling cell signaling pathways that lead to aberrant proliferation of cancer cells. In our laboratory, we use estrogen receptor (ER+) and epidermal growth factor receptor positive (EGFR/HER2+) cancer cells that are subjected to treatment with various growth factors, hormones or drug inhibitors to reveal the critical components that drive proliferation. MS-based proteomic profiling of various cell fractions commonly leads to the identification of several thousands of proteins, and the comparison of different cell states enables the selection of protein clusters of interest for targeted detection on the chip. In this work we will describe the efforts oriented toward the detection of phosphorylated proteins that are implicated in mitogen activated protein kinase (MAPK) signaling pathways in cells. Such pathways are critical to processing the signal captured by cell surface receptors and translate it into various cell fate outcomes (proliferation, death, migration, etc.). We will discuss the challenges posed by such analyses, and propose solutions for addressing these challenges in terms of ability to detect the presence of phosphorylation on biologically-relevant time-scales and benefits enabled by the implementation of such analyses on microfluidic platforms.

Zig-zag silver nanorods could generate hot spots for surface-enhanced Raman scattering (SERS) in their bends. This phenomenon has created the possibility to realize three-dimensional plasmonic crystals which may further increase the sensitivity of SERS. We have systematically studied the near- and far-field optical response of zig-zag nanorods via three-dimensional finite element method (FEM) calculations. We show the red shift of multipole resonance peaks with the increase of nanorod length and the enhancement of local electric fields in bends decreases with larger nanorod diameter. These phenomena arise from the stimulation of multipole resonance with larger nanorod sizes. We further demonstrate the interference of hot spots in zig-zag nanorods with larger folded numbers. This three-dimensional alignment of hot spots shed light on further investigation on three-dimensional plasmonic crystals.

C24: DNA-based high multiplex detection methods

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Highly specific and fast multiplex detection methods are essential to conduct reasonable DNA-based diagnostic tests and are especially important to characterise infectious diseases. More than 1000 genetic targets such as antibiotic resistance genes, virulence factors and phylogenetic markers correlating to pathogens have to be identified as fast as possible to facilitate the correct treatment of a patient. A wide range of molecular technologies such as microarrays, multiplex PCR, next-generation sequencing, etc. has been developed to detect multiple targets in samples. They differ strongly regarding specificity, sensitivity, detection time, price and handling. In this talk, an overview of the advantages and disadvantages of the most popular DNA-based multiplex diagnostic techniques will be given. Additionally, the proceedings made at the AIT regarding multiplex detection will be presented and discussed.
C25: DNA electrochemical sensor Obtained by "layer by layer" deposition of "viologen" - thymine derivatives and oligo-adenines on mesoporous TiO2 films

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Recently, we synthesized bifunctional derivatives consisting of quaternized 4,4'-bipyridinium units so-called “viologens” and nucleobases i.e. thymine and/or adenine respectively. Such compounds combine the redox/electrochromic properties of 4,4'-bipyridinium with the molecular recognition function of nucleobases thymine or adenine. The “viologens” nucleobase derivatives exhibit interesting optoelectronic properties due to charge transfer interaction between nucleobases and the viologen units, which can be used successfully to create highly ordered supramolecular aggregates by hydrogen bonding with complementary oligonucleotides on TiO2 electrodes. Layer-by-layer (LbL) technique can be used to modify the surface of mesoporous TiO2 thin film with electroactive viologen-nucleobase derivatives using complementary hydrogen bonding between adenine and thymine nucleobases. A monolayer of oligonucleotide (dAn) was first electrostatically immobilized on TiO2 to confer affinity to the surface of the next nucleobase-viologen alternating layers. Cyclic voltammetry and spectroelectrochemical methods (SEC-UV-VIS) have been employed for the characterization of the modified films. The stability of the deposited hydrophobic layers was checked by desorption experiments in water. The modified TiO2 mesoporous film with viologen-nucleobase may be used as electrochemical sensors based on modulated marker ion current. It is the consequence of analyte-membrane interaction, which is supported on an electrode surface. The sensing membrane could be a layer of biological or synthetic material such as peptides, protein, DNA, or PNA attached to the electrode. The signal is the electrochemical current related to the oxidation or reduction of marker ions at the electrode, i.e. a heterogeneous electron transfer (ET) underneath the membrane.

Reference:

C26: Digital X-ray Sources Based on Carbon Nanotube Electron Emitters

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Carbon nanotube (CNT) has attracted a great deal of attention as the most promising field electron emitter due to its geometric high aspect ratio with a nanometer-sized diameter and high chemical inertness [1]. However, the stability and reliability of CNT field emitters is a still big problem in vacuum electronic device applications like field emission digital x-ray sources. That’s why any field electron devices have not been commercialized yet. In this paper, we report great improvement in CNT field emitters and their application to vacuum-sealed
digital x-ray tubes for medical diagnoses. Some advantages of CNT-based digital x-ray tubes are the ability to operate in fast digital mode, ease of size reduction and high-voltage insulation, and removal of heating elements for a hot-cathode electron source.

The CNT emitters were printed from the optimized paste consisting of multi-walled CNTs, carbide fillers, and an organic binder on a metal substrate [2]. Two kinds of digital x-ray tubes with a stationary anode target, for a stationary digital breast tomosynthesis (sDBT) and an intra-oral x-ray imaging, have been fabricated by vacuum brazing of a CNT emitter cathode, an anode with W target, and a ceramic of Al2O3 at an elevated temperature. The digital x-ray tubes have a gate electrode to control field emission from the CNT emitters independently of the anode voltage. Here, we note that the vacuum level of the sealed x-ray tubes is maintained with only a non-evaporable getter instead of active vacuum pumps like a turbo molecular or ion pump.

The digital x-ray tube for sDBT imaging has a cathode current of above 30 mA along with a focal spot size of around 0.3 mm at an anode voltage (VA) of 30 kV [2]. The sDBT imaging could be successfully achieved by an advanced active-current control (ACC) unit for multiple digital x-ray tubes. The advanced ACC unit could enhance uniformity of x-ray tubes strongly, leading to the successful sDBT imaging even from irregular performance-x-ray tubes. The digital x-ray tube for portable intra-oral x-ray imaging has a high anode current of 3 mA under a VA of 65 kV in a compact size with a diameter of 15 mm, providing a clear dental x-ray imaging. The reliability of the two digital x-ray tubes was evaluated to have a commercial lifetime of pulse shots over 100,000. The digital x-ray tubes developed are expected to be commercialized in the near future.

References:

C27: Fabrication of Gold Nanoparticles into 1D and 2D Structures with Amyloidogenic Protein of Alpha-Synuclein and Their Applications

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Fabrication of nanoparticles (NPs) into hierarchical structures is crucial for not only maximizing the physical and chemical properties of NPs, but also their applications in the development of high-performance nano-devices. NPs have been assembled with an amyloidogenic protein of alpha-synuclein (S), the major pathological component of Lewy bodies found in the degenerating neurons of Parkinson’s disease. By taking advantage of the unit-assembly process of S, gold-nanoparticles (AuNPs) coated with S were aligned in either anisotropic 1-D chain or tightly packed single-layered 2-D array on a chemically diverse set of substrates. The resulting peapod-type AuNP chains embedded within the amyloid protein nanofibrils were shown to be capable of exhibiting photoconductance with visible-light, essential for the development of subwavelength-size light guiding system. The S-mediated single-layered AuNP adsorption was also employed in surface-enhanced Raman scattering (SERS)-based biosensor development, non-volatile memory development, fuel-cell performance improvement, plasmonic solar-cell enhancement, and photodynamic cell-culture platform fabrication, where the outlying S has played versatile roles such as specific ligand interaction, dielectric layer for charge retention, dielectric layer for charge retention,
sacrificial layer to expose AuNPs for chemical catalysis, reaction center for bio-silicification, and bio-interface for cell attachment, respectively. In addition, the tightly packed 2-D AuNP array was successfully unleashed from polycarbonate substrate in the form of free-floating monolayer film showing unlimited expandability, robustness for patterning, and flexibility leading to conformal contact. Not only these approaches introduced here, therefore, offer a facile and general way to fabricate NPs into either 1-D or 2-D structure, but also the unique properties provided by the protein sheath make the resulting hybrid structures multifunctional photoelectric fusion materials suitable for applications in nano-bio-technology.

C28: Photo-design of metal nanoparticles and metal/polymers nanoassemblies
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This paper reports on a simple and easy method to engineer plasmonic nanoscale silver films directly on a variety of substrates (glass or food packaging plastic wraps) through a low cost and environmentally friendly method, which involves a common UV source.

The novelty of this work lies in the possibility to coat a very thin film of silver nanoparticles onto available substrates (glass or food packaging plastic wraps) through a low cost and environmentally friendly method, which involves a common UV source.

Very important, the process avoids handling dry powder metal nanoparticles and aggregation that takes place during dispersion in a liquid formulation and it does not need extra toxic stabilizers or reducing agents that could contaminate food.

The natural antibacterial activity of the material was evaluated and food plastic wraps top-coated in this way exhibited a high antibacterial activity.

Fig1. Photographs of the films coated onto glass samples: a) homogeneous beam; b) illumination through an amplitude mask.

References:

C29: Development of Indoline Dyes in Dye-sensitized Solar Cells
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Indoline dyes are one of the most efficient organic sensitizers in dye-sensitized solar cells (DSSCs). In 2003, D149 was reported to exhibit the conversion efficiency ($\eta$) of 8.85% [1]. In 2008, D205, in which the ethyl group of D149 is substituted with octyl group, showed higher $\eta$ value than D149 due to larger open-circuit photovoltage ($V_{oc}$) [2]. Further improvement of
cell performance of indoline dyes in DSSCs is reported.

To improve $\eta$, it is effective to produce more bathochromic indoline derivatives, which can enhance short-circuit photocurrent ($J_{sc}$). DN319 is more bathochromic than D205 due to electron-withdrawing dicyanovinylidene group at the terminal rhodanine moiety. DN319 could show larger $J_{sc}$ value to exhibit higher $\eta$ value than D205.

It is also effective to inhibit H-aggregate formation of dye molecules to improve $J_{sc}$. DN350 has bulky 2-(9,9-dimethylfluorenyl) group in the molecule. The UV-vis absorption spectra on semiconductor indicated that the H-aggregate formation of DN350, observed at slightly short wavelength than the monomer form, was least among D205, DN363, DN319, DN351, DN362, and DN350. DN350 could show the highest conversion efficiency among them.

The degradation of solar cells can come from desorption of dye molecule from semiconductor surface. GU117, in which two carboxy groups are attached in a molecule, could show better stability than GU115, GU116, and DN351 under contentious fluorescence lamp irradiation at room temperature.

References:

C30: Electrochemical property of binary metal oxide conversion anode synthesized from Layered double hydroxides and its reaction mechanism

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A new conversion type anode material for lithium ion battery utilizing the redox activity of aluminum (III) ion has developed. Conversion type materials are known to have a serious weak point as anode materials, that is the high reaction voltage in spite of its high capacity (over 600 mAh/g). This high reaction voltage originates in high redox potential of transition metal oxide such as NiO or CoO, those are known as representative conversion anode materials for lithium ion battery. In order to improve this high reaction voltage, it is effective to use oxides of light metal with lower redox potentials such as aluminum oxides, titanium oxide and so on. However, aluminum oxides are difficult to use as the electrode materials owing to the low
electric and ionic conductivity. We have synthesized solid solution of nickel oxide and aluminum oxide with nano level particle size by calcination of Ni-Al layered double hydroxides (LDH). In the previous studies, we have investigated the structure and electrochemical properties for the solid solution of NiO with TiO2 or V2O5. [1-3] The fine structure of calcinated materials are determined by XRD and XAFS: Ni2+ and Al3+ ions are randomly locating metal ion sites of NiO with rock salt structure and cation vacancies are introduced to compensate the excessive charges brought by the aluminum ions. In this structure, electron and lithium ion are expected to be supplied via NiO type host structure and cation vacancies, respectively.

The charging capacity of the half cell with lithium metal counter electrode from 0.03 V to 1.5 V, that corresponds to the discharge capacity of the full cell was improved to 600 mAh/g, whereas that for pristine NiO was 230 mAh/g. This improvement of capacity in the lower voltage region is expected to originate in redox of aluminum ion. The redox activity of aluminum ion was confirmed by ex-situ XANES measurement at Al K edge. The absorption edge of aluminum ion shifted to lower energy direction with discharge from 1560 keV to 1556 keV. With charging, the absorption edge of aluminum shifted back to the initial position. This directly indicates the redox activity of aluminum ion during charge-discharge. This is the first report of anode material for lithium battery that utilizes redox of aluminum ion as far as we know.

In order to investigate the detailed reaction mechanism, ex-situ XRD and XAFS measurements were carried out. On the basis of these results, the reaction mechanism of Ni-Al binary metal oxide was concluded as follows. In the higher voltage discharge process (OCV-1.0 V), lithium intercalation into the cation vacancy and lithium ion adsorption to the surface of Ni-Al binary metal oxide with the partial redaction of nickel ion are proceeding. [1] In the lower voltage discharge (1.0-0.03 V), the conversion reaction proceeds with the reduction of Ni and Al ions. In the lower voltage charge process (0.03-1.0 V), only aluminum ion is oxidized to form an intermediate state, where aluminum ion makes complex with surrounding oxide ions. In the higher voltage charge process, nickel metal is oxidized to re-form the Ni-Al binary metal oxide with the rock salt structure.

References:

C31: Optimization of Li4Ti5O12 based material as high performance electrode for energy storage devices
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Spinel Li4Ti5O12 (LTO) has been considered one of excellent materials to improve and reinforce the weak points of conventional carbon anode material. It has advantages of negligible structural change during the charge/discharge process, good Li+ diffusion channels due to 3-dimensional structure, and no formation of solid electrolyte interphase (SEI).

However, LTO has low conductivity. In order to overcome this demerit, doping with anions and cations, coating with metal-oxide and carbon, and making composite with other materials. In doping method, most of studies have been focused on single doping material.

In this study, we tried co-doping of two different element as well as one element. After studying extremely many different pairs of samples, we found the best doping combination. To improve the cycle performance even more, we coated ZnO, Al2O3, Al-doped ZnO of several nm on the surface of LTO electrode using atomic layer deposition. The best thin coating layer for high discharge capacity was found and the role of thickness and composition of thin layer was investigated.

LTO is also excellent anode materials for Li-ion capacitor. We found the best size of TiO2 precursor nano particles and calcination temperature. We report the electrochemical performance of fabricated Li-ion capacitor using
differently prepared LTO samples. Finally, we will present about the LTO particles wrapped by reduced graphene oxide (rGO). The used rGO is synthesized by very simple one step method. The reduction and doping of rGO is done simultaneously in our process.

C32: Redox orbital and complex electronic mechanism in Li battery materials measured by X-ray Compton scattering

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Compton scattering was performed on the beam line 08W at the SPring-8 synchrotron facility of Japan. The incident x-ray energy was 115 keV. The scattering angle was fixed to 165 degrees. The measurement was done under room temperature. Samples were polycrystalline of LixMn2O4 (x=0.476, 1.079, 1.233) and LixCoO2 (x=0, 0.5, 0.625, 0.75, 1). All samples were prepared by extracting lithium chemically. Lithium concentration of the samples were confirmed by inductively coupled plasma (ICP) analysis.

Results of our Compton profile measurement show an increment of itinerant electrons with lithium insertion in LixMn2O4 and LixCoO2. By comparing experiment with first-principles calculations, we deduce that this increase of itinerant electrons has oxygen 2p character. Therefore, the redox reaction occurs via oxygen 2p orbitals in both materials. On the other hand, 3d orbitals of transition metal becomes less localized at the range of Li concentration corresponding to the optimal battery performance both for the LixMn2O4 and LixCoO2 cathodes. This 3d orbital delocalization effect is associated with electron conductivity properties. Therefore, Compton scattering spectroscopy can provide new descriptors for electrode conductivity.

This work was supported by the Japan Science and Technology Agency, MEXT KAKENHI, and the U.S. Department of Energy (Basic Energy Science/Division of Materials Science)

References:
Poster Session:

P1: Novel nickel iron phosphide (NIP) nanoparticles for photocatalytic hydrogen generation

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Development of novel and robust photocatalyst is one of the important research issues to tackle the increasing global energy demand and global warming concern in 21st century. Inorganic semiconductors that can convert photons to hydrogen through hydrogen evolution reaction (HER) are attractive to chemists. TiO2 and CdS are semiconductors well-known by their excellent hydrogen production rate. However, with regard of their limitations of sustainable usage,1, 2 development of more efficient and robust semiconductor-based photocatalysts is urgently needed.

Nickel phosphide is one of the potent catalyst for HER.3 Through decomposition of metal precursors and phosphorus source in the presence of capping ligands, novel nickel iron phosphide nanoparticles (NIP) were successfully synthesized and characterized using XRD, HR-TEM and EDX (Figure 1a). The photocatalytic reactivity of NIP in HER was investigated under acidic medium.

References:

P2: Hierarchical spherical activated carbon with high performance for ultracapacitors

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To resolve the pore-associated bottleneck problem observed in the electrode materials used for ultracapacitors, which inhibits the transport of the electrolyte ions, we designed a hierarchically structured activated carbon (HAC) by synthesizing a mesoporous silica template/carbon composite and chemically activating it to simultaneously remove the silica template and increase the pore volume. The resulting HAC had a well-designed, unique porous structure, which allowed for large interfaces for efficient electric double-layer formation. Given the unique characteristics of the HAC, we believe that the developed synthesis strategy provides important insights into the design and fabrication of hierarchical
carbon nanostructures. The HAC, which had a specific surface area of 1957 m$^2$ g$^{-1}$, exhibited an extremely high specific capacitance of 157 F g$^{-1}$ (95 F cc$^{-1}$), as well as a high rate capability. This indicated that it had superior energy storage capability and was thus suitable for use in advanced ultracapacitors.

![Fig1](image)

Fig1. (a) Illustration of the method used for synthesizing HAC. HRTEM images of the (b) mesoporous silica template, (c) carbon/silica composite, and (d) HAC.

**P3: The Magnetic Levitated Loading of the Dipole Trap for Cesium Atom**

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We report a detailed study of effective magnetically levitated loading of cold atoms in a crossed dipole trap: an appropriate magnetic field gradient precisely compensates for the destructive gravitational force of the atoms and an additional bias field simultaneously eliminates the anti-trapping potential induced by the magnetic field gradient. The magnetic levitation is required for a large-volume crossed dipole trap to form a shallow but very effective loading potential, making it a promising method for loading and trapping more cold atoms. For cold cesium atoms in the F = 3, mF = 3 state prepared by three-dimensional degenerated Raman sideband cooling [1], a large number of atoms \( \sim 3.2 \times 10^6 \) have been loaded into a large-volume crossed dipole trap with the help of the magnetic levitation technique. The dependence of the number of atoms loaded and trapped in the dipole trap on the magnetic field gradient and bias field, respectively, is in good agreement with the theoretical analysis. The optimum magnetic field gradient of 31.13 G/cm matches the theoretical value of 31.3 G/cm well [2]. This method can be used to obtain more cold atoms or a large number of Bose-Einstein condensation atoms for many atomic species in high-field seeking states.

**References:**


**P4: Flexible and Controllable Photoluminescence Enhancement of Monolayer MoS2 through Continuous-wave Laser Irradiation**

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Monolayer transition metal dichalcogenides such as molybdenum disulfide, MoS2, have attracted considerable interesting for a wide range of electronics, photonics, and optoelectronics applications. However, inherent atomically thickness with an extremely poor quantum yield of light emission poses a significant challenge for practical applications.
Although many efforts have been developed to improve the photoluminescence (PL) [1-3], the precision control routes are still limited. Here, we report a flexible and controllable method to enhance the PL of monolayer MoS2 by continuous-wave laser irradiation. Both peak position and intensity of the fluorescence can be conveniently controlled via the changing of either laser power or irradiated time. The modulation results measured in ambient, nitrogen and vacuum conditions associated with the first-principles calculations revealed that the enhanced optical response are not only attributed to the defect engineering on the monolayer surface, but also linked to the switching between excitations and trions in MoS2. Our scheme allows engineering the light-matter interaction in two-dimensional materials with spatial resolution and controllable intensity, which are enable highly efficient light emitters, photodetectors and sensors[4].

References:

Flexible organic optoelectronic devices such as organic solar cells, perovskite solar cells and organic light-emitting diodes require transparent conducting electrodes (TCEs) having high transparency and conductivity be fabricated on plastic substrates. Indium tin oxide (ITO), the material most commonly used in display industry, are not the most suitable for the fabrication of flexible devices because it is brittle and cracks easily under bending stress. At present, several classes of flexible transparent electrodes, including those based on graphene, metal nanowires, conducting polymers, and carbon nanotubes are being investigated. However, despite their strong potential as replacements for ITO, these materials suffer from the classic trade-off between optical transmittance and electrical conductivity. Thicker layers afford higher conductivity, but this increase comes at the expense of optical transmittance and vice versa. In addition, large-area organic devices built using flexible TCE based on these materials exhibit low efficiency, owing to the low conductivity of TCEs, in the absence of additional metal grids.

We have developed all-printed flexible TCEs by using a combination of Ag grid and transparent electrodes embedding architecture into plastic substrate, leading to highly transparent (optical transmittance ≈ 90%), highly conducting (sheet resistance ≈ 20 Ω □ -1), highly smooth (root-mean-square roughness ≈ 0.5 nm), and extremely flexible (bending radius ≈ 500 μm) electrodes. These electrodes used to fabricate flexible organic and inorganic thin film solar cells that exhibited performances similar to that of devices fabricated on glass substrate. Moreover, the flexible devices did not show degradation in their performance even after being bended with a radius of ~500 μm.

P5: Solution-Processed Flexible Transparent Electrodes for Organic Solar Cell Applications
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P6: Thermal drift optimization technique for silicon microgyroscope

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The bias stability is one of the most important parameters of silicon microgyroscope, and it is also the biggest obstacle for high precision application. Currently, high accurate gyroscopes has achieved tactical-grade performance, whose bias stability is on the order of 0.1 to 10°/h, however, such performance is obtained in room temperature environment. In practice, gyroscope is usually required to operate in a wide temperature range, therefore, thermal drift is also plays an important role to gyroscope's bias stability. In the paper, we analyze the origin of thermal drift in z-axis gyro and a new method is proposed to reduce it. The paper is organized in three sections.

In Section I, the sources of the zero-rate output (ZRO) is identified, as shown in Figure 1, and related formulas have been calculated, then the design criterion of the mechanical structure are obtained.

The ZRO can be divided into in phase signal and quadrature signal. The in phase signal has same frequency and phase with the angular rate signal, and can’t be distinguished, which must be suppressed in structure design level. The quadrature signal can be eliminated by synchronous demodulation, while interface circuit will introduce inevitable phase error \( \Delta \phi \), leading to some residual quadrature signal in output. By calculating and testing, we know that the residual quadrature signal is much bigger than the in phase signal, then the ZRO can be written as:

\[
ZRO \approx \frac{1}{2} V_{\phi} K_{\phi} A_k \Delta \phi
\]

where \( A_k \) is the amplitude of quadrature signal before demodulation. \( A_k \) and \( \Delta \phi \) are both temperature related, resulting in thermal drift of ZRO. Because \( \Delta \phi \) is almost 0, so greater impact on ZRO is caused by the change of \( \Delta \phi \) compared to quadrature signal [1].

In Section II, a new method is proposed to reduce the influence of temperature on bias stability. At present, quadrature error compensation is the commonly used method to improve gyroscope bias stability [2], which reducing the absolute value of ZRO. This method requires additional feedback electrodes in structure design and a specialized control circuit, increasing the gyroscope’s complexity. In
this paper, we proposed a novel interface circuit based on two cascaded integrators. Compared with other interface circuits [3], lower noise and phase error could be realized, which lowers down gyroscope's thermal drift.

In section III, the newly proposed interface circuit with a silicon microgyroscope is tested and compared with the previous. Results shows that equivalent input current noise of the improved interface circuit is 18fA/√Hz, the demodulation phase error is 0.97 degrees with a standard deviation of 0.0079 degrees for 1h test in room temperature, corresponding 1σ bias stability is below 1° /h. Test at full temperature -40-60 °C, the phase error only changed 0.32 degrees compared with 4.5 degrees using transimpedence interface circuit, and the 1σ bias stability is below 20° /h, which is greatly improved.

References:

P7: Cross-linked Thermoplastic Polyurethane Electrospun Nanoweb with Improved Piezocapacitive Sensor Performance

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Electrospun thermoplastic polyurethane (TPU) nanowebs have been used as piezocapacitive sensors which can be applied for monitoring both static and dynamic pressures [1]. Since piezocapacitive sensor made of TPU nanoweb with top and bottom electrodes can be considered as a simple capacitor, its capacitance is inversely proportional to thickness when pressure is applied to the sensor and released repeatedly. Compared to conventional TPU foam sheet based piezocapacitive sensor, TPU nanoweb based one has many advantages such as large initial capacitance, very large relative capacitance change to press, and nano scale cellular size. However, the TPU nanoweb based piezocapacitive sensor has a little higher hysteresis than the TPU foam sheet, because the air released out of the open cells of the TPU nanoweb when pressed cannot help recovery to the initial state after pressure releasing as compared to the TPU foam sheet having closed cell structure. TPU has, moreover, lower thermal resistance and lower elasticity than rubber.

So, in this study, we have paid our attention to improving the performance of electrospun TPU sensor through the crosslinking of TPU nanoweb using a thermally reversible tolylene diisocyanate adduct (TDA). We synthesized tolylene diisocyanate-ε-caprolactam and tolylene diisocyanate-phenol adducts and crosslinked intermolecular urethane bonds with them by thermal treatment of as-electrospun TPU/TDA nanofiber web with different concentrations of TDA, and investigated how the degree of crosslinking can have an effect on the hysteresis through measuring capacitance values during cyclic loading and unloading. Creep and stress relaxation behaviors were also tested through measuring capacitance as a function of time under the constant loading and through measuring loading as a function of time under the constant capacitance, respectively, using Instron®5584 and LCR meter.

Figure 1(b) shows the calibration curve between pressure and capacitance of as-electrospun TPU and crosslinked TPU nanoweb based piezocapacitive sensor for evaluation of their hysteresis. More detailed results will be discussed in the presentation.
I
nternational Conference on Small Science 2016  PROGRAM & ABSTRACTS

Figure 1. (a) Crosslinked TPU nanoweb based piezocapacitive sensor, (b) The calibration curve of TPU nanoweb based piezocapacitive sensor for pressure-capacitance.

References:

Acknowledgement: This work was supported by Industrial Strategic Technology Development Program Founded by Ministry of Trade, Industry and Energy (MOTIE), Korea (Grant No. 10047976).

P8: Electrospun Poly (lactic acid) Nanofiber Web Based Piezoelectric Sensors for Vital Signal Monitoring

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Poly (lactic acid) (PLA) based on renewable resource is well known to have biocompatibility and biodegradability. In addition to that, recently the piezoelectric properties of PLA caused by its unique helical structure formed by chiral molecules have attracted many attentions. [1,2] Compared to the conventional piezoelectric fluoropolymers such as PVDF and P(VDF-TrFE), the piezoelectricity of PLA is known to be inferior to that of PVDF. However, PLA has some peculiar characteristics that PVDF and P(VDF-TrFE) do not have. To be specific, a piezoelectric PLA nanofiber web based sensor can be easily obtained just through electrospinning process. Therefore, it does not require further poling process unlike PVDF film. In addition, the cost merit of PLA cannot be excluded.

Recently, we found that poly (L-lactic acid) (PLLA) nanofiber web obtained through electrospinning could be used as a power source to operate LEDs. This is associated with preferential orientation of molecular chains and C=O dipoles induced by very high electric field during electrospinning. [3] However, the main problem of piezoelectric PLLA is low thermal resistance, which limits its applications and also affects piezoelectric constant. It is well known that the melting point of stereocomplex crystal (SC) of PLA is 50 oC higher than that of pure PLLA. In addition, it has been reported that SCs of PLA could be obtained via cold crystallization of as-electrospun nanofiber web obtained from the racemic mixture solution of PLLA and PDLA. Hence, we prepared PLLA, PDLA and SCs of PLA nanofiber webs through electrospinning process, and evaluated and compared their piezoelectric properties. To find the real application of the electrospun SC of PLA, we fabricated several types of physiological sensing belt (PSB) with a SC-PLA nanofiber web imbedded between two elastic bands to monitor vital signals such as respiration, muscle movement and heart pulse. We also installed SC-PLA nanofiber web based sensors into insole and investigated the plantar pressure distribution during walking on a treadmill [Fig. 1]. More details will be discussed in the presentation.
Fig. 1. Piezoelectric signals recorded by SCs of PLA nanofiber web sensor installed in insole; 4 km/h.

References:

Acknowledgement: This work was supported by the Industrial Strategic Technology Development Program (Grant No. 10044953 and 10047976) funded by the Ministry of Trade, Industry and Energy (MOTIE, KOREA)

P9: Optical and lasing properties of micrometer-sized simple oxides: MgO and ZnO

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We have recently reported that broadband laser emission in the near-ultraviolet to the blue-green spectral range is realized in micrometer-sized MgO crystals with neutral and positively charged oxygen vacancies (F and F+ centers) [1-3]. In MgO, the F and F+ color centers absorb essentially the same energy of ~5 eV (~250 nm) and show different photoluminescence (PL) bands peaking at ~500 and ~385 nm, respectively. Accordingly, the laser actions is achieved in these colored MgO crystals under pulsed laser excitation using the fourth harmonic (266 nm) of a pulsed Nd: yttrium-aluminum-garnet (YAG) laser.

In this presentation, we further show that the micrometer-sized MgO crystals exhibit a different but intriguing lasing behavior when the samples are annealed in air atmosphere at temperatures of 1000 oC and above [4]. The MgO microcrystals used in this work are basically the same with those reported in [3] (see Fig. 1) except the post-annealing procedure performed in air atmosphere. The thus annealed MgO microcrystals hardly show PL bands related to the F and F+ centers, but the laser action is still achieved under pulsed laser excitation at longer wavelength or by excitation with the third harmonic (355 nm) of a Nd: YAG laser (Fig. 2). The lasing characteristics, including emission wavelength, lasing threshold, width of the laser line, and decay time, are inherently different from those of the MgO-based color center laser reported previously.
Fig. 2. PL characteristics of (a), (b) the as-prepared and (c), (d) the 1100-°C annealed MgO microcrystals obtained under nanosecond pulsed laser excitation. The third harmonic of a nanosecond Nd: YAG laser (355 nm) is used as a pump source. (a), (c) Laser fluence dependence of the emission spectra. (b), (d) Spectrally integrated emission intensity as a function of pump fluence.

We also demonstrate that oxygen-deficient micrometer-sized ZnO crystals show the stimulated emission at room temperature under high optical pumping. From the temperature dependent characteristics, we propose that the stimulated emission results from exciton scattering with donor electros.

References:
## AUTHOR INDEX

*P – page in program

A – page in abstract

<table>
<thead>
<tr>
<th></th>
<th>P</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Abderrazzak Douhal</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Agnese Sonato</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Ajay Giri Prakash Kottapalli</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Alexander S. Mayorov</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Anuj Dhawan</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Arife Yurdakul</td>
<td>13</td>
</tr>
<tr>
<td>B</td>
<td>Barisic Ivan</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Boris Semenov</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>Chaoyang Li</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Carmen-Simona Asaftei</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Chengbing Qin</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Chui-Shan Tsang</td>
<td>18</td>
</tr>
<tr>
<td>D</td>
<td>Dae-Eun Kim</td>
<td>9</td>
</tr>
<tr>
<td>F</td>
<td>Fei Wang</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Felix Sima</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Fengyu Li</td>
<td>11</td>
</tr>
<tr>
<td>G</td>
<td>Gen-ichi Konishi</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Grzegorz Jóźwiak</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>Haruisa Kato</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Hilmi Yurdakul</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Hirotomo Nishihara</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Hosein Zareie</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Huaiyu Shao</td>
<td>13</td>
</tr>
<tr>
<td>I</td>
<td>Ibrahim Abdulhalim</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Ichiro Hisaki</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Ilia Kurochkin</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Iuliana Lazar</td>
<td>16</td>
</tr>
<tr>
<td>J</td>
<td>J. Marcos Fernández-Pradas</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Jae Hyun Kim</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Jae-Wook Kang</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Jan Halamek</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Jarek Antoszewski</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Jian Zhou</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Jianghao Li</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Jie Ma</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Jonathan Prance</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>José Carlos Gª Abadillo-Uriel</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Jun Dai</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Junhua Yu</td>
<td>11</td>
</tr>
</tbody>
</table>

Abstract 69
Abstract 70

K
Kap Jin Kim 13 34
Kazuo Azuma 10 15
Kentarou Sawano 9 11
Kimihisa Yamamoto 9 9
Kosuke Suzuki 17 59
Kwang Chul Roh 18 61
Kyohei Hisano 11 21

L
Lap Van Dao 8 3
Lavinia Balan 17 56
Lawrence YoonSuk Lee 13 36
Liantuan Xiao 12 30

M
Ma Lingwei 8 6
Makoto Anraku 10 15
Masahide Terazima 10 20
Masaki Matsui 17 56
Masaki Nakano 14 41
Matthieu Chatras 12 28
Mi Kyong Yoo 18 65
Michihisa Koyama 9 9
Minh D. Nguyen 9 10
Moshe Einat 15 44

N
Nasrin Al Nasiri 15 45
Noriyuki Sonoyama 17 57

R
Rajeswari Jayaraman 15 46
Renshi Sawada 12 29
Robert Boeck 12 32

S
Sangin Kim 10 13
Satoshi Habuchi 11 27
Seung R. Paik 17 55
Shinsuke Ifuku 11 22
Sivacarendran Balendhran 16 51
Soon-Hong Kwon 10 14
Sungmoon Choi 15 48
Supriyo Bandyopadhyay 8 1

T
Takao Hanawa 13 37
Thomas Von Wantoch 15 43
Tokuei Sako 11 25
Tomohiro Seki 10 19
Toshihiro Hirai 15 48

U
Uchino Takashi 18 67

V
Vladimir Privman 16 52

Abstract 70
<table>
<thead>
<tr>
<th>Name</th>
<th>Session</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamato Hayashi</td>
<td>10</td>
<td>17</td>
</tr>
<tr>
<td>Yannick De Wilde</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Yong-Hoon Cho</td>
<td>14</td>
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</tr>
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<td>Yoon-Ho Song</td>
<td>17</td>
<td>54</td>
</tr>
<tr>
<td>Young-Rae Cho</td>
<td>13</td>
<td>39</td>
</tr>
<tr>
<td>Yu Jin Ahn</td>
<td>18</td>
<td>66</td>
</tr>
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<td>Zhengjun Zhang</td>
<td>8</td>
<td>4</td>
</tr>
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</table>