Second National Workshop on Nanoscience and Biochips (Nano-Bio 2009)

February 16-17, 2009

Indian Statistical Institute

203, B.T. Road, Kolkata, India

The theme of this year's workshop is:

Combinatorial and Algorithmic Aspects of Bio-chips

Venue: Geology Auditorium

16th February 2009	
9:30 – 10am	Registration
10:15 – 11am	**Inauguration and Tea**
Invited Lecture 1 *11am -12 noon*	➢ *Towards a silicon based diagnostic chip* - **Prof. Enakshi Bhattacharya**, Microelectronics and MEMS Laboratory, Department of Electrical Engineering, IIT Chennai
Invited Lecture 2 *12noon -1pm*	➢ *Biomicrofluidics: Recent Trends and Future Challenges* – **Prof. Suman Chakraborty**, Department of Mechanical Engineering, IIT Kharagpur
1 - 2:30pm: **Lunch at ISI Guest House**	
Invited Lecture 3 *2:30 - 3:30pm*	➢ *Silicon and silicon oxide core-shell nanocomposites: potential application in biological imaging* – **Prof. N. R. Bandyopadhyay**, Director, School of Material Science and Engineering, Bengal Engineering and Science University, Shibpur
Invited Lecture 4 *3:30 – 4:30pm*	➢ *Pushing Cells on a Square Grid with Applications to Cell Sorting for Lab-on-a-chip* - **Dr. Arijit Bishnu**, ACMU, Indian Statistical Institute
Coffee and Discussion	
17th February 2009	
Invited Lecture 5 *10:30 -11:30am*	❖ *Nanotechnology for Drug Delivery* – **Prof. Dwijesh Dutta Majumder**, ECSU, Indian Statistical Institute
11:30 -12noon **Tea break**	
Invited Lecture 6 *12noon – 1pm*	❖ *Nanobiotechnology: Deciphering hidden network parameters in simpler and combinatorial rules in complex biological models* – **Dr. Arunava Goswami**, AERU, Indian Statistical Institute
1-2:30pm: **Lunch at ISI Guest House**	
Invited Lecture 7 *2:30 -3:30pm*	❖ *Design and Testing of Digital Micro-fluidic Nano-bio chips* – ❖ **Mr. Sudip Roy**, ACMU, Indian Statistical Institute
Invited Lecture 8 *3:30 – 4:30pm*	❖ *Quantum Nano-Engineering: Quantum and High-Field Nanoelectronics Transport* - **Prof. Vijay K. Arora**, Department of Electrical Engineering and Engineering Management, Wilkes University, U.S.A
Coffee and Discussion	
6:30 – 9:00pm	**Banquet at ISI Guest House**

Registration is free

http://www.isical.ac.in/~walcom

Lecture 1

Towards a silicon based diagnostic chip

Enakshi Bhattacharya
Microelectronics and MEMS Laboratory,
Department of Electrical Engineering, IIT Chennai

Abstract

Biosensors find applications in medical diagnostics, environmental analysis, food quality control, process control, drug detection, etc. Silicon based sensors have the advantages of being compact and thus requiring small sample quantity for testing, ease in signal processing and possibility of circuit integration and also lower costs if made by batch processing. Electrolyte–Insulator-Semiconductor capacitors (EISCAP) show a shift in the measured capacitance voltage (CV) characteristic with changes in the pH of the electrolyte. Many biological reactions, especially enzyme mediated ones, involve changes in the pH of the electrolyte and an EISCAP can be effectively used for the detection of biological compounds and hence can function as biosensors. We have optimized the sensor structure and measurements to increase the sensitivity and range of operations. The biosensor is calibrated and used for the detection of tributyrin - a short-chained triglyceride, urea, rancidity of butter and triglyceride content in human blood. Direct readout electronics for the EISCAP sensor has also been designed. The technique uses an EISCAP relaxation oscillator embedded in a successive approximation analog-to-digital conversion algorithm to give a digital readout of the pH of the test solution. Miniaturisation of the devices by micromachining can lead to detection of multiple bioanalytes by forming sensor arrays on a single biochip.

Microcantilever beams can also be used as sensors. Resonance frequency of a beam is sensitive to changes in mass, damping, etc. Use of surface micromachined cantilevers for hypersensitive detection of tributyrin and urea will also be discussed briefly.

Biography

Enakshi Bhattacharya completed her MSc (Physics) from IIT Bombay in 1980 and PhD from TIFR, Mumbai in 1985. She carried out Post-doctoral work at the National Renewable Energy Laboratory, USA from 1986-88. She was a member of the faculty in the Department of Physics, IIT Kanpur during 1988-91. Since 1991, she has been on the faculty of the Department of Electrical Engineering at IIT Madras and is with the Microelectronics and MEMS laboratory. She was a Visiting Scientist at the Micromachined Products Division of Analog Devices, USA in 2000. She has interest in material properties and devices of all forms of silicon – crystalline, poly, amorphous and porous and her current major interests are in Biosensors and MEMS She has over 80 published papers in journals and International conference proceedings. She has supervised 3 PhD and 12 MS (by research) theses. At present 3 PhD and 2 MS scholars are working with her. She has successfully handled 9 sponsored projects and is currently engaged in 5 projects.

Lecture 2

Biomicrofluidics: Recent Trends and Future Challenges

Suman Chakraborty
Professor, Department of Mechanical Engineering, Indian Institute of Technology
Kharagpur-721302, INDIA
e-mail: suman@mech.iitkgp.ernet.in; URL: http://www.stanford.edu/~sumancha/

Abstract

Ever increasing desire to explore biology at single entity level has made microfluidics remarkably paving into the biological domain. By virtue of its compatible length scale, explicit capability of exploring surface effects and unique ability to reduce the reagent volume, timescale and required manual labor, microfluidics has opened up novel and emerging vistas in the field of biological science, which, even a decade ago, looked utterly unattainable. Boosted by the recent exhilarating developments in the design and utilization of microfluidic devices for fluid transport, the technology of the micro Total Analysis Systems (μ-TAS) has revolutionized the processes associated with sample handling, detection and analysis in stand-alone integrated microfluidic platforms for bioassays. Applications of novel lab-on-a-chip devices range from bioscience industries for pharmaceuticals and medicine (e.g. drug design, detection and delivery, diagnostic devices) to industrial applications of combinatorial synthesis (e.g. high throughput screening and rapid chemical analyses). In conjunction, the ability to create fluidic structures mimicking biovasculation with micron-level precision in device length scale has released new paradigms for noninvasive diagnostics and surgery with minimal post-surgical trauma. As an instance of the swiftly escalating demand for biomedical microdevices it should be acknowledged that the biochip market was $400M in the year 2000 and has subsequently grown eightfold by 2006 (according to the recent market analysis by MarketReseach™). In the wake of such unprecedented advancement of microfluidics into biomolecular and biomedical technologies, this lecture attempts to delineate a synoptic picture of the field's progress. Commencing with a concise discussion on the basic physics of microfluidics, we discuss on the major instances where microfluidics has been implemented with respect to cell biology, protein and DNA biophysics, structural biology, biosensors and finally tissue engineering. Future trends and challenges on research related to these areas are also discussed.

Suman Chakraborty has research interests in the area of Microfluidics and Microscale transport processes, including their theoretical, computational, and experimental modeling, encompassing the underlying fundamentals as well as bio-medical, bio-technological, chip cooling, and energy related applications. He has been a Visiting Professor at the Stanford University (USA), Pennsylvania State University (USA), and a Visiting Scientist at the Aachen University and University of Erlangen (Germany). He is the lead research coordinator and PI of several International collaborations, including those with University of Illinois at Urbana Champaign, University of California at Irvine, Northwestern University, Stanford University, and the University of California at Berkeley in the USA, University of Southampton in the UK, as well as with the University of Tokyo/ Tokai University in Japan, in the areas of Microfluidics and Nanofluidics. He has been the recipient of the Swarnajayanti Award (Govt. of India), Indo-US Research Fellowship, Scopus Young Scientist Award, and Young Scientist/ Young Engineer Award from various National Academies of Science and Engineering. He has also been an Alexander von Humboldt Fellow. He has delivered invited Lectures in several Conferences and special events of National and International importance, including a special Lecture for the Mathematical Physics Colloquium at MIT, USA. He has 125+ International Journal publications, including papers in the Physical Review Letters, Applied Physics Letters, Physical Review E, Langmuir, Lab on a Chip, Journal of Applied Physics, Journal of Fluid Mechanics, Physics of Fluids, Physics Letters A, ACS Nano, Analytica Chimica Acta, Sensors and Actuators B, Microfluidics and Nanofluidics, etc. He has also been a lead author in the 'Encyclopedia of Microfluidics and Nanofluidics' (Springer, 2008). More detailed information on his work and recent innovations can be found at http://www.stanford.edu/~sumancha/ and http://geocities.com/sumanchakraborty_iitkgp/

Lecture 3

Silicon and silicon oxide core-shell nanocomposites: potential application in biological imaging

Mallar Ray* and Nil Ratan Bandyopadhyay

School of Materials Science and Engineering,
Bengal Engineering and Science University, Shibpur, Howrah: 711103, West Bengal, India.

Abstract

Synthesis of stable core-shell structure of nanocrystalline silicon and silicon oxide is a demanding problem. Such core-shell structures represent an important class of nanoscale building blocks with substantial potential for exploring fundamental electronic properties and realizing novel applications. Here, we discuss about successful synthesis of spherical core-shell structures of silicon and silicon oxide by forced external oxidation of ball milled silicon, and fabrication of rod like Si/Si-oxide core/shell structures by exfoliating the affected layer of porous Si. Colloidal suspensions of the synthesized core-shell structures exhibit strong room-temperature photoluminescence (PL), detectable with the unaided eye. The observed PL characteristics are explained in terms of dominant electronic transitions between the parametrically resonated surface states and quantum confinement induced widened band states. Surface modification of silicon nanocrystals allows them to be conjugated to biomolecules. Since silicon nanocrystals are superior to organic dyes in terms of photostability and less cytotoxic than commercially available III-V or II-VI quantum dots, they could serve as the next generation fluorophores for biological imaging.

Biography of Prof. N R bandyopadhay

Education : B.E. (Cal), M.E. (J.U.), Ph.D.(Cal)

Area of work: Physical Metallurgy of Steel, Materials Characterization, Nano-materials, Energy Materials

Important Engineering and Research Achievements and Awards

- Recipient of "Eminent Materials Scientist Award 2004 "in recognition of eminence and contribution to the profession of Metallurgical & Materials Engineering, on the occasion of 18th National Convention of Metallurgical & Materials Engineers of The Institution of Engineers (India)
- Keynote Speaker: New generation metal matrix composites – ACUN-5 Int. Composites Conf. Developments in Composites: Advanced, Infrastructural, Natural and Nano-Composites, July 11-14, 2006, The University of New South Wales, Australia.
- State-of-the-art lecture on 21st Century Materials: An overview, Proc.18th National Convention of Metallurgical and Materials Engineers, October 11-12, 2004, Jaipur, India.
- Recipient of Metallurgical and Materials Engineering Division Medal of The Institution of Engineers (India) in January 2000 for best research publication on TRIP aided micro alloyed Dual Phase Steel
- Recipient certificates of merit for the publication of papers in the journal of Metallurgical and Materials Engineering Division of The Institution of Engineers (India), 2001, 2005-06, 2006-07.

Professional and other Academic Engagements

- Fellow, The Institution of Engineers (India) and Member of its National Council
    - Consulting Editor, Journal of The Institution of Engineers (India) for Metallurgical & Materials Engineering Division
    - Member, Board of Consulting Editors, Technorama, Journal of The Institution of Engineers (India) for professional engineers and decision makers
    - Chairman, Metallurgical & Materials Engineering Division Board, The Institution of Engineers (India)

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    - Chairman, Strategic Plan Committee, The Institution of Engineers (India)
    - Chairman –The Institution of Engineers (India), West Bengal State Centre (2004-06)
- Life Member, Material Research Society of India and Member of its National Council
    - Chairperson, Materials Research Society of India (MRSI), Kolkata Chapter
- Member, American Society of Non-Destructive Testing (ASNT)
- Member, India Society of Non-Destructive Testing (ISNT)

Biography of Mr. Mallar Ray

- *Education :*
    - PhD (ongoing, registered at BESUS, 2006)
    - Master of Science in Environmental Sciences from University of Nottingham, UK (2003)
    - MSc in Physics from University of Calcutta (1996)
    - BSc in Physics (Hons.) from University of Calcutta (1994)

  Area of interest:
  (a) Nanostructured semiconductors
  (b) Energy and environmental materials
  (c) Materials for water treatment
  Area of work:
  (a) Theoretical and experimental investigations on silicon nanostructures
  (b) Synthesis and characterization of materials for water purification.
  Awards, recognition and special lectures
- Awarded the Joint British Chevening Scholarship for Developing Solutions, in 2002.
- Awarded the National Scholarship under the National Scholarship Scheme, 1994-'95, Govt. of India, for the B.Sc. results in Physics (Hons.).
- Recipient of certificate of merit for the paper entitled "Oxide ion conducting electrolyte materials for solid oxide fuel cell applications" in the Journal of The Institution of Engineers (India), 2006-2007.
- Visiting Scientist at School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Australia, August-October, 2007.
- Invited lecture on: Luminescence from silicon nanostructures, at the School of Materials Science and Engineering, UNSW, Australia, July, 2007.
- Invited lecture in the Refresher Course on 'Environmental Studies': 'Radiative forcing of the climate', UGC-Academic Staff College, University of Calcutta, February 02, 2007.
- Invited extension lecture for the students of Sarojini Naidu College for Women, Calcutta, Special Theory of Relativity and Beyond, January 31, (2006).
- Delivered lecturers at Jagadish Bose National Science Talent Search (JBNSTS), Summer Program for the JBNSTS scholars in 1998, 2000 & 2001.

Lecture 4

Pushing Cells on a Square Grid with Applications to Cell Sorting for Lab-on-a-chip

Arijit Bishnu
ACMU, Indian Statistical Institute

ABSTRACT:
Rare cell population, e.g. adult stem cell, are available in very small quantities in samples that also have limited supply. Automatic cell sorting and isolation for recovery of such live cells is a challenging task. A Lab-on-a-Chip (LOC) is a device that can integrate several laboratory functions on a single chip of very small size. Lab-on-a-Chip devices implemented as cell arrays are used for the purpose of cell sorting. For an abstract model of the problem, we can assume the cell array to be represented by a matrix where each cell can be any of the three types: empty, desired and undesired. We have to empty the cell array by pushing the desired and undesired cells to their respective receptors at the corners of the cell array using the empty cells. We address some combinatorial problems and heuristics related to this physical phenomenon.

Biography:
Arijit Bishnu obtained his undergraduate degree in Electrical Engineering from Burdwan University in 1995; M. Tech. and Ph.D. degrees both in computer science from Indian Statistical Institute in 1998 and 2003 respectively. He worked as an Associate in the Japan Advanced Institute of Science and Technology (JAIST), Japan from September, 2003 to April, 2005. Prior to joining Indian Statistical Institute as an Assistant Professor in May, 2008, he worked as an Assistant Professor in the Computer Science and Engineering Department of Indian Institute of Technology, Kharagpur from May, 2005 to May, 2008.

Lecture 5

Nanotechnology for Drug Delivery

Dwijesh Dutta Majumder
ECSU, Indian Statistical Institute

Abstract:
An overview of nanotechnology along with its importance to drug delivery and other medical applications will be presented.

Biography
Dwijesh Kumar Dutta Majumder, the founder & Honorary Director – Secretary & Chairman of Advisory Board of Institute of Cybernetics Systems and Information Technology (ICSIT) is a renowned scientist known around the globe. He is Professor Emeritus, Electronics & Communication Sciences Unit, Indian Statistical Institute. He is also an *Emeritus Scientist*, Council of Scientific & Industrial Research (CSIR), Goverenment of India; *Member, Board of Directors*, World Organisation of Systems and Cybernetics (WOSC), U.K; *Founder President*, Indian Unit for Pattern Recognition and Artificial Intelligence (IUPRAI); *Member, Governing Body and Fellow*, International Association of Pattern Recognition (IAPR), USA; *Founder President*, Indian Society for Fuzzy Mathematics and Information Processing (ISFUMIP); *Member, Governing Body*, International Fuzzy Systems Association (IFSA), USA.

Lecture 6

Nanobiotechnology: Deciphering hidden network parameters in simpler and combinatorial rules in complex biological models

Arunava Goswami
Assistant Professor, AERU, Biological Sciences Division, Indian Statistical Institute, Kolkata.

Abstract
High throughput genomics and proteomics based computational network analyses have increased enormously our understanding on small and peripheral sensory biological networks in recent years. Hijacking of host lipid rafts by disease causing organisms like malarial parasite, BmNPV, HIV and Ebola in animal models and breaking of lipid based `water barrier' in agricultural insect pests are examples of relatively `non-smart' small networks. We have measured hidden parameters with high level of precision experimentally while perturbing aforesaid networks with novel lipophilic nanoparticles (LNPs) and thereby generating new approaches for drug development against malaria, BmNPV and designing biopesticides of agricultural importance etc. Examples of complex peripheral sensory networks are sense of gustation and olfaction in agricultural pests. Combinatorial odor codes of G-ptn coupled 7TM olfactory (OR) and gustatory receptors (GR) were perturbed using a number of different nanoparticles on *Drosophila melanogaster* model. Conflicting theories on combinatorial rules of ORs and GRs were used to analyze the mechanism of action of these complex networks.

1. Goswami *et al*., Journal of Nanoscience and Nanotechnology (2009) 9: 1–5.
2. Goswami *et al*., Naturwissenschaften (2009) 96:31–38.

Short Biography

Bachelor degree (Agriculture; specialization: Genetics and Biochemistry; BCKV) and Masters (Agriculture; specialization: Genetics; Calcutta University), Arunava completed PhD (Molecular Biology) from Tata Institute of Fundamental Research (TIFR; 1992-1997). During PhD, he was selected as Burroughs Wellcome Fund Fellow at Marine Biological Laboratory (MBL), USA and completed part of PhD work at UPenn, USA. Financially supported by grants of Prof. Christiane Nüsslein-Volhard (Nobel Prize winner, Physiology and Medicine, 1995) and Tata Trusts, Arunava delivered PhD student special seminar series in 1997 at Baylor College of Medicine, Arizona State Univ., UC (Irvine), UCSF, Univ. of Heidelberg, Max-Planck Institute (MPI, Tubingen), Univ. of Freiburg, Biozentrum (Basel), Pasteur Institute (Paris & Lille). Arunava joined the laboratory of Prof. Linda B. Buck (Nobel Prize winner, Physiology and Medicine, 2004) as post doctoral fellow at Harvard, USA and worked on advanced biotechnology problems (1997-2000). He joined Indian Statistical Institute (ISI), Kolkata in June 2000 as lecturer and was promoted to Assistant Professor in 2004. During 2004-2005, Arunava went on long term academic leave (LTAL) at Brown University, USA and Humboldt University, Berlin (financially supported by NIH, USA) where he taught as well as did research as visiting scientist. After initial years of preparation (World bank-NATP project from ICAR, 2000-2004), Arunava's laboratory secured three major DBT, GOI and NAIP projects from ICAR, GOI on Nanobiotechnology in 2008 based on their findings published during 2000-2007. In DBT projects, Arunava's collaboration partners are two important institutes of India, viz., Saha Institute of Nuclear Physics (Calcutta) & Central Mining and Fuel Research Institute (Dhanbad) and for NAIP project, Indian Agricultural Research Institute (IARI; New Delhi).

Lecture 7

Design and Testing of Digital Micro-fluidic Nano-bio chips

Sudip Roy
ACMU, Indian Statistical Institute

Abstract

In this talk, he will discuss about the computer-aided design (CAD) techniques and the algorithmic aspects of different related problems in the field of digital microfluidic nano-bio chips. The EWOD (electrowetting-on-dielectric) technique is used for droplet movement in such biochips. The controlling of the two-dimensional array of electrodes and the automation of the process raises combinatorial optimization issues, which need to be solved efficiently. Design automation tools for the development of digital microfluidic nano-bio chips are getting benefits from the classical CAD techniques of the VLSI chip design. Some typical problems during the design, synthesis and testing of such biochips will be presented and algorithmic techniques to solve them will be discussed.

Short Biography

After receiving his B.Sc. degree with Physics honours in 2001 from Rahara R. K. Mission Vivekananda Centenary College under University of Calcutta and B.Tech. in Computer Science and Engineering in 2004 from University of Calcutta, Sudip Roy worked with Machine Intelligence Unit, Indian Statistical Institute Kolkata in a research project under the supervision of Professor C. A. Murthy till July, 2005. Then he joined Indian Institute of Technology Kharagpur and worked in a research project related to CAD for VLSI chips and submitted his MS (by research) thesis in the Department of Computer Science and Engineering in August 2008 under the guidance of Professor Ajit Pal. He has five international conference paper publications, one international workshop presentation and one international journal paper publication. Since July 2008 he is working in a research project at Advanced Computing and Microelectronics Unit of Indian Statistical Institute Kolkata under the guidance of Professor Bhargab B. Bhattacharya in the field of nano-bio chips. His areas of interest are CAD techniques and algorithms for VLSI chips and nano-bio chips.

Lecture 8:

Quantum Nano-Engineering
Quantum and High-Field Nanoelectronics Transport

Vijay K. Arora
Department of Electrical Engineering and Engineering Management,
Wilkes University, U.S.A

Abstract

Quantum (digital-type) concepts are gaining predominance over and above classical (analog-type) ones in miniaturized devices where nanometer size can be less than or equal to the de Broglie wavelength of an electron in any of the three cartesian directions. An electric field driving electrons in these devices can be extremely high. This converts random carrier motion to a streamlined one, thereby limiting the velocity to thermal velocity or Fermi velocity depending on the degeneracy of the sample. This re-organization of the carrier velocities makes familiar Ohm's law invalid, thereby enhancing the role of high-field velocity saturation in performance evaluation and characterization of nanostructures. Further, a free flight of a carrier may be interrupted by an emission of a quantum of energy in the form of a phonon or photon. This emission further limits the saturation velocity and also degrades the diffusion coefficient. This workshop module will cover applications of these concepts as possible applications in low-dimensional nanoelectronic devices and circuits. Possible application to bioscience will also be discussed. The attendees will go home charged with tools to tackle their own research problems in the nano arena, may these be in physical or bio sciences.

Vijay K. Arora is a tenured Professor of Electrical Engineering and Engineering Management at Wilkes University, U. S. A. At present, he is a Distinguished Visiting Professor at the Universiti Teknologi Malaysia. Professor Arora has held eminent visiting appointments at the University of Illinois, the University of Tokyo, National University of Singapore, Nanyang Technological University, the University of Western Australia, and the Universiti Malaysia Sabah. In addition to his long-term visiting appointments, Professor Arora visited several international institutions on short-term consulting assignments and enjoys the privilege of knowing the cultures and educational methods being practiced around the globe. In recognition of his research, he is invited to give presentations at several international scientific gatherings. His research interests include mobility limiting mechanisms in high-speed devices, including quantum and high-field effects. Professor Arora has authored or co-authored over 200 papers on scientific, educational, and management issues. On May 15, 2008, Universiti Teknologi Malaysia honored Professor Arora with Hadiah Utama (Premier Award) for Most Impact-Worthy paper in an International Journal. As past chair of the International Division of the American Society for Engineering Education (ASEE), he organized several international events. As chair of the 1996 ASEE Mid-Atlantic Conference, he edited and published the proceedings entitled *Re-Engineering Education and Training for a Competitive Global Economy*. He chaired NanoSingapore2006. Professor Arora is on the Distinguished Lecturer Program of the IEEE Electron Devices Society and APS Forum on Industrial and Applied Physics. He is listed in *500 Greatest Geniuses of the 21st Century*, *Leading Educators of the World* 2005, *Leading Scientists of the World 2005*, *Great Minds of the 21st Century*, *Leading Intellectuals of the World, Millennium Hall of Fame*, *Five Thousand Personalities of the World*, *International Man of the Year 1998/99*, *Outstanding People of the 20th Century*, *International Who's Who of 20th Century Achievement*, *International Directory of Distinguished Leadership, Who's Who in the World, American Men and Women of Science*, *Who's Who in Science and Engineering*, *Who's Who in the East*, *Who's Who Among Asian Americans, Dictionary of International Biographies*, *Man of the Year—1996*, and *Most Admired Men and Women of the Year (1994-95)*.