Pacific Centre for Advanced Materials and Microstructures (PCAMM)

14th Annual Meeting: Sponsored by Systems for Research and SFU

Date: Sat., Dec. 12, 2009
Where: 4D Labs Atrium, Technology and Science Complex (TASC) II, Simon Fraser University, Burnaby Mountain
Registration: On site, no fee

10:00 Welcome Coffee and Poster Session

Morning Talks: Chair: Simon Watkins

11:00 Invited Talk: **CZT Detectors for SPECT Tomography**,
Kris Iniewski, *Redlen Technologies*, Victoria

11:30 Invited Talk:
Science of nano-structures used for magnetic and solar applications,
Erol Girt, *Dept. of Physics*, SFU

12:00 Lunch and Poster Session

Afternoon Talks: Chair: Tom Tiedje

13:00 Invited Talk: **Structural characterization of molecules adsorbed at the solid-liquid interface,**
Dennis Hore, *University of Victoria*

13:30 Invited Talk: **Latest News from Firebird**
Alan Enns, *Firebird Technologies Inc*.

14:00 **Capillary-driven microfluidics and its application to biosensing chips**
Byung-Kwon Kim,[1] Sung-Jin Kim,[2] Haesik Yang[1]
[1]Dept of Chem., Pusan National University; [2]Elec. Telecomm. Res. Inst., Korea

14:20 **Electronic structure of the $SrTiO_3/LaAlO_3$ interface revealed by resonant soft x-ray scattering** H. Wadati[1], D. G. Hawthorn[1], J. Geck[1], T. Higuchi[2], Y. Hikita[2], H. Y. Hwang[2], S.-W. Huang[3], D. J. Huang[3], H.-J. Lin[3], C. Schüßler-Langeheine[4], H.-H. Wu[3,4], E. Schierle[5], E. Weschke5, G. A. Sawatzky[1] *[1]UBC, [2]Univ. of Tokyo, [3]NSRRC, [4]Univ. of Cologne, [5]HZB c/o BESSY*

14:40 **Electrical and Magnetic Properties of Carbon/Fe_3O_4 Nanofibre Composites**
Masoumeh Bayat, Heejae Yang, and Frank Ko, *Dept. Matls Eng., UBC.*

15:00 Coffee and Poster Session

Posters (to be left up all day beginning at 10 am)

Nanostructures

1. **Localized surface plasmon resonance (LSPR)-based sensor on plastics as versatile platforms for bio-sensing,** Meikun Fan, Alexandre G. Brolo, *Department of Chemistry, University of Victoria, BC, V8W 3V6, Canada † mkfan@uvic.ca*

2. **Template Assisted Synthesis of InSb Nanowires,** J.Wang and M. Beaudoin, *Advanced Nanofabrication Facility, AMPEL, University of British Columbia 2355 East Mall, Vancouver, BC V6T 1Z4*

3. **Surface plasmon localization through Cross Bow-tie nano aperture for polarization independent surface enhanced Raman spectroscopy,** Mohammad M. Rahman, and Alexandre G. Brolo, *Department of Chemistry, University of Victoria, Victoria, British Columbia, V8W 3V6, Canada,* E-mail: mrahman@uvic.ca

4. **Mechanical and electronic properties of carbon nanotubes in a cross structure,** Ali Kashefian Naieni, and Alireza Nojeh, *Department of Electrical and Computer Engineering, University of British Columbia, Vancouver BC, V6T 1Z4*

5. **New Techniques for making a Biprism for Electron Holography,** Azadeh Akhtari-Zavareh , Ricky Chu, Donna Hohertz, and Karen L. Kavanagh, Rodney A. Herring, *Depts of Physics, Simon Fraser University*, and *Mechanical Engineering,University Victoria.*

6. **Electrodeposition of Copper on GaAs Nanowires,** Chao Liu, Omid Salehzadeh Einabad, Simon Watkins, and Karen L. Kavanagh, *Dept. of Physics, Simon Fraser University, Burnaby, BC V5A 1S6*

7. **Field-Emission Properties of Individual GaN Nanowires Grown by the Vapour-Liquid-Solid Method,** Yongho Choi[1], Juan Mario Michan[1], Jason Johnson[2], Ali Kashefian Naeini[1], Ant Ural[2], Alireza Nojeh[1] , *[1]Department of Electrical and Computer Engineering, The University of British Columbia, Vancouver BC, V6T 1Z4 , [2]Department of Electrical and Computer Engineering, The University of Florida, Gainsville FL, 32611*

8. **Carbon Nanotube Reinforced Fibers,** Yuqin Wan and Frank Ko, *Advanced Materials and Process Engineering Laboratory, University of British Columbia, 2355 East Mall, Vancouver, BC, Canada, V6T 1Z4*

9. **Electrical and Magnetic Properties of Carbon/Fe_3O_4 Nanofibre Composites,** Masoumeh Bayat[1], Heejae Yang[1], and Frank Ko[1], *[1]Dept. Materials Engineering, Advanced Fibrous Materials Laboratory, University of British Columbia*

10. **Structure and properties of hemp fibre-reinforced Envirez bio-based composite,** Chunhong Wang[1,2], Frank K. Ko[1], Steven Zacharski[1], [1]*Dept of Materials Engineering, AMPEL, University of British Columbia, Vancouver, BC, Canada*; [2] Textile College, Tianjin Polytechnic University, Tianjin, China

11. **Electrokinetic Assembly of Semiconducting and Metallic Nanowires,** Michael (Chih-Pin) Wang, Elham Majidi, Kevin Nedelec, and Byron Gates, *Simon Fraser University, Chemistry Dept., Burnaby, BC, V5A 1S6. e-mail: mwangl@sfu.ca.*

12. **Artificial nanopores for biophysical investigations and bioanalytical applications,** Dhruti Trivedi[1], Jason Dwyer[1], Vincent Tabard-Cossa[3], Matthew Wiggin[1,2] , Nahid Jetha[1] and Andre Marziali[1] *[1]Department of Physics & Astronomy, University of British Columbia, Vancouver, BC V6T 1Z1[2] Department of Biochemistry & Molecular Biology, University British Columbia, Vancouver, BC V6T 1Z3 Genome Technology Center, Stanford University, Palo Alto, CA 94304*

13. **Effects of carbon dopant on the morphology of GaAs nanowires,** Omid Salehzadeh Einabad and Simon Watkins, *Department of Physics, Simon Fraser University*

14. **Synthesis and polarization properties of NIR emitting PbSe nanorods for quantum optical applications,** Enrico Bovero, Frank C. J. M. Van Veggel, *Department of Chemistry, University of Victoria, Box 3065, Victoria, BC, Canada, V8W3V6*

15. **Double-hole nanostructure in a metal film approaching single-molecule SERS,** Qiao Min, Marcos Jose Leite Santos, Emerson M Girotto, Alexandre Brolo, Reuven Gordon, *University of Victoria, BC*

16. **Metal Nano-grid Reflective Wave Plate,** Yuanjie Pang, Reuven Gordon, *Department of Electrical and Computer Engineering, University of Victoria, Victoria, BC, Canada*

Bulk Materials

17. **Structural and electrical characterizations of Ti-doped multiferroic $BiFeO_3$-$PbTiO_3$ thin films prepared by pulsed laser deposition,** Ling Chen,[1,2] Wei Ren,[1] Weimin Zhu,[2] Zuo-Guang Ye,[2,1] [1] *Electronic Materials Research Laboratory, Key Laboratory of the Ministry of Education, Xi'an Jiaotong University, Xi'an 710049, China;[2] Department of Chemistry and 4D LABS, Simon Fraser University, Burnaby, British Columbia, V5A 1S6*

18. **The morphotropic phase boundary and dielectric properties of $Bi(Zn_{1/2}Ti_{1/2})O_3$-$PbZrO_3$-$PbTiO_3$ ferroelectric ceramics,** Yujuan Xie and Z.-G. Ye, *Department of Chemistry and 4DLabs, Simon Fraser University, Burnaby, BC, V5A 1S6, Canada*

19. **Lead-Free Ferroelectric Materials Derived from the (1-*x*)$AgNbO_3$- *x*$K_{0.5}Na_{0.5}NbO_3$ Solid Solution System,** Chia-Yin Wei and Zuo-Guang Ye, *Department of Chemistry and 4D LABS, Simon Fraser University, 8888 University Drive, Burnaby, BC, V5A 1S6, CANADA*

20. **The Importance of High Momentum Transfer Shallow Core-to-valence Spectroscopy in the Actinides,** Subhra Sen Gupta[1], J. A. Bradley[2], M. W. Haverkort[3], G. T. Seidler[2], G. A. Sawatzky[11]*Department of Physics and Astronomy, University of British Columbia, Vancouver,BC V6T 1Z1, Canada.*[2]*Department of Physics, University of Washington, Seattle, Washington 98105, USA.*[3]*Max Planck Institute for Solid State Research, Heisenbergstraße 1, D-70569 Stuttgart,Germany.*

Films and Interfaces

21. **Electronic structure of the $SrTiO_3$/$LaAlO_3$ interface revealed by resonant soft x-ray scattering,** H. Wadati[1], D. G. Hawthorn[1], J. Geck[1], T. Higuchi[2], Y. Hikita[2], H. Y. Hwang[2], S.-W. Huang[3], D. J. Huang[3], H.-J. Lin[3], C. Schüßler-Langeheine[4], H.-H. Wu[3,4], E. Schierle[5], E. Weschke[5], G. A. Sawatzky[1] , [1]*UBC,* [2]*Univ. of Tokyo,* [3]*NSRRC,* [4]*Univ. of Cologne,* [5]*HZB c/o BESSY*

22. **Magnetotransport properties and Microstructure of Co-Au Alloy Films,** Conrad Rizal[a1] and Ueda Yuji[b] ,[a] *Dept of Electrical and Computer Engineering, University of British Columbia, Vancouver BC, V6T-1N7.* [b]*Muroran Institute of Technology, Mizumoto-cho, Muroran-shi, Hokkaido, Japan. 050-8585*

23. **Effect of annealing on structural and optical properties of heavily carbon doped ZnO,** He Huang, Z.W. Deng, D.C. Li, E. Barbir, W.Y. Jiang, M.X. Chen, K.L. Kavanagh, P.M. Mooney, and S.P Watkins, *Dept. of Physics, Simon Fraser University, Burnaby, BC V5A 1S6*

24. **Strain balanced InAs/InAsSb superlattice structures with optical emission to 10 µm,** D. Lackner, O. J. Pitts*, M. Steger, A. Yang, M. L. W. Thewalt, and S. P. Watkins, *Department of Physics, Simon Fraser University, Burnaby, British Columbia V5A 1S6 Present address: CPFC, NRC Institute for Microstructural Sciences, Ontario K1A 0R6*

25. **Investigation of thin NiMnSb using TEM,** Christoph Herrmann[1], Charles Gould[1], Laurens Molenkamp[1], and Karen L. Kavanagh[2] , [1]*Dept. Physics, Wurzberg U., Germany;* [2]*Dept. Physics, Simon Fraser University*

26. **Effect of NO Annealing on 6H- and 4H-SiC MOS Interface States**
A.F. Basile[1], J. Rozen[2], X.D. Chen[1]** S. Dhar[2]*,J.R. Williams[3], L.C. Feldman[2]***, and P.M. Mooney[1]
[1]Simon Fraser University, Canada, [2]Vanderbilt University, USA, [3]Auburn University, USA
**Cree, Inc, USA, **Redlen Technologies, Canada, ***and Rutgers University, USA*

Devices and Systems

27. **Capillary-driven microfluidics and its application to biosensing chips,** Byung-Kwon Kim,[1] Sung-Jin Kim,[2] Haesik Yang[1] *[1]Department of Chemistry, Pusan National University, Korea, [2]Biosensor Group, Electronics and Telecommunication Research Institute (ETRI), Korea hyang@pusan.ac.kr*

28. **The Discrimination of the Continental Origin of Atlantic Salmon on a Microfluidic Microarray Device,** Lin(Leon) Wang[1], Krzysztof Lubieniecki[2], William S. Davidson[2] and Paul C.H. Li[1,2] *[1]Department of Chemistry, [2]Department of Molecular Biology and Biochemistry, Simon Fraser University*

29. **Long-term Stability and Function of Molecular Diodes,** Richard T. W.Popoff, and Hua-Zhong (Hogan) Yu, *Simon Fraser University, Dept. of Chemistry, Burnaby, BC, Canada, V5A 1S6, rpopoff@sfu.ca,* hzyu@sfu.ca.

30. **A Disc-Based "ELISA" Protocol for Detecting Blood-Borne Cancer Markers,** Miao-Ling Lily Ou, Honglun Wang, Bixia Ge, Hua-Zhong Yu, *Simon Fraser University, Dept. of Chemistry, Burnaby, BC, Canada, V5A 1S6, lilyo@sfu.ca, honglunw@sfu.ca, bge@sfu.ca, hzyu@sfu.ca.*

31. **Exploring the Detection Limit of Nanohole Array Sensors,** Donna Hohertz, Naveed Gulzar, Sean Romanuik, Alex Brolo, Reuven Gordon, Bonnie Gray, Jamie Scott, and Karen Kavanagh, *Depts.of Physics, Engineering Science, and Molecular Biology and Biochemistry, Simon Fraser University, Burnaby, British Columbia V5A 1S; Depts. Chemistry, and Electrical Engineering, Univ. Victoria, Victoria, BC*

32. **Development of Bismuth Hall-Effect Sensors,** R. Chu, N. David, T. Chouinard, A. Schneider, and D. Broun, *Dept. Physics, Simon Fraser University*

33. **Wireless actuation of responsive hydrogel for implantable drug delivery applications,** S. Rahimi, E.H. Sarraf, G.K. Wong, and K. Takahata* *Dept. of University of British Columbia, Vancouver*

Structural characterization of molecules adsorbed at the solid-liquid interface

Dennis Hore*, Shaun Hall, Travis Trudeau, and Kailash Jena
Department of Chemistry, University of Victoria, Victoria, BC, Canada, V8W 3V6

The adsorption of molecules at interfaces is central to a wide range of chemical, biological, and environmental processes. Of particular interest is the orientation which the molecules adopt at the interface, along with their potential change in conformation as a result of the unique interfacial environment. Part of the reason why predicting and generating basic empirical rules governing these effects is so difficult is that the adsorbed structures are very sensitive to the nature of the adsorbate, the nature of the substrate surface *in situ*, and the solution conditions. Vibrational spectroscopy is a natural choice for probing molecular-level interactions since it offers a label-free approach to investigate specific functional groups of adsorbate, substrate, and solvent molecules. We employ a combination of nonlinear vibrational spectroscopy, electronic structure calculations, and molecular dynamics simulations to arrive at a three-dimensional orientation distribution for molecular monolayers adsorbed at solid-liquid interfaces. This talk will first highlight our recent progress in developing general tools to enable quantitative analysis of experimental data. Prospects for the future of this technique will then be discussed.

Science of nano-structures used for magnetic and solar applications

Erol Girt, *Dept. of Physics, Simon Fraser University, Burnaby, BC V5A 1S6*

CZT Detectors for SPECT Tomography

Kris Iniewski, *Redlen Technologies*

CZT is currently the only semiconductor material that is capable of room temperature operation for X-ray and γ-ray radiation detector application. In this talk I will review basic principles operation of CZT detectors and associated signal processing in CMOS hardware as required by Single Photon Emission Computed Tomography (SPECT). Current state-of-the-art in CZT detector manufacturing and research directions will be highlighted. The material presented is an abbreviated version of the short-course to be offered at IEEE ISCAS-2010 conference to be held in Paris next year.

The Latest News from Firebird Technologies Inc

Alan Enns, alan@firebird.bc.ca *Firebird, Trail, BC (www.firebird.bc.ca)*

Contributions:

Nanostructures

1. Localized surface plasmon resonance (LSPR)-based sensor on plastics as versatile platforms for bio-sensing

Meikun Fan and Alexandre G. Brolo
Department of Chemistry, University of Victoria, BC, V8W 3V6, Canada † mkfan@uvic.ca

LSPR sensor can be easily incorporated into microchips and offers much smaller spatial resolution compared with planar SPR. Moreover, the wavelength of LSPR can be adjusted, which provides extra flexibility for sensor designing and sometimes higher sensitivity as well.
In this report, a cost-effective fabrication method for the preparation of LSPR biosensors supported on plastics, PET, is described. The PET plastic was firstly cut into 9×40 mm strips and then chemically modified with amine functionality. This allows the efficient immobilization of Ag NPs. It is found that the LSPR of the PET-Ag NPs showed good sample to sample reproducibility and a moderate response to bulk refractive indices changes (~150 nm/RIU (refractive index unit)). The reproducibility of the sensor was evaluated by protein adsorption experiment. The analytical performance of the PET sensor strip was evaluated from monitoring the protein-protein interaction and the biotin-streptavidin binding. A linear response to streptavidin in the range from 9.5~189.4 nM was observed with a LOD of 3.5 nM.

2. Template Assisted Synthesis of InSb Nanowires

J.Wang and M. Beaudoin
Advanced Nanofabrication Facility, AMPEL, University of British Columbia
2355 East Mall, Vancouver, BC V6T 1Z4

InSb nanowires have been synthesized by pulsed electrodeposition using anodic alumina membranes (AAM) as templates. Two sets of AAMs were used: one set had 150 nm diameter pores and a porosity of 32% with a density of $2x10^9$ pores/cm^2 while the other set had 35 nm pores and 12% porosity with a density of 10^{10} pores/cm^2. Both sets of membranes were 50 μm thick. The InSb AAMs were dissolved with a drop of NaOH and rinsed several times in deionized (DI) water and then dispersed in solution in an ultrasonic bath. The NWs were deposited on a native Si wafer with an eyedropper and dried on a hotplate at 120°C. Scanning electron microscopy (SEM) imaging shows that the free standing nanowires had uniform diameters but varied in length although they were all

several μm long. Powder X-Ray Diffraction (XRD) shows that the nanowires exhibit polycrystalline properties with the <111> and <220> being slightly more prominent than the <331>, <422> and even <333> peaks and also showed the presence of an In metallic phase. Energy Dispersive X-Ray (EDX) spectra were collected for a set of typical InSb nanowires. EDX shows an In:Sb ratio of 61:39, still far from the ideal stoichiometry.

3. Surface plasmon localization through Cross Bow-tie nano aperture for polarization independent surface enhanced Raman spectroscopy

Mohammad M. Rahman, and Alexandre G. Brolo
Department of Chemistry, University of Victoria, Victoria, British Columbia, V8W 3V6, Canada; E-mail: mrahman@uvic.ca

Cross bow-tie (XBT) shaped nano aperture arrays have been fabricated on gold thin film using focused ion beam (FIB) technique. A XBT aperture consists of two bow-tie aperture pairs placed perpendicular to each other. Tip orientation of the individual triangles favor the localization of electromagnetic field. Polarization and tip to tip separation dependent visible light transmission through the array with various refractive indexes solutions and surface enhanced Raman scattering from oxazine 720 deposited on the same structures have been investigated. The transmission measurements show the sensitivity of the arrays about 450 nm/RIU (refractive index unit) with various refractive indexes solutions. Polarization independent and enhanced Raman scattering intensity from oxazine 720 show that this subwavelength aperture arrays can be potential candidate for an efficient and durable surface enhanced Raman scattering spectroscopy (SERS).

4. Mechanical and electronic properties of carbon nanotubes in a cross structure

Ali Kashefian Naieni, and Alireza Nojeh
Dept. of Electrical and Computer Engineering, University of British Columbia, Vancouver BC, V6T 1Z4

Carbon nanotubes (CNTs) have attracted considerable attention since their discovery in 1991 due to their extraordinary properties. The extremely small diameter and a length that can be on the order of centimetres, in addition to a complete and strong structure, make CNTs highly promising for building quantum electronic devices.
A CNT cross is a structure made by lying one CNT over another one at an angle. The mechanical alterations imposed on each nanotube in this structure significantly change their electronic properties compared to undisturbed CNTs.

We report the results of simulations to find mechanical and electronic properties of CNTs in a cross structure made of semiconducting or metallic carbon nanotubes. Molecular dynamics simulations were performed to find the physically viable and stable configurations. It is seen that structures with a variety of different initial configurations tend to go toward the same final configuration after relaxation. Ab-initio simulations were used to find the effect of the induced mechanical changes on the electronic properties of the most deformed part of the top CNT. Band gap change as a result of deformation was observed in tubes with different chiralities and different degrees of deformation.

5. New Techniques for making a Biprism for Electron Holography

Azadeh Akhtari-Zavareh , Ricky Chu, Donna Hohertz, and Karen L. Kavanagh,
Department of Physics, Simon Fraser University
Rodney A. Herring
Department of Mechanical Engineering,University

6. Electrodeposition of Copper on GaAs Nanowires

Chao Liu, Omid Salehzadeh Einabad, Simon Watkins, and Karen L. Kavanagh
Dept. of Physics, Simon Fraser University, Burnaby, BC V5A 1S6

Epitaxial copper (Cu) electrical contacts to freestanding gallium arsenide (GaAs) nanowires have been fabricated via electrodeposition as a function of the wire carbon concentration. The nanowires are (111) oriented grown epitaxially on *n*-type Si-doped GaAs (111)B substrates by gold-catalyzed Vapor Liquid Solid (VLS) growth in a metal organic vapour phase epitaxy (MOVPE) reactor. The carbon concentration is controlled with the addition of carbon tetrabromide gas to the Ga and As precursors. The epitaxial electrodeposition process is based on previous work with bulk GaAs substrates. [1]
For carbon-doped GaAs nanowires, we find that copper has a preference for growth on the gold catalyst avoiding the sidewalls. Energy Dispersive X-ray analysis (EDS) in scanning TEM shows a very weak signal of Cu around the nanowire while a strong signal on the Au end. The geometry of the Cu on the wire depends on the current density and concentration of the electrolyte as well as the C concentration and deposition time. In comparison, for undoped GaAs nanowires, we find that Cu grows uniformly around the wire and Au particle. TEM diffraction combined with imaging finds the Cu to be epitaxially aligned with the GaAs. We believe that supersaturation of C in the GaAs results in the growth of graphitic surface layers that inhibit the adhesion of electrodeposited Cu to the nanowire sidewall.
[1] Z. L. Bao, S. Grist, S. Majumder, L. B. Xu, E. Jensen, and K. L. Kavanagh, *J. Electrochem. Soc*. 156 (2009) D138.

7. Field-Emission Properties of Individual GaN Nanowires Grown by the Vapour-Liquid-Solid Method

Yongho Choi[1], Juan Mario Michan[1], Jason Johnson[2], Ali Kashefian Naeini[1], Ant Ural[2], Alireza Nojeh[1]
[1]Dept. of Electrical and Computer Eng., University of British Columbia, Vancouver BC, V6T 1Z4
[2]Dept. of Electrical and Computer Eng., University of Florida, Gainsville FL, 32611

Gallium Nitride (GaN) is a direct bandgap semiconductor with unique properties and broad applications in light emitting diodes, laser diodes, photo detectors, high speed field-effect transistors, and high temperature and high power electronics. The successful synthesis of GaN nanowires, which are quasi-one-dimensional structures, has broadened the application areas, for example into field-emission electron sources because of the high aspect ratio of the nanowires. Previous studies on the field-emission properties of these structures have focused on bundles of GaN nanowires. It has been shown that they follow the Fowler-Nordheim behaviour and have better performance compared to bulk GaN. However, it is important to study the properties of individual GaN nanowires in order to gain deeper understanding and compare them to other nanoscale materials such as carbon nanotubes. We have grown GaN nanowires using the Vapour-Liquid-Solid method and fabricated devices containing individual GaN nanowires lying on a dielectric surface. The nanowires were characterized using transmission and scanning electron microscopy. The field-emission properties were studied. The typical turn-on field was ~21 [V/μm] and current densities of as high as 1.62×10^6 [mA/cm^2] were obtained. The field enhancement factor was found to be in the 100-200 range.

8. Carbon Nanotube Reinforced Fibers

Yuqin Wan and Frank Ko
AMPEL, University of British Columbia, Vancouver, BC, Canada, V6T 1Z4

Due to its amazing mechanical properties and conductivities, carbon naotube (CNT) has drawn tremendous attention since it was discovered. To employ and exploit CNT's extraordinary mechanical properties, many approaches have been developed to manufacturing CNT assemblies including pure CNT yarn and CNT's reinforced fibers. Comparing the various approaches, it is believed that pure CNT assemblies are unable to attain high strength due to the lack of bonding media. It is believed that liquid crystal spinning could be a promising technique for obtaining high performance CNTs reinforced nanocomposite fibers. In this study, multi-wall carbon naotubes(MWNTs) reinforced

cellulose fibers was fabricated using liquid crystal electrospinning. The presence of MWNTs was investigated by AFM and SEM, and verified by TGA. The improvement of the mechanical properties contributed by MWNTs was proved by tensile testing results. Due to the high level of MWNT content, the composite fibers were also found to be conductive thus providing multifunctionability to the fibers.

9. Structure and properties of Hemp fibres reinforced Envirez bio-based composite

Chunhong Wang, Frank K. Ko, and Steven Zacharski,

Dept of Materials Engineering, AMPEL, University of British Columbia, Vancouver,

Hemp mat reinforced Envirez L 86300 T-25 resin (one kind of bio-based resin, Envirez) composites were prepared by Vacuum Assisted Resin Infusion Molding (VARTM) and heat pressing. The effects of the processing methods, weight fraction of the hemp mats on the tensile property and the hardness of the composites were examined. The adhesion between the fibres and the resin was examined by scanning electron microscopy (SEM). The tensile strength of the composites made by heat pressing is 30% higher than that made by heat pressing. The strength of the composite with 25wt% is 8% higher than that made of the 20wt%Hemp. The hardness of the 25wt% hemp/ Envirez is 14% lower than that of the 20wt%Hemp/Envirez. SEM pictures show voids and gaps occurring between hemp fibers and the matrix indicating fibers pull-out.

10. Electrical and Magnetic Properties of Carbon/Fe_3O_4 Nanofibre Composites

Masoumeh Bayat[1], Heejae Yang[1], and Frank Ko[1]

[1]*Dept. Materials Engineering, Advanced Fibrous Materials Laboratory, University of British Columbia*

The aim of this study is to examine the electrical conductivity and magnetic properties of C/Fe_3O_4 electrospun composite nanofibres. Polyacrylonitrile (PAN) has been used as a matrix for the preparation of the composite nanofibres containing different contents of magnetite nanoparticles (1, 5 and 10wt.% Fe_3O_4). Electrospun composite nanofibres were pyrolized at two different temperatures 700°C and 900°C for a comparative study. The nanocomposite fibres were characterized by Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), X-ray diffractometry (XRD), Raman spectroscopy, four-point probe technique, and superconducting quantum interference

device (SQUID). SEM showed the formation of uniform fibres with a diameter of about 550 nm which decreased to 370nm after carbonization. XRD and Raman results indicate that graphitization degree of carbon fibres increases due to the introduction of Fe_3O_4 nanoparticles into the PAN matrix. They also confirmed the presence of both Fe_3O_4 and graphitic structures after heat treatment. According to the four-point probe measurement and SQUID results, electromagnetic composite nanofibres have been produced with electrical conductivity as high as 11S/cm and saturation magnetization of 17emu/g. These interesting electromagnetic properties may enable these composite nanofibres for a wide range of shielding, sensing and actuating applications.

This study is sponsored by AOARD/AFOSR

11. Electrokinetic Assembly of Semiconducting and Metallic Nanowires

Michael (Chih-Pin) Wang, Elham Majidi, Kevin Nedelec, and Byron Gates
Simon Fraser University, Chemistry Dept., Burnaby, BC, V5A 1S6.
e-mail: mwangl@sfu.ca.

We report the first demonstration of the directed assembly of flexible single crystalline selenium and silver nanowires within an applied electric field. Dispersions of these nanowires are assembled into centimetre long fibrous structures that are up to ~3 orders of magnitude longer than the individual nanowire. The assembled nanowires can be re-dispersed through mechanical agitation and re-assembled upon applying an electric field. This reversible electrokinetic assembly can work over a wide range of nanowire concentrations. In addition, various geometries of assembled fibres can be produced by manipulation of the applied electric field. This technique has demonstrated the potential in directed assembly and incorporation of flexible nanowires into arrays of electronic devices.

12. Artificial nanopores for biophysical investigations and bioanalytical applications

Dhruti Trivedi[1], Jason Dwyer[1], Vincent Tabard-Cossa[3], Matthew Wiggin[1,2], Nahid Jetha[1] and Andre Marziali[1]
[1]*Dept. of Physics & Astronomy, University of British Columbia, Vancouver, BC V6T 1Z1*
[2]*Department of Biochemistry & Molecular Biology, University British Columbia, Vancouver, BC V6T 1Z3*
[3]*Genome Technology Center, Stanford University, Palo Alto, CA 94304*

The complexity and time required by existing genotyping techniques is a major barrier to the use of genetic information in personalized health care. We are developing the technique

of nanopore force spectroscopy as a means to allow rapid and direct detection of DNA sequence mutations (e.g. single nucleotide polymorphisms [SNPs]). By using nanopore force spectroscopy to perform a hybridization-based assay, we demonstrate single-base specificity. We present results from recent investigations using 2 nm – 6 nm diameter nanometer-scale pores (nanopores) in freestanding silicon nitride membranes for the detection of SNPs.

13. Effects of carbon dopant on the morphology of GaAs nanowires

Omid Salehzadeh Einabad and Simon Watkins
Department of Physics, Simon Fraser University

Carbon is a well known dopant in the growth of planar III-V materials such as GaAs, however its use has not yet been investigated for nanowire growth by the vapor-solid-liquid growth mechanism. In this work we show that the morphology of gold catalyzed GaAs nanowires is significantly modified by the presence of CBr_4 vapor during growth by metalorganic vapor phase epitaxy (MOCVD). Nanowires grown in the presence of CBr_4 exhibit negligible tapering and much lower levels of Au catalyst migration than nanowires grown in the absence of CBr_4 under the same conditions. Increasing concentrations of CBr4 lead to increased linear growth rate and reduced wire diameter. Nanowires grown with CBr_4 show no detectable stacking faults, in contrast to wires grown in the absence of CBr4 which show a high density of stacking faults. We propose a simple model in which adsorbed carbon blocks the surface migration of Au down the wire. This work suggests a simple method to control the degree of tapering which should be applicable to other III-V materials. Preliminary Raman measurements indicate substantial shifts in the lattice phonon modes with increasing carbon doping, indicating that carbon is actually incorporated effectively into the nanowires.

14. Synthesis and polarization properties of NIR emitting PbSe nanorods for quantum optical applications

Enrico Bovero, Frank C. J. M. Van Veggel,
Department of Chemistry, University of Victoria, Box 3065, Victoria, BC

The emission of PbSe nanocrystals is interesting for two reasons: their optical properties are size dependent and their emission is in the NIR, which is attractive for Telecommunication and quantum optics. Elongated nanocrystals are particularly interesting because their emission polarization and shape may improve the coupling with optical devices that have directional properties, such as nano-cavities, amplifier, nonlinear elements etc. The difficulty in the synthesis of such nanoparticles is that cubic crystals tend

to grow with a cubic aspect, and for this reason there are almost no reports on the synthesis and spectroscopy of NIR emitting lead chalcogenides rods. To overcome this problem we used gold nanoparticles as seeds that nucleate and stimulate a directional growth of PbSe crystals. The reaction time is directly proportional with the length of the crystals and 2×10 nm^2 rods with a 5-10 % size distribution can be consistently grown. The photoluminescence consists of an intense linearly polarized band at 900 nm with $a \sim 3$ μm lifetime. Such an orientation of the emission makes these particles suitable for fluorescence anisotropy studies, which by analysing the correlation time of the emission dipole confirmed the size and shape observed in the TEM. The understanding of the relationship between shape and spectroscopy is of fundamental importance for the design of new optically active materials suitable for telecommunication, quantum information processing, energy harvesting devices, etc. Studies are underway to examine nanocrystals with different shapes, which can be obtained by varying reaction parameters like reaction temperature, time and composition.

15. Double-hole nanostructure in a metal film approaching single-molecule SERS

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Surface-enhanced Raman scattering (SERS) increases the Raman signal and provides much greater sensitivity. An isolated double-hole nanostructure was used as a highly efficient SERS substrate, and a 20-molecule detection limit was also found. Even refined grating periodicity structure has also been designed which provides a good substrate candidate for single molecule SERS.

16. Metal Nano-grid Reflective Wave Plate

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We present an optical wave plate using a metal nano-grid. The wave plate makes use of gap plasmon modes that discriminate between TM and TE waves in the reflection geometry. The wave plate is simple and compact, and it is amenable to existing nanofabrication techniques [1]. The reflective geometry is especially promising for applications including liquid-crystal displays [2] and laser feedback [3]. A significant benefit of the nano-grid wave plate is that it can be angle-tuned for broad-band operation and for varying retardation.

Bulk Materials

17. Structural and electrical characterizations of Ti-doped multiferroic $BiFeO_3$-$PbTiO_3$ thin films prepared by pulsed laser deposition

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Thin films of Ti-modified multiferroic (0.72)$Bi(Fe_{0.98}Ti_{0.02})O_3$-(0.28)$PbTiO_3$ ($BFPT_{1+0.02}$) solid solution were prepared by pulsed laser deposition on $Pt/TiO_2/SiO_2/Si$ substrates under the oxygen pressure from 2 Pa to 15 Pa. The microstructures and electrical properties have been systematically investigated using various techniques. X-ray diffraction shows that all of the $BFPT_{1+0.02}$ films possess a tetragonal structure with highly preferential (001) orientation. Effect of the oxygen pressure and deposition temperature on dielectric and ferroelectric properties has been studied. It is found that the dielectric constant is significantly enhanced for the films deposited under the oxygen pressure of 10 Pa and the dissipation factor decreases with frequency from 1 kHz to 1 MHz. The ferroelectric properties of the $BFPT_{1+0.02}$ films at room temperature will be discussed in detail.

18. The morphotropic phase boundary and dielectric properties of $Bi(Zn_{1/2}Ti_{1/2})O_3$-$PbZrO_3$-$PbTiO_3$ ferroelectric ceramics

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A new $Bi(Zn_{1/2}Ti_{1/2})O_3$-$PbZrO_3$ -$PbTiO_3$ [BZT-PZT] ternary ceramic system has been synthesized by solid state reaction and investigated by x-ray diffraction (XRD), dielectric spectroscopy, and ferroelectric measurements. Studies were focused on three series (0.05)BZT-(0.095)PZT, (0.1)BZT-(0.9)PZT and (0.15)BZT-(0.85)PZT with the compositions around the morphotropic phase boundary (MPB). It was found that the introduction of BZT into PZT system brings the MPB to the lower PT content and enlarges the MPB region. The dielectric spectra of the MPB compositions show relatively a high Curie temperature Tc (>280°C) and rhombohedral to tetragonal phase transition temperature T_{R-T} (195°C ~250°C). The examination of the remnant polarization (Pr) reveals

an increase with BZT addition, the maximum value of which was found to be 33μC/cm^2 in MPB region of (0.15)BZT-(0.85)PZT series.

19. Lead-Free Ferroelectric Materials Derived from the (1-*x*)$AgNbO_3$- (*x*)$K_{0.5}Na_{0.5}NbO_3$ Solid Solution System

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A new lead-free solid solution of (1-*x*)$AgNbO_{3-x}K_{0.5}Na_{0.5}NbO_3$ [(1-*x*)AN-*x*KNN, with x = 0 - 0.50], has been prepared in the form of ceramics. The substitution of $(K_{0.5}Na_{0.5})^+$ for Ag^+ greatly enhances dielectric, ferroelectric, and piezoelectric properties. With increasing KNN content, the maximum dielectric constant increases significantly, i.e. ~9 times higher for x = 0.12 than for the pure AN, and the Curie Temperature decreases from 345 ºC in x = 0 to 250 ºC in x = 0.10 and then increases again from 250 to 295 ºC for x = 0.12 - 0.50. It is also found that the remnant polarization (P_r) increases dramatically, giving rise to a maximum polarization (P_r = 6.5 μC/cm^2) at x = 0.30.

20. The Importance of High Momentum Transfer Shallow Core-to-valence Spectroscopy in the Actinides

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We calculate the dynamic structure factor S(q,ω) within a renormalized atomic multiplet approach, to describe the 5d □5f non-resonant inelastic x-ray scattering (NIXS) in actinide compounds ThO_2 ($5f^0$) and UO_2 ($5f^2$). For small q, the spectra select the dipole-allowed transitions which are degenerate with continuum states, hindering their use in ground electronic structure determination. However, dipole-forbidden multiplets reached with large q are strongly bound to the core-hole, enabling the use of a renormalized atom approach to extract the ground state electronic structure. This crossover from unbound to bound states, reachable by low-q and high-q experiments respectively, is a result of the large multiplet spread of the $5d^9 5f^{N+1}$ multiplets exceeding the attractive core-hole potential. We discuss the details of the calculations and emphasize the importance of high-q experiments in studies of the ground state electronic structure of actinides.

Thin Films and Interfaces

21. Electronic structure of the $SrTiO_3/LaAlO_3$ interface revealed by resonant soft x-ray scattering

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The recent advances in oxide thin-film fabrications enabled us to obtain high-quality single-crystal oxide thin films and complex artificial hetero-junctions with an atomic-level precision. When we consider the surface or the interface of such thin films, the polarity is a big problem when each layer has a non-zero net charge. In this context, the metallic interface between two band insulators $SrTiO_3$ (STO) and $LaAlO_3$ (LAO) has been attracting great interest because this system is composed of non-polar STO and polar LAO. We investigated the electronic structure of the STO-LAO superlattice by resonant soft x-ray scattering [1]. By tuning photon energies to the energy of Ti $2p \rightarrow 3d$ or O 1s→2p absorption edges, one can obtain the information on the electronic structures near the Fermi level, which are composed of Ti $3d$ and O $2p$ states. From the analyses of reflectivity spectra, focusing on the (003) peak which is forbidden for our "ideal" superlattice structure, we concluded that the $LaO|TiO_2/SrO$ and the $SrO|AlO_2/LaO$ interfaces have distinct reconstructions, breaking the heterostructure symmetry. I will also introduce the experimental setup for resonant soft x-ray scattering in Canadian Light Source.

[1] H. Wadati *et al.*, J. Appl. Phys. 106, 083705 (2009).

22. Magnetotransport properties and Microstructure of Co-Au Alloy Films

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The use of electroplating in magnetic applications has seen considerable potential due to the advent of pulse electro-plating. This is increasingly important as the magnetic memories pack more information into smaller volumes. Mainly, the paper will discuss how the preparation conditions have an effect on the giant magnetoresistance. The structure of the deposit film can be varied by controlling the pulse potential in the single bath that contains both the cobalt and gold ions. In this paper, we show the results on studying the

structure of a pulsed plated Co-Au alloy at different compositions. Also, we show the results of the effect of Co particle size in the alloy on the magnetic properties.

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23. Effect of annealing on structural and optical properties of heavily carbon doped ZnO

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There have been remarkably few studies on the incorporation of carbon in ZnO in contrast to III-V MOVPE. Carbon is expected to act as a double acceptor when residing on oxygen sites, and there have been reports of graphitic clusters in MOVPE grown ZnO, as well of some reports of ferromagnetism in intentionally carbon doped films. The growth of ZnO is via a flow modulation epitaxy technique (FME) technique in which the group II and VI precursors are alternately exposed to the growth surface. At low growth temperatures, in conjunction with certain precursors (diethlyzinc and N_2O) remarkably high concentrations of carbon can be achieved without extrinsic dopant sources. In this work we report on the effect of thermal annealing on the structural and optical properties of heavily carbon-doped ZnO films grown on sapphire. (101) pole figure scans show 6 well resolved peaks showing single crystal alignment for both as-grown and annealed films. Raman spectra show strong graphitic bands at 1100 and 1500 cm^{-1} in the as-grown samples. Remarkable narrowing of the (002) x-ray rocking curves, complete removal of these graphitic bands, and a strong increase in the intensity of the ZnO lattice phonon E1 mode at 535 cm^{-1} is observed upon annealing under air at temperatures of 1000C.

24. Strain balanced InAs/InAsSb superlattice structures with optical emission to 10 μm

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We report the growth and optical characterization of InAsSb/InAs strain balanced superlattice structures on GaSb substrates for potential application in midinfrared photodetectors. Photoluminescence (PL) emission was observed in the range 5 μm $\leq \lambda \leq$

10 μm at 4 K for Sb compositions $0.14 \leq x_{Sb} \leq 0.27$. The PL energy was found to depend approximately linearly on antimony, consistent with a type II band lineup. The dependence of the emission energies on the Sb mole fraction is in agreement with trends predicted by various theoretical works. The data suggest that this transition reaches zero energy for a composition of $x_{Sb} = 0.37$.

25. Investigation of thin NiMnSb using TEM

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Thin NiMnSb layers grown on an (In,Ga)As buffer layer on an InP substrate were investigated using transmission electron microscopy (TEM). Bright Field (BF) images and their associated selected area diffraction (SAD) patterns were obtained in planview as a function of layer thickness and substrate orientation to analyze the material crystallinity. We found stacking faults (SF) only in [111] oriented materials and calculations showed these to be located in the (In,Ga)As buffer layer not the film. In [100] oriented material we found dislocations and defects with varying density depending on the material thickness and/or other growth parameters. These dislocation lines became visible starting at a thickness of about 40 nm with densities about two orders magnitude lower than observed in former samples. They are assumed to be due to partial relaxation of the lattice mismatch strain. The structural analysis is being correlated with magnetic properties as a function of temperature.

26. Effect of NO Annealing on 6H- and 4H-SiC MOS Interface States

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The electrical properties of the SiC/SiO_2 interface resulting from oxidation of the ntype 6H-SiC polytype were studied by hi-lo CV, temperature dependent CV and constant capacitance deep level transient spectroscopy (CCDLTS) techniques. Several trap species differing in energy and capture cross section were identified. A trap distribution at 0.5 eV below the 6H-SiC conduction band energy and a shallower density of states in both the 6H and 4H polytypes are passivated by post-oxidation NO annealing. However, other ultra-shallow and deeper defect distributions remain after nitridation. The latter may originate from traps in the semiconductor.

Devices and Systems

27. Capillary-driven microfluidics and its application to biosensing chips

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Microfluidic control is essential for a heterogeneous phase biosensing in a microchip. Among fluidic control methods, the fluidic control based on capillarity (capillary-driven microfluidic control) is favorable to realizing miniature microchips, because it offers spontaneous fluid flow without using external forces. However, its application is highly restricted, because it is difficult to pre-program multiple flows, even single flow, by considering the complex effect of contact angle, surface tension, and channel geometry. A passive regulation of two merging flows has been developed by controlling channel geometry at the fluid junction. This passive regulation greatly simplifies the control of merging streams. A passive washing protocol has also been designed for microfluidic washing. This approach uses the inlet-pressure difference between two solution inlets, and it employs a washing valve to regulate the merging of two solutions. The developed capillary-driven microfluidic control including the passive washing has been applied to a sensitive electrochemical biosensing chip.

28. The Discrimination of the Continental Origin of Atlantic Salmon on a Microfluidic Microarray Device

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Salmon stocks originated from North American (NA) and European (EU) waters were mixed on feeding grounds or migration routes. Mixed-stock fisheries imply a genetic risk to some salmon species and fast genotyping of multiple salmon samples is thus in need. There are some knowledge of variable sites in Atlantic salmon mitochondria DNA (mtDNA) sequence in differentiating between NA and EU salmons [1]. Hence, oligonucleotide probes for NA and EU salmons were designed and pre-printed on glass slides using a developed microfluidic microarray method [2]. With this method, we successfully hybridized and identified the North American salmon DNA samples (209~226-bp PCR products). Samples from multiplex PCR amplification of salmon

mtDNA were also detected under optimized conditions. The results were confirmed by conventional DNA sequencing method. Microfluidic chips avoid the use of large sample volumes and only a small amount of oligonucelotides (8-fmol) or PCR products (3-ng) was needed in the experiment.

[1] So, M.S.Y. Master Thesis, Simon Fraser University, 2006.
[2] Wang, L.; Li, P.C.H. J. Agric. Food Chem. 2007, 55, 10509-10516.

29. Long-term Stability and Function of Molecular Diodes

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The ability to tune the structural and electronic properties of a metal-semiconductor junction based on molecular modifications to the interface is very attractive for their potential applications in nanoscale electronic devices. However, the long-term performance of these junctions is seldom investigated making their viability in real electronics completely unknown. We are currently investigating the stability of Si(111) modified with organic monolayer's (≡Si-$(CH_2)_{11}CH_3$ [C12] and ≡Si-$(CH_2)_3C_6H_5$ [C3Ph]), in order to correlate the growth of SiO_x to the electrical performance, or electron transport mechanism, of these diodes. For C12 modified devices the electrical transport mechanism in the low-forward bias shows recombination to become significant, in addition to the already existing thermionic emission, as oxidation occurs. In the C3Ph modified devices, recombination in the low-forward bias appears to be limited, despite approximately twice the oxygen content as C12, suggesting –Ph terminated monolayer's may improve stability to these diodes. It has been suggested that the monolayer bound to silicon is removed as the underlying wafer oxidizes, however we found that the carbon content remains constant over the timescale of the measurements based on C-Si/Si_{2p} XPS data.

30. A Disc-Based "ELISA" Protocol for Detecting Blood-Borne Cancer Markers

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This work is aiming to combine ELISA and compact disc (CD) technology, with an ultimate goal of improving the sensitivity and accessibility of existing diagnostic tools. This novel approach is demonstrated with the detection of immunoglobulin (IgG)

molecules at first and will be applied to the detection of blood-borne cancer markers. After activating the CD surface using UV light in the presence of ozone, a capture antibody can be immobilized on the CD surface. This surface will then be used to detect IgG in a standard buffer or diluted serum. The signal readout will be based on the use of an anti-IgG that has a gold nanoparticle (20 nm) attached to it to construct a "sandwich" structure. The gold nanoparticle will serve as a seed for the deposition of silver, which will generate reading errors upon checking with a standard optical drive. Because the number of reading errors is proportional to the amount of IgG binding events on the CD surface, a quantitative detection would be realized.

31. Exploring the Detection Limit of Nanohole Array Sensors

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32. Development of Bismuth Hall-Effect Sensors

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Scanning Hall probe microscopy is a quantitative magnetic imaging technique that combines high spatial resolution with high flux sensitivity, occupying a unique niche in magnetic microscopy [S.J. Bending, *Adv. Phys.* **48**, 449 (1999)]. Hall sensors are useful in studying materials with microscopic or nanoscale magnetic structures, like high temperature superconductors and magnetic thin films. The use of conventional semiconductor Hall sensors at the nanoscale has run into problems with charge depletion and excess noise as a consequence of the low carrier density, which makes number fluctuations more prominent and makes characteristic length scales such as the Fermi wavelength and the thickness of depletion layers comparable to device size.

An alternative approach used, for example, by Sandhu et al. [*Jpn. J. Appl. Phys.* **40**, L524 (2001)] is to employ semimetals in the place of semiconductors, with elemental bismuth as a common choice. However, separate problems then arise, as bismuth is a compensated metal, leading to strong cancellations of the Hall effect. I will discuss our work aimed at breaking this impasse through the use of chemically doped bismuth.

33. Wireless actuation of responsive hydrogel for implantable drug delivery applications

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This paper describes a wireless actuation technique for micro-devices that are controlled with radiofrequency magnetic fields, targeting the application of implantable drug delivery. Poly (*N*-isopropylacrylamide) is a thermo-responsive hydrogel that serves as the actuator driven by a passive resonant circuit that effectively generates heat only when the field frequency is tuned to the resonant frequency of the circuit. The hydrogel has a phase transition temperature called the lower critical solution temperature above which it starts to shrink and induces drug release from a reservoir. The heater devices were micro-fabricated using a flex-circuit-based process and designed to have the resonant frequencies of 30-100 MHz. The fabricated heaters provide temperature increases of up to 20 °C at their resonances in a wireless set-up, causing ~ 40% shrinkage of the hydrogel. The frequency-defined release of a test solution is experimentally demonstrated using a fabricated device, which is shown to exhibit an active frequency range of ~2 MHz. Integrated drug-delivery devices based on the demonstrated principle are being developed for long-term operation as well as multiple actuator control for selective delivery of different drugs.