Inaugural meeting of the Oregon Section Chapter of the IEEE Nanotechnology Council

Date: Friday, December 6
Time: 1:00-5:30 pm
Location: Portland State University
Engineering Building, Room: EB-103
1930 SW 4th Ave, Portland, Oregon, 97201

Approximate Agenda

- 1:00 PM Arrival & Networking
- 1:15 PM Introduction & Chapter Officer Nominations
- 1:30 PM John Yeow "Highly Miniaturized Biomedical Imaging Devices"
- 2:30 PM Jean-Pierre Leburton "2D Nano-Electronic Materials for Bio-sensing"
- 3:30 PM Break
- 4:00 PM Supriyo Bandyopadhyay "Straintronics: Boolean and Non-Boolean Computing with Tiny Nanomagnets Switched with Electrically Generated Mechanical Strain"
- 5:00 Wrap-up

Highly Miniaturized Biomedical Imaging Devices

John T.W. Yeow

The emergence of minimally invasive diagnostics and therapeutics in modern high-tech medicine has generated an unmet demand in miniaturized biomedical devices, thereby, forecasting an interesting future for clinical diagnostic and treatment instruments that are based on micro and nanotechnologies. In the past decade, micromachining technology and nanomaterials are making big impacts in many fields, especially in the field of biomedical instrumentation. The small size and low mass provided by micro/nanodevices make medical instruments portable, power efficient, and, in many cases, more effective. This talk will focus on the current development of miniaturized x-ray CT machines, and ultrasound imaging devices in the Advanced Micro/Nanodevices Laboratory at the University of Waterloo.

Biography

John T. W. Yeow received the B.A.Sc. degree in electrical and computer engineering, and M.A.Sc. and PhD. degrees in mechanical and industrial engineering from the University of Toronto, Toronto, ON, Canada. He is currently a Professor in the Department of Systems Design Engineering at University of Waterloo, Waterloo, ON, Canada. His current research interests are in the field of developing miniaturized biomedical instruments. He is a recipient of the Professional Engineering Ontario Young Engineer Medal, Professional Engineering Ontario Engineering Excellence Award, Natural Science & Engineering Research Canada Innovation Challenge Award, Douglas R. Colton's Medal of Research Excellence, Micralyne Microsystems Design Award, Ontario Ministry of Research and Innovation's Early Researcher Award, and University of Toronto Alumni Association 7T6 Early Career Award. He is a Canada Research Chair in Micro/Nanodevices, and a University Research Chair. He is the Editor-in-Chief of the IEEE Nanotechnology Magazine, and an Associate Editor of the IEEE Transactions of Nanotechnology. He is a Fellow of the Canadian Academy of Engineering, the Engineering Institute of Canada, Engineers Canada, and a Member of College of New Scholars, Artists and Scientists of the Royal Society of Canada. He is also a 2017/2018 IEEE Nanotechnology Technical Council Distinguished Lecturer.

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2D Nano-Electronic Materials for Bio-sensing

Jean-Pierre Leburton
G. Stillman Professor of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign. Urbana Il 6180, USA

The last two decades have experienced rapid technological developments in the search of cheap and high accuracy devices for fast bio-molecular identification. In the realm of DNA and protein sequencing, there has been an increasing interest in the use of nanopores in solid-state materials because of their distinct advantage over biological pores in terms of flexibility in pore design and mechanical strength. Two-dimensional (2D) solid state materials such as graphene and Molybdenum di-sulphide (MoS2) in particular have attracted attention because of their atomically thin layered structure and electrically active characteristics, predisposing them to offer single base resolution and simultaneously multiple modalities of detecting biomolecular translocation. 2D nanopore devices promise seamless integration with semiconductor electronics and are poised to revolutionize a variety of technologies such as genomics, point-of-care diagnostics and digital data storage to name a few.

The past year has witnessed a flurry of activity to experimentally realize nanopore Field Effect Transistors (FETs) and understand the fundamental sensing mechanism in such devices. Currently, the dominant consensus from theoretical calculations has involved the electrostatic modulation of the FET current due to the translocating biomolecules. In this talk, we review and provide insights into this sensing principle by modeling the electron flow through 2D material nanopore FETs. We describe a method to systematically characterize nanopores FETs by contrasting the changes in the FET behavior before-and-after nanopore drilling and DNA translocation. We outline measurable predictions of high-resolution FET based sensing of DNA-protein complexes and damaged DNA. We compare these FET signals to the corresponding ionic current signals calculated from all-atom Molecular dynamics simulations. Further, we also outline possible techniques to improve the detection SNR by augmenting pore and device design with statistical signal processing algorithms. Finally, we propose a scalable device design of nanopore FETs to detect and identify translocations of single-biomolecules in a massively parallel scheme.

Biography

Dr. Leburton joined the University of Illinois in 1981 from Germany, where he worked as a research scientist with the Siemens A.G. Research Laboratory in Munich. In 1992, he held the Hitachi LTD Chair on Quantum Materials at the University of Tokyo, and was a Visiting Professor in the Federal Polytechnic Institute in Lausanne, Switzerland in 2000. He is involved with research in nanostructures modeling and in quantum device simulation. His present research interest encompasses non-linear transport in quantum wires and carbon nanotubes, and molecular and bio-nanoelectronics

Professor Leburton is author and co-author of more than 300 technical papers in international journals and books, and served in numerous conferences committees. In 1993 he was awarded the title of “Chevalier dans l’Ordre des Palmes Academiques “ by the French Government. He is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE), the American Physical Society (APS), the Optical Society of America (OSA), the American Association for the Advancement of Science (AAAS), the Electrochemical Society (ECS) and the Institute of Physics (IOP). He is also a member of the New York Academy of Science. In 2004 he was the recipient of the ISCS Quantum Device Award, and of the Gold medal for scientific achievement by the Alumnus association of the University of Liege, Belgium. He is a Distinguished Lecturer for the IEEE Nanotechnology Council. In 2011 he was elected to Royal Academy of Sciences of Belgium.

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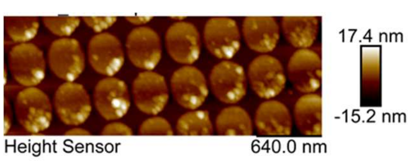
Straintronics: Boolean and Non-Boolean Computing with Tiny Nanomagnets Switched with Electrically Generated Mechanical Strain

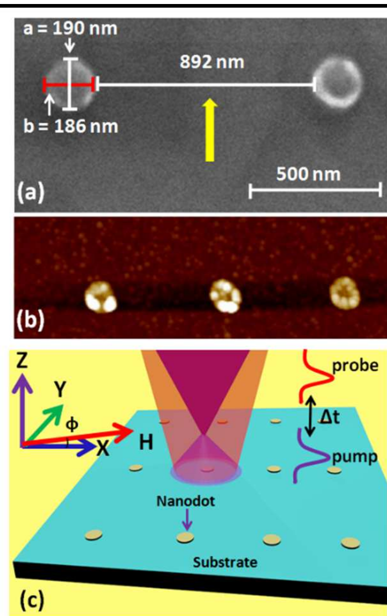
Supriyo Bandyopadhyay
Commonwealth Professor, Electrical and Computer Engineering
Virginia Commonwealth University, Richmond, VA 23284, USA

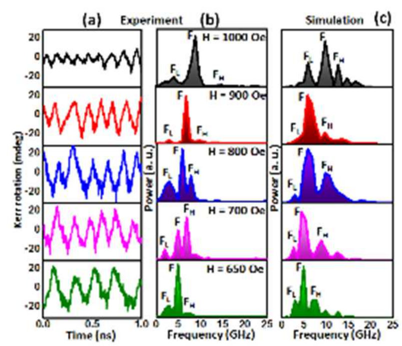
The impending demise of Moore's law that has guided and sustained the electronics industry for the last five decades has prompted many new ideas that articulate novel devices and paradigms for computing and signal processing. Notable among them is "straintronics" that envisions replacing transistor switches with bistable multiferroic nanomagnets which can be switched between two stable magnetization states (encoding binary bits 0 and 1) with electrically generated mechanical strain. Both theory and experiments suggest that the energy dissipated in straintronic switching can be less than 10 aJ (while switching in ~1 ns), which would make these switches at least an order of magnitude more energy-efficient than state of the art transistors (e.g. the 14-nm FINFET).

A spintronic switch consists of a magnetostrictive nanomagnet elastically coupled to an underlying piezoelectric substrate. Application of a voltage to the piezoelectric generates strain in the nanomagnet and switches its magnetization via the Villari effect. We have demonstrated memory elements, elementary Boolean logic gates and Bennett clocking with straintronic switches. These experiments have revealed that while straintronic switches are extremely energy-efficient (~4 aJ of switching energy), they are also relatively error-prone, which may inhibit logic applications. Consequently, we have focused on non-Boolean computing and signal processing including neuromorphic, stochastic (restricted Boltzmann machines), belief networks, bit comparators, ternary content addressable memory, image processors and analog multipliers. We have experimentally demonstrated a number of straintronic platforms including a hardware emulator of simulated annealing, a sub-wavelength acoustic antenna actuated by the giant spin Hall effect and a spin-wave generator (with rich power and phase profiles of the confined spin waves) excited by a surface acoustic wave in a single nanomagnet. This talk will describe these results.



Atomic force micrograph of arrays of dipole-coupled nanomagnets of lateral dimension ~ 200 nm fabricated on a piezoelectric PMN-PT substrate in the speaker's lab that emulated simulated annealing when excited by time-varying strain pulses..





Spin waves excited in a single elliptical Co nanomagnet of major axis 190 nm and minor axis 186 nm excited by a surface acoustic wave (SAW) in the underlying piezoelectric substrate. The SAW is generated by ultrashort (100 fs) laser

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Biography

Supriyo Bandyopadhyay is Commonwealth Professor of Electrical and Computer Engineering at Virginia Commonwealth University where he directs the Quantum Device Laboratory. Research in the laboratory has been frequently featured in national and international media (newspapers, internet blogs, magazines, journals such as Nature and Nanotechnology, and internet news portals). The laboratory's educational activities were featured in a pilot study conducted by the ASME.

Prof. Bandyopadhyay was named *Virginia's Outstanding Scientist* by Virginia's Governor Terence R. McAuliffe in 2016. His alma mater, the Indian Institute of Technology, Kharagpur, India named him a distinguished alumnus in 2016. His current employer Virginia Commonwealth University bestowed upon him the Distinguished Scholarship Award (given annually to one faculty member in the University) and the University Award of Excellence (the highest honor the University can bestow on a faculty member). His department gave him the Lifetime Achievement Award for sustained contributions to scholarship, education and service (one of two given in the department's history). His earlier employer, University of Nebraska-Lincoln, conferred on him the College of Engineering Research Award (1998), the College of Engineering Service Award (2000) and the Interdisciplinary Research Award (2001) given jointly by the College of Engineering, the College of Science, and the Institute for Agricultural and Natural Resources. In 2018, he received the *State Council of Higher Education for Virginia Outstanding Faculty Award*. This is the highest award for educators in private and public universities in the State of Virginia and recognizes outstanding scholarship, teaching and service.

Prof. Bandyopadhyay has authored and co-authored over 400 research publications and presented over 150 invited talks and colloquia across four continents. He has also authored/co-authored three classic textbooks that have taught the field of spintronics and quantum device theory to students across the world. Prof. Bandyopadhyay is a Fellow of IEEE, APS, IoP, ECS and AAAS.