NMDC 2018 Invited Speakers Program

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Zlatan Aksamija	Electronic and Thermoelectric Transport in 2-Dimensional Materials and Heterostructures	T3-W2	10/17 13:30
Antonio Di Bartolomeo	Persistent Photoconductivity, Hysteresis and Field Emission in MoS2 Back-Gate Field-Effect Transistors	T2-W1	10/17 10:30
Matthias Batzill	Interfaces and Defects in 2D Materials	T4-W1	10/17 10:30
Can Bayram	Atomic Engineering of Gallium Nitride Semiconductors for Ultraviolet-to-Terahertz Photonics	T1-W3	10/17 15:30
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Sorin Cotofana	On Energy Effective Graphene Based Boolean Gates	T2-W3	10/17 15:30
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Bonnie Gray	Polymer Nanocomposites for Flexible and Wearable Fluidic and Biomedical Microdevices	T3-M2	10/15 13:30
Mona Jarrahi	Plasmonic Enhanced Terahertz Devices	T1-W3	10/17 15:30
Kaili Jiang	Growth and Characterization of Semiconducting Carbon Nanotubes for Nanoelectronics	T2-W3	10/17 15:30
Xiaoning Jiang	Nano-acoustics: Materials Devices and Applications	T2-T2	10/16 13:30
Jun Jiao	A Strategic Approach for Low Temperature Graphene Growth Towards Direct Device Integration	T2-T1	10/16 10:30

NMDC 2018 **Invited Speakers Program**

Speaker	Topic	Session ID	Session Time
Richard Jones	Between Promise Fear and Disillusion Two Decades of Public Engagement Around Nanotechnology	P1-M4	10/15 19:30
Milo Koretsky	Reshaping a Nanotechnology Undergraduate Program	T4-M1	10/15 10:30
Santosh Kurinec	Molecular Monolayer Doping for Forming Ultra Shallow Junctions in Silicon	T1-T2	10/16 13:30
Wen Li	Nanomaterial Based Pressure Sensor for Sphygmographic Pulse Pattern Analysis	T1-T1	10/16 10:30
Lih Lin	Solution-processed Perovskite Optoelectronics	T1-M3	10/15 15:30
Jan Linnros	Silicon Nanotechnology for Biomolecule Sensing	T2-M1	10/15 10:30
Kremena Makasheva	'Protein-adsorption Problem' Revealed by Using Plasma Deposited AgNPs-based Nanocomposites	T3-T1	10/16 10:30
Cyrus Mody	Ethics in Nano Education, but First the Ethics of Nano Education	P1-M4	10/15 19:30
Peter Moeck	Nanotech/Science Education at a Research University	T4-M1	10/15 10:30
Roberto Murphy	Some Considerations Regarding the Modeling and Characterization of Bulk CMOS Devices for High-Frequency Applications	T3-M1	10/15 10:30
Eric Pop	Self-Heating in Devices Based on 2D and Phase-Change Materials	T4-M3	10/15 15:30
Raj Pulugurtha	Nanostructures for Enabling Implantable Bioelectronic Systems	T2-M3	10/15 15:30
Evan Reed	A Guided Safari Through the Properties of over 1000 2D Materials Revealed by Data Mining Techniques	T4-T2	10/16 13:30
Ricardo Reis	Power and Reliability Challenges in IoT Nanoelectronics	T2-T3	10/16 15:30
Bertrand Reulet	Current/voltage Fluctuations in Nanodevices: From Thermal and Shot Noise to Quantum Optics	T4-T1	10/16 10:30
Clara Santato	Biosourced Electroactive Materials Towards Green Electronics	T2-M3	10/15 15:30
Li Shi	Recent Progress in High-Thermal Conductivity Materials Research	T4-M2	10/15 13:30
Georgios Sirakoulis	Future and Emergent Materials and Devices for Resistive Switching	T3-W3	10/17 15:30

Speaker	Topic	Session ID	Session Time
Raj Solanki	2-Dimensional Materials a Journey Across Flatland	T1-M2	10/15 13:30
Mircea Stan	Back to the Future How FinFETs and 3DIC are Making It Difficult for Emerging Nanotechnologies	T3-T2	10/16 13:30
Yonhua Tzeng	Carbon Nanotechnology for Lithium Ion Battery	T1-W2	10/17 13:30
Dragica Vasileska	A Unified Numerical Solver for Modeling Metastability and Reliability of CdTe Solar Cells	T1-M3	10/15 15:30
Christina Villeneuve-Faure	Characterization of the Electrical Behaviour of Thin Dielectric Films at Nanoscale Using Methods Derived from Atomic Force Microscopy: Application to Plasma Deposited AgNPs-based Nanocomposites	T4-W2	10/17 13:30
Zhaohao Wang	Advanced Nanoscale Magnetic Tunnel Junctions for Low Power Computing	T1-M1	10/15 10:30
Zhongrui Wang	Pseudo-memcapacitive Neuro-transistor Based Capacitive Neural Network	T3-T3	10/16 15:30
Benedicte Warot-Fonrose	TEM Investigations for Nanomaterials Properties	T2-W2	10/17 13:30
Sheng Xu	Materials and Devices for Wearable Healthcare from the Skin to Below the Skin	T3-M3	10/15 15:30
Qing Zhang	Conduction Current and Displacement Current Created in One Generator	T1-W1	10/17 10:30

Carbon Nanotubes Directly Integrated in CMOS by Local Synthesis - Towards a Wafer-Level Process

Knut Aasmundtveit

Session: Modeling & Simulation I, T3-M3, 10/15/2018 15:30

Abstract

Integrating nanomaterials in electronic circuitry and in microsystems is highly desired for fully exploiting the functionality of nanomaterials such as Carbon Nanotubes (CNTs), utilizing the signal processing of micro/ nano-electronics such as CMOS. An example device is a CNT-based gas sensor, where the extreme surface-to-volume ratio of CNTs provides ultra-high sensitivity, and direct integration with CMOS enables a device rendering processed, amplified and calibrated signals in a single, low-cost device. The CNTs should be synthesized on-chip directly into electric circuits. One challenge to overcome is the contradiction between temperature requirements for CNT growth (800-1000 oC) and CMOS compatibility (< 300 oC).

We achieve local CNT growth temperatures while keeping the main part of the chip at CMOS compatible temperatures by designing resistive micro-heaters. Synthesized CNTs are directed towards an electrode for desired contact by applying a voltage that gives a guiding electric field. All process parameters are controlled electrically, enabling a wafer-level process compatible with high-volume, low-cost manufacturing.

This paper shows results from CNT integration in test vehicles manufactured in MEMS processes (using silicon microheaters), as well as our status towards realizing CNT integration in a purpose-designed CMOS chip (optionally using the chip's metal or polysilicon layers for microheaters).

Authors: Knut Aasmundtveit, Avisek Roy and Bao Ta (University of South-Eastern Norway, Norway)

Knut Aasmundtveit is professor at Department of Microsystems, University of South-Eastern Norway (USN). Knut Aasmundtveit obtained his Ph.D. in materials physics from the Norwegian University of Science and Technology in 1999. He then worked in Alcatel Space Norway as a RF system design engineer, before joining USN in 2004, becoming full professor in 2013. He has authored or co-authored close to 100 publications. His research interests include integration of nanomaterials and microsystems, as well as system integration/packaging technology.

Electronic and Thermoelectric Transport in 2-Dimensional Materials and Heterostructures

Zlatan Aksamija

Session: Modeling & Simulation V, T3-W2, 10/17/2018 13:30

Abstract

This talk will cover theory and numerical simulation of the electronic conductivity across grain boundaries and heterointerfaces in two-dimensional (2D) materials, including graphene and transition metal dichalcogenides (TMDs), as well as the thermoelectric (TE) power factors in such structures in the presence of boundaries, materials interfaces, and potential barriers. The talk will focus on ways to minimize resistance and maximize the TE Seebeck coefficient as a function of mismatch angle and barrier height at the interface. Throughout the work, the emphasis is on accounting in detail for the relevant interactions, such as electron-phonon and electron-impurity scattering, as well as quantum effects like tunneling through potential barriers. I will devote equal attention to the underlying theory, numerical methodology, and results. The results will show that grain boundaries and interfaces can have a significant impact on transport in polycrystalline 2D materials and in 2D hetero-interfaces, such as those between graphene and MoS2, with a sharp dependence on the crystallographic mismatch angle. Further, the results will show that sharp and narrow potential barriers can be utilized to further increase the TE efficiency. This work will be relevant to researchers interested in applying 2D materials in nanoelectronic devices, sensors, and energy converters.

Author: Zlatan Aksamija (University of Massachusetts Amherst, USA)

Persistent Photoconductivity, Hysteresis and Field Emission in MoS_2 Back-Gate Field-Effect Transistors

Antonio Di Bartolomeo

Session: Properties / Fabrication V, T2-W1, 10/17/2018 10:30

Abstract

I present the current-voltage (I-V) characteristics of bilayer MoS_2 back-gate field-effect transistors at high drain bias. I show that oxidized Ti contacts, due to a long air exposure, form slightly asymmetric back-to-back Schottky barriers, which originate rectifying output characteristics. The device achieves a photoresponsivity greater than 2.5 AW^{-1} under 5 mW/cm^2 white-LED light. I demonstrate that features commonly observed in MoS_2 transistors, such as persistent photoconductivity and hysteresis, are peculiarities of the MoS_2 channel rather than effects of the contacts. I use MoS_2 transistors with ohmic contacts, at low drain bias, to deeply investigate such features. I find that the n-type transistors exhibit threshold voltage depending on the illumination, which is explained by photoconductive and photogating effects. The photoconductivity can persist with a decay time longer than 10^4 s, due to photo-charge trapping at the MoS_2/SiO_2 interface and in MoS_2 defects. The hysteresis is strongly enhanced by increasing the gate voltage, the pressure, the temperature or the light intensity. I conclude that H_2O or O_2 adsorbates and intrinsic defects in MoS_2, such as S vacancies, strongly affect the transistor behavior. Finally, I show that an electric field of ~200 V/µm is able to extract electrons from the flat part of MoS_2 flakes, an effect that could be exploited for field emission applications.

Author: Antonio Di Bartolomeo (University of Salerno, Italy)

Antonio Di Bartolomeo is an Associate Professor of Experimental Condensed Matter Physics at the Salerno University, Italy. He spent several years in Industry, working as System Engineer for Creative Electronic Systems (CH) and as Device Engineer for ST Microelectronics (AZ) and Intel Corporation (IE). He started his scientific career as an experimental particle physicist at the CERN (Geneva, CH) in the CHORUS and ALICE experiments, and was visiting scientist at IHP Microelectronics, Frankfurt Oder, Germany, and at the Georgetown University, Washington, DC. Prof. Di Bartolomeo has co-authored two textbooks on general Physics and about 90 peer-reviewed research articles, and is in the editorial board of several journals such as Nanotechnology, Journal of Physics D and Nano Future by IOP, Nanomaterials by MDPI, and Micro & Nano Letters by IET. His present research interests include: Optical and electrical properties of carbon nanotubes, graphene and 2D materials; graphene/semiconductor heterojunctions and their application as photodetectors, solar cells and chemical sensors; Van der Waals heterojunctions of 2D layered materials; field-effect transistors; non-volatile memories; solid-state radiation detectors; field emission.

Interfaces and Defects in 2D Materials

Matthias Batzill

Session: Special Session VI, T4-W1, 10/17/2018 10:30

Abstract

Electronic devices are made by interfaces and one promise of 2D materials is that interfaces are well defined by a van der Waals gap. However, even in van der Waals heterostructures hybridization between the dissimilar materials exist that cause modification of the electronic structure compared to single materials. We illustrate this by electronic structure characterization of graphene/MoS2 interface by angle resolved photoemission spectroscopy (ARPES) [1]. In the second part of this talk, we investigate the modification of transition metal dichalcogenides (TMDs), particularly MoSe2 and MoTe2, with transition metals [2]. Such modifications can impose new functionalities in these materials. We demonstrate that incorporation of excess Mo in these materials results in the formation of metallic twin grain boundaries. Such metallization of the material is useful for making controlled electric contacts in these semiconductors. Finally, we show that incorporation of transition metals into interstitial sites of MoTe2 can induce ferromagnetic ordering and such form a dilute ferromagnetic 2D material, with potential spintronics applications. [1] H Coy Diaz, J Avila, C Chen, R Addou, MC Asensio, M Batzill Nano Lett. 15, 1135-1140 (2015). [2] PM Coelho, HP Komsa, H Coy Diaz, Y Ma, AV Krasheninnikov, M Batzill ACS Nano 12, 3975-3984 (2018).

Author: Matthias Batzill (University of South Florida, USA)

Dr. Matthias Batzill is a Physics Professor at the University of South Florida in Tampa. His expertise is in atomic-scale surface and interface properties, with current focus on 2D materials grown by molecular beam epitaxy and characterization of van der Waals heterostructures. Among other recognitions he received an NSF-CAREER award and a Hans-Fischer fellowship of the Technical University of Munich, Germany. He has published over 120 articles with an H-index of 40.

Atomic Engineering of Gallium Nitride Semiconductors for Ultraviolet-to-Terahertz Photonics
Can Bayram, ***IEEE Nanotechnology Council 2018 Early Career Awardee***

Session: Materials and Devices IX, T1-W3, 10/17/2018 15:30

Abstract

Gallium Nitride (GaN)-based compound semiconductors, throughout their entire composition (tuned by varying the Aluminum (Al), Gallium (Ga), and Indium (In) elemental content), possess direct bandgap and their bulk-layer-spectrum can be tuned from deep ultraviolet (~200 nm) to near-infrared (~1700 nm). Furthermore, subband-energy engineering of AlGaN/GaN superlattice quantum structures enable the spectral response be pushed up to terahertz (~300 µm). As such, GaN-based photonic technology can be used in everyday to biotech and scientific applications including solid state lighting; detection of bio-agents/drugs/explosives; and optogenetics. However, inherit polarization fields hinder the electron and hole recombination in the "quantum wells" of such photonic devices. This "polarization" effect is so pronounced in LEDs that reduced efficiencies under high injection currents - a phenomenon known as "droop" - is imminent in all devices. Hence, polarization-free approach is essential for droop-free photonics across the Ultraviolet-Visible-Terahertz spectrum. In this talk, we are going to discuss the opportunities in addressing issues in advanced III-nitride photonics through atomic engineering of GaN semiconductors.

Author: Can Bayram (University of Illinois at Urbana-Champaign, USA)

Can Bayram is an Assistant Professor in the Department of Electrical and Computer Engineering of University of Illinois at Urbana-Champaign, IL, USA. His current research interests lie in the intersection of novel III-V materials, hetero-structures, and photonic and electronic quantum devices. Particularly, his research group investigates heat transport across/through semiconductors; efficiency droop mechanisms and remedies in AlInGaN emitters; and ultra-fast THz photonics/electronics. Prof. Bayram's work has been recognized widely. He is the recipient of the 2018 IEEE Nanotechnology Council Early Career Award, a 2018 Dean's Award for Excellence in Research, a 2017 NSF CAREER Award, a 2016 AFOSR Young Investigator Award, the 2014 IEEE Electron Devices Society Early Career Award.

Applications of Nano-electronics in Electrophysiology and Mitochondrial Biology

Peter Burke

Session: Nanotech / Nanostructures I, T3-T1, 10/16/2018 10:30

Abstract

We demonstrate imaging using scanning microwave microscopy (SMM) of vital mitochondria in respiration buffer. The mitochondria are isolated from cultured HeLa cells and tethered to a solid graphene support. The mitochondria are kept vital (alive) using a respiration buffer, which provides nutrients to sustain the Krebs cycle. We verify that the mitochondria are "alive" by measuring the membrane potential using a voltage sensitive fluorescent dye (TMRE). The organelles are measured capacitively at 7 GHz. Several technical advances are demonstrated which enable this work: 1) The SMM operates in an electrophysiologically relevant liquid (hence conducting) environment; 2) The SMM operates in tapping mode, averaging the microwave reflection measurement over many tapping periods; 3) A tuned reflectometer enables increased sensitivity; 4) Variable frequencies up to 18 GHz are used; 5) In contrast with traditional matching/resonant methods that exhibit high quality factor that fail in the presence of liquids, interferometric/tuned reflectometer gives the possibility to adjust the quality factor or sensitivity even in the presence of the liquid.

Author: Peter Burke (University of California at Irvine, USA)

Peter Burke is a pioneer in nanoelectronics and its application to biotechnology. He is the recipient numerous awards including Young Investigator award from the Office of Naval Research, the Young Investigator Program award from the Army Research Office. His lab has made fundamental contributions to nanotube and graphene electronics, nano-electromagnetics, as the application of nanotechnology to electrophysiology and metabolomics. He received the Ph.D. degree in physics from Yale University, New Haven, CT, in 1998. From 1998 to 2001, he was a Sherman Fairchild Postdoctoral Scholar in physics at the California Institute of Technology, Pasadena. He is currently a Professor in the Departments of Electrical Engineering & Computer Science, Chemistry & Materials Science and Engineering, and Biomedical Engineering at the University of California, Irvine.

On Energy Effective Graphene Based Boolean Gates

Sorin Cotofana

Session: Properties / Fabrication VI, T2-W3, 10/17/2018 15:30

Abstract

In this presentation we argue and provide Non-Equilibrium Green's Function Landauer formalism-based simulation evidence that in spite of Graphene's bandgap absence, Graphene Nanoribbons (GNRs) can provide support for energy effective computing. We start by demonstrating that: (i) band gap can be opened by means of GNR topology and (ii) GNR's behaviour can be controlled according to some desired functionality via top/back gate contacts. Afterwards, we introduce a generic GNR based Boolean gate structure, composed of a pull-up GNR performing the gate Boolean function and a pull-down GNR performing the gate inverted Boolean function. Subsequently, by properly adjusting GNRs' dimensions and topology, we design 2-input Graphene based Boolean gates (AND, NAND, and XOR), inverter, and buffer. Our SPICE simulations indicate that the proposed gates exhibit a smaller propagation delay, from 23% for the XOR gate to 6x for the AND gate, and 2 orders of magnitude smaller power consumption, when compared with 7nm CMOS based counterparts, while requiring 1 to 2 orders of magnitude smaller active area footprint. These results clearly indicate that GNR-based gates have great potential as basic building blocks for future beyond CMOS energy effective nanoscale circuits.

Author: Sorin Cotofana (Delft University of Technology, The Netherlands)

Graphene Foam Based Biochemical Sensors and Energy Harvesting Devices

Liang Dong

Session: Properties / Fabrication I, T2-M1, 10/15/2018 10:30

Abstract

As an interconnected three-dimensional network of graphene, graphene foam (GF) has demonstrated the ability to serve as a platform for biochemical sensing, water remediation, and energy storage. Because the networked interior structure of GF provides a favorable environment to attract many functional nanomaterials via electrostatic interactions, several GF-based composites have also been developed as electrochemical electrode materials. The composites of GF and nanomaterials are strong candidates for microfluidics-based electrochemical sensors, owing to their fast transport of charge carriers, large surface area, high electrical conductivity and mechanical strength, and ease of functionalization with receptor biomolecules. This presentation will cover our recent development of GF and GF-based microfluidic soil nitrate sensor, cancer biomarker sensor, and microbial fuel cells, for agricultural, biomedical, and energy harvesting applications.

Author: Liang Dong (Iowa State University, USA)

Technological Aspects of Silver Nanoparticles Sintering for Electronic Packaging

Jan Felba

Session: Properties / Fabrication II, T2-M2, 10/15/2018 13:30

Abstract

Generally, there are three main aims of electronic packaging: mechanical joining of an electronic element to base structure, its electrical connection, and heat transfer from element by the thermal conduction. Mostly, the reflow soldering technology is used as all these targets are met and to a much lesser degree - joining with the use of an conductive adhesive. Both these techniques are strongly limited in case of high temperature and high power electronics. As an alternative, a low temperature joining technique (LTJT) by silver sintering can be used. The joining temperature of LTJT technique and lead-free soldering are similar (usually below 300 °C), however, the maximum operating temperature, electrical and thermal conductivity, density and CTE for TLJT technique in comparison with soldering are multiplied by the factors 4, 5, 4, 1 and 1, respectively. These indexes make LTJT technique attractive and it is increasingly used in electronic packaging. The aim of the paper is to identify all factors influencing the silver nano- and micro-particle sintering results, assess their significance and the choice of their values depending on the parameters required in the electronic packaging. The analysis was made on the basis of the literature and own author's experience.

Author: Jan Felba (Wroclaw University of Science and Technology, Poland)

Jan Felba received his M.Sc. degree in 1970, PhD degree in 1979 and Dr. Sc. degree in 1997. In 2011 The President of Poland awarded him the title of professor of technical sciences. Since 1970 he has been employed at Wroclaw University of Science and Technology — presently in Faculty of Microsystem Electronics and Photonics. In the years of 1999 - 2017 he was the head of the Laboratory of Interconnecting and Packaging Electronic Circuits. His research is generally connected with electronic packaging. He is involved in technological processes oriented into long-term-reliability, polymer and flexible electronics, polymer composites filled with nano-sized particles for electronics, ink-jet printing technology.

2D Semiconductor and Van Der Waals Heterostructure Devices and Systems
Philip Feng

Session: Special Session V, T4-T3, 10/16/2018 15:30

Abstract

Atomically thin semiconducting crystals derived from new classes of layered materials have rapidly emerged to enable two-dimensional (2D) nanostructures with unusual electronic, optical, mechanical, and thermal properties. While graphene has been the forerunner and hallmark of 2D crystals, newly emerged 2D semiconductors offer intriguing, beyond-graphene, attributes. The sizable and tunable bandgaps of compound and single-element 2D semiconductors offer attractive perspectives for strong multiphysics coupling and efficient transduction across various signal domains. In this talk, I will describe my research group's latest efforts on investigating how electromechanically active atomic layer semiconductors and their heterostructures interact with optical and electronic interrogations, and on engineering such structures into new ultralow-power signal processing components and ultrasensitive transducers for physical sensing. The devices are based on single- and few-layer transition metal di-chalcogenides (TMDCs), black phosphorus, and hexagonal boron nitride (h-BN) crystals, and their van der Waals heterostructures. The functional devices we have demonstrated include high-performance transistors, low-noise photodetectors, multimode radio frequency (RF) 2D NEMS resonators with remarkably broad dynamic range (DR~70 to 110dB) and frequency tunability, and sensors that have demonstrated potential for ultrasensitive detection of physical quantities, such as pressure, gamma ray radiation, and others.

Authors: Philip Feng (Case Western Reserve University, USA)

Philip Feng is an associate professor and currently holds the Theodore L. & Dana J. Schroeder Professorship in the Department of Electrical Engineering & Computer Science at Case School of Engineering, Case Western Reserve University (CWRU), Cleveland, OH, USA. His research group is primarily focused on studying emerging solid-state devices and systems, particularly nano/microelectromechanical systems (NEMS/MEMS), atomic layer semiconductors and 2D devices, silicon carbide (SiC) NEMS/MEMS, and their integration with CMOS circuits and optical/photonic technologies. He received the Ph.D. degree in electrical engineering at California Institute of Technology (Caltech), Pasadena, CA, USA, in 2007 for developing ultra-high frequency (UHF) nanoelectromechanical systems (NEMS) with low-noise technologies for real-time single-molecule sensing. Dr. Feng was one of the 81 young engineers selected to participate in the National Academy of Engineering (NAE) 2013 U.S. Frontier of Engineering (USFOE) Symposium. Subsequently, he received the NAE Grainger Foundation Frontiers of Engineering (FOE) Award in 2014. He is a recipient of the National Science Foundation CAREER Award (2015), the Case School of Engineering Research Award (2015), and the Case School of Engineering Graduate Teaching Award (2014). He and his students won the Best Paper Award at the IEEE NEMS 2013, a Best Paper Award at the IEEE International Frequency Control Symposium (IFCS 2014), and two Best

Presentation/Paper Awards at the American Vacuum Society (AVS) International Symposium (2014, 2016). His other research awards include a T. Keith Glennan Fellowship, a Mihajlo Mesarovic Award, and an Innovative Incentive Award. He was nominated for the university-wide John S. Diekhoff Award (2016) for distinguished graduate student mentoring, and for the Bruce Jackson Award (2016) for excellent undergraduate mentoring. He has been serving on the Technical Program Committees (TPCs) for IEEE International Electron Devices Meeting (IEDM), IEEE International Conference on Micro Electro Mechanical Systems (MEMS), International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers), IEEE International Frequency Control Symposium (IFCS) & European Frequency and Time Forum (EFTF), IEEE SENSORS, IEEE NANO, and other international conferences and workshops. He served as a Track Chair for IEEE SENSORS 2016-2017, and has been serving as the TPC Group 4 Chair for IEEE IFCS 2018 and IFCS-EFTF 2019. He also served as the Technical Program Chair for the MEMS/NEMS Technical Group at the 61st to 63rd AVS International Symposium &Exhibition.

Nonequilibrium Electron and Phonon Dynamics in Advanced Photovoltaic Devices
Stephen Goodnick

Session: Modeling & Simulation IV, T3-W1, 10/17/2018 10:30

Abstract

The realization of advanced concept solar cells that circumvent the limitations of conventional devices depends strongly on the competition between energy relaxation processes and high energy processes that do useful work. Nanostructured systems offer advantages in terms of reduced channels for energy relaxation in reduced dimensional systems. Here we use ensemble Monte Carlo simulation of electrons and holes to investigate the role of ultrafast carrier processes in the realization of two advanced concept devices, hot carrier capture and multi-exciton generation. The particle based simulation approach includes the electron-phonon scattering in quantum wells and quantum wires, intercarrier scattering including impact ionization, and nonequilibrium phonon effects. For quantum well devices in particular, we show how nonequilibrium phonon effects can contribute to the slower energy relaxation rates observed in quantum well structures. For nanowire systems, we show that energy relaxation slowed due to bandstructure effects and reduced dimensionality, and that impact ionization is enhanced above the threshold, leading to strong carrier multiplication, which is beneficial for multi-exciton generation solar cells.

Author: Stephen Goodnick (Arizona State University, USA)

Stephen Goodnick is the David and Darlin Ferry Chair of Electrical Computer and Energy Engineering at Arizona State University, where presently serves as Deputy Director of ASU Lightworks and the Quantum Energy and Sustainable Solar Technology (QESST) Engineering Research Center. He served as President (2012-2013) of the IEEE Nanotechnology Council. His main research areas include Monte Carlo simulation of ultrafast carrier relaxation in quantum confined systems, global modeling of high frequency and energy conversion devices, full-band simulation of semiconductor devices, transport in nanostructures, and fabrication and characterization of nanoscale semiconductor devices. He is a Fellow of IEEE (2004) for contributions to carrier transport fundamentals and semiconductor devices.

Subnanometer Plasmonics: Quantum Regime Functional Metasurfaces and the Plasmonic Coulomb Blockade

Reuven Gordon

Session: Materials and Devices VI, T1-T3, 10/16/2018 15:30

Abstract

Metal nanostructures provide enhanced light-matter interaction by confining light to extreme subwavelength volumes. Plasmonic confinement to nanometer gaps has long enabled many applications, like single molecule surface enhanced Raman spectroscopy. Here we probe the transition to tunneling in subnanometer gaps. These gaps are exponentially sensitive to displacement, and therefore allow for an artificial phase transitions when integrated in metasurfaces or metamaterials, switching from conducting to insulating and back again. Demonstrations of order-of-magnitude switching of second and third harmonic signals from subnanometer gaps have been demonstrated by my group. We have also shown strong switching of the plasmonic resonance with a voltage by using the Coulomb blockade effect. The possibility for extreme field enhancements in subnanometer gaps close to the onset of tunneling due to the epsilon near zero effect will also be introduced. Future energy-efficient ultra-fast optical switching is envisioned using subnanometer plasmonics.

Author: Reuven Gordon (University of Victoria, Canada)

Reuven Gordon is the Canada Research Chair in Nanoplasmonics and a Professor position in the Department of Electrical and Computer Engineering at the University of Victoria. He was elected Fellow of the Optical Society of America (OSA) in 2016 and Fellow of the Society for Photographic Instrumentation Engineers (SPIE) in 2018. Dr. Gordon has authored and co-authored over 150 journal papers (including 12 invited contributions) and he has co-authored 6 book chapters. He is co-inventor for four patents and three patent applications. Dr. Gordon is a Professional Engineer of BC. Dr. Gordon has been recognized as an "Outstanding Referee" by the American Physical Society.

Polymer Nanocomposites for Flexible and Wearable Fluidic and Biomedical Microdevices

Bonnie Gray

Session: Special Applications II, T3-M2, 10/15/2018 13:30

Abstract

Microfluidics and biomedical microdevices can be made highly portable and wearable, with applications in medical screening and diagnostics including the monitoring of both bio-signals and biomarkers in real time. Fluidic and biomedical microdevices can be fabricated on flexible substrates such as elastomers or textiles to improve their wear-ability, or for high-stroke actuation, deformability of devices, or conformability of devices to curved surfaces. We present the development of conductive and magnetic polymer nanocomposite materials for use in flexible and wearable fluidic and biomedical microdevices. We show how these materials are fabricated and tested, and how they are applied to the development of flexible and wearable biosensors, electronic and fluid routing, and devices for biological cell manipulation.

Author: Bonnie Gray (Simon Fraser University, Canada)

Bonnie Gray is a Full Professor, and the Graduate Chair, of Engineering Science at Simon Fraser University. Dr. Gray is also an Associate Member of Biomedical Physiology and Kinesiology, and 2014 recipient of the SFU Dean of Graduate Studies Award for Excellence in Student Supervision. She has over 130 peer-reviewed journal and conference publications, including 25 invited and keynote papers, and 2 patents. Dr. Gray was Chapter Chair for the Vancouver Electron Devices Society from 2007-2017, and organizer of two EDS Mini Colloquia. She is Chair of the 2019 SPIE Microfluidics, BioMEMS, and Medical Microsystems Conference. Her current research interests include the application of novel materials and fabrication techniques to biomedical and microfluidic devices.

Plasmonic Enhanced Terahertz Devices

Mona Jarrahi

Session: Materials and Devices IX, T1-W3, 10/17/2018 15:30

Abstract

Although unique potentials of terahertz waves for chemical identification, material characterization, biological sensing, and medical imaging have been recognized for quite a while, the relatively poor performance, higher costs, and bulky nature of current terahertz systems continue to impede their deployment in field settings. In this talk, I will describe some of our recent results on developing fundamentally new terahertz electronic/optoelectronic components and imaging/spectrometry architectures to mitigate performance limitations of existing terahertz systems. In specific, I will introduce new designs of high-performance photoconductive terahertz sources that utilize plasmonic antennas to offer terahertz radiation at record-high power levels of several milliwatts - demonstrating more than three orders of magnitude increase compared to the state of the art. I will describe that the unique capabilities of these plasmonic antennas can be further extended to develop terahertz detectors and heterodyne spectrometers with quantum-level detection sensitivities over a broad terahertz bandwidth at room temperatures, which has not been possible through existing technologies.

Author: Mona Jarrahi (University of California Los Angeles, USA)

Mona Jarrahi is a Professor of Electrical and Computer Engineering at the University of California Los Angeles and the Director of the Terahertz Electronics Laboratory. Her research is focused on ultrafast electronic and optoelectronic devices and integrated systems for terahertz, infrared, and millimeter-wave sensing, imaging, computing, and communication by utilizing novel materials, nanostructures, and quantum well structures as well as innovative plasmonic and optical concepts

Growth and Characterization of Semiconducting Carbon Nanotubes for Nanoelectronics

Kaili Jiang

Session: Properties / Fabrication VI, T2-W3, 10/17/2018 15:30

Abstract

Carbon nanotubes (CNTs) are anticipated to be the successor to silicon in next generation integrated circuits. However, great challenges to the practical application of this concept include the need to grow horizontal semiconducting CNT (s-CNT) arrays with very high purity, and an efficient method to evaluate the purity. Here we show high throughput methods for evaluating the purity of large area carbon nanotube arrays by using SEM, with the imaging contrast coming from conductivity and bandgap. Recently, we found that charge is generated during the CVD growth of CNTs, which inspired us to use electic field to twists the chirality of the CNTs during synthesis. As a result, nearly-defect-free s-CNTs horizontally-aligned on the substrate have been synthesized with less than 0.1% residual metallic CNT (m-CNT), thus offers a potential pathway to practical applications of CNT nanoelectronics.

Author: Kaili Jiang (Tsinghua University, P.R. China)

Nano-acoustics: Materials Devices and Applications

Xiaoning Jiang

Session: Nanotech / Nanostructures II, T2-T2, 10/16/2018 13:30

Abstract

Research involving acoustics-associated nanomaterials, nanostructures, nanofabrication and devices for a broad range of applications has been actively pursued over the past decade or so. In this talk, reviews are firstly given to the areas including: interactions of acoustic waves with nano materials including nanoparticles, nano-bubbles, gas vesicles; nano-materials and nanostructures for acoustics (photoacoustics, laser ultrasound, etc.); acoustic sensors and devices involving nanomaterials, and the associated applications in drug delivery, therapy, imaging, characterization, manufacturing, etc. Laser ultrasound transducers consisting of a layer of carbon nanomaterials and a layer of thermal elastic material are next reported as an example of nano-acoustic devices. Design, fabrication and characterization of laser ultrasound transducers are presented, followed by the demonstration of drug delivery and industrial non-destructive testing using these laser ultrasound transducers.

Author: Xiaoning Jiang (North Carolina State University, USA)

A Strategic Approach for Low Temperature Graphene Growth Towards Direct Device Integration

Jun Jiao

Session: Properties / Fabrication IV, T2-T1, 10/16/2018 10:30

Abstract

Applications requiring growth of continuous graphene films directly on designated substrate surfaces, as opposed to transferred or integrated in aqueous platelet forms, call for suitable graphene fabrication techniques, especially for applications with low temperature requirements. We report here a strategic approach using an inductively coupled plasma chemical vapor deposition (ICPCVD) system where a remote plasma was used to generate energetic hydrocarbon ions. During the graphene growth, manipulation of the inlet from the remote plasma location was performed to screen and direct the desirable hydrocarbon ions to the substrate. Furthermore, a thin layer (30 nm ~ 50 nm in this study) of catalyst was used. This is in contrast to the catalyst thickness of 2500 nm for most conventional high temperature CVD processes, which require graphene growth temperatures in excess of 800°C. This presentation demonstrates a method of using Ni-Au and Ni-Cu thin-film catalysts to control and minimize the carbon adsorbed in the catalyst, utilize plasma enhanced CVD to promote surface growth, and identify avenues for graphene synthesis at temperature ranges from 450°C to 500°C. The results are exciting and promising. It is expected that systematic optimization of the growth parameters may enable the semiconductor industry to directly incorporate graphene on desired substrates as diffusion barriers during device fabrication. The synergistic relationships among, plasma power, hydrocarbon ion screening, multistage ionization events, catalyst alloy content, catalyst thickness, synthesis temperature, and the resultant graphene film characteristics will be discussed.

Authors: Jun Jiao, Otto Zietz and Samuel Olson (Portland State University, USA)

Dr. Jun Jiao holds an M.S. in Physics and a Ph.D. in Materials Science and Engineering from the University of Arizona and is a professor of Mechanical & Materials Engineering and Physics. She is the Director of the Center for Electron Microscopy and Nanofabrication at Portland State University. Current research in the Jiao lab is concentrated on the development of nanofabrication techniques for the property-controlled growth of graphene and its metal and metal oxide hybrids, nanotubes, nanowires, and nanocrystals for use in nanoelectronic devices and in industrial catalysts for ground water treatments. Another important effort is to use nanoscale materials and devices for biomedical applications including cancer therapy, cancer vaccine, and adjuvant for infectious diseases. The results of her research are documented in more than 250 publications and five issued patents.

Between Promise Fear and Disillusion Two Decades of Public Engagement Around Nanotechnology

Richard Jones

Session: Panel Session - Nanotechnology Education Worldwide, P1-M4, 10/15/2018 19:30

Abstract

Nanotechnology emerged as a subject of public interest and concern towards the end of the 1990's. A couple of decades on, it's worth looking back at the way the public discussion of the subject has evolved. On the one hand we had the transformational visions associated with the transhumanist movement, together with some extravagant promises of new industries and medical breakthroughs. The flipside of these were worries about profound societal changes for the worse, and, less dramatically, but the potential for environmental and health impacts from the release of nanoparticles.

Since then we've seen some real achievements in the field, both scientific and technological, but also a growing sense of disillusion with technological progress, associated with slowing economic growth in the developed world. What should we learn from this experience? What's the right balance between emphasising the potential of emerging technologies and cautioning against over-optimistic claims?

Author: Richard Jones (United Kingdom, United Kingdom (Great Britain))

Richard Jones is Professor of Physics at the University of Sheffield. His first degree and PhD in Physics both come from Cambridge University, and following postdoctoral work at Cornell University, U.S.A., he was a lecturer at the University of Cambridge's Cavendish Laboratory. In 1998 he moved to the University of Sheffield. He is an experimental physicist who specializes in elucidating the nanoscale structure and properties of polymers and biological macromolecules at interfaces. He is the author of more than 190 research papers, and three books, including Soft Machines: nanotechnology and life, published by Oxford University Press in 2004. He was the Senior Strategic Advisor for Nanotechnology for the UK's Engineering and Physical Sciences Research Council from 2007 to 2009, and was a member of EPSRC Council between 2013 and 2018. In 2006 he was elected a Fellow of the Royal Society, and in 2009 he won the Tabor Medal of the UK's Institute of Physics for his contributions to nanoscience. His blog – at www.softmachines.org - has, since 2004, discussed topics related to nanotechnology in all its varieties, together with other issues in science and innovation policy. He has recently released the free e-book *Against transhumanism: the delusion of technological transcendence.*

Reshaping a Nanotechnology Undergraduate Program

Milo Koretsky

Session: Nanotech Education, T4-M1, 10/15/2018 10:30

Abstract

In 2010, we instituted a Nanotechnology Processes Option for chemical engineers and other students in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. These classes provided students with appropriate content for careers related to nanotechnology and included many innovative learning opportunities. However, we became concerned that the extent to which teaching innovations were marginalized and isolated deterred from their effectiveness. To address this issue, we are in the process of transforming to a more holistic, inclusive, professionally-based learning environment woven through both curricular requirements and co-curricular opportunities for students. We specifically target social inequality by seeking to create engineering educational systems and interpersonal interactions that are professionally and personally life-affirming for all people across their differences. We seek to catalyze change through construction of a culture of inclusion and a shift in our learning environments from sequestered activities to realistic, consequential work. This requires a fundamental change in the nature of department culture (values, norms and structure). This paper provides an overview of this programmatic change and the lessons learned as we seek transformation.

Author: Milo Koretsky (Oregon State University, USA)

Milo Koretsky is a Professor of Chemical Engineering at Oregon State University. He received his B.S. and M.S. degrees from UC San Diego and his Ph.D. from UC Berkeley, all in Chemical Engineering. He currently has research activity in areas related engineering education and is interested in integrating technology into effective educational practices and in promoting the use of higher-level cognitive skills in engineering problem solving. His research interests particularly focus on what prevents students from being able to integrate and extend the knowledge developed in specific courses in the core curriculum to the more complex, authentic problems and projects they face as professionals. Dr. Koretsky is one of the founding members of the Center for Lifelong STEM Education Research at OSU.

Molecular Monolayer Doping for Forming Ultra Shallow Junctions in Silicon

Santosh Kurinec

Session: Materials and Devices V, T1-T2, 10/16/2018 13:30

Abstract

IC devices are accomplished by selectively changing the conductivity of the semiconductor by precise doping. Through clever innovations in photolithography, doping, depositions & etching the semiconductor IC industry has steadily made circuitry smaller, faster, and more powerful. To reach the next frontier, 5 nm finFETs and below, there is need to devise chemical means to deposit ultrathin layers of dopant molecules in precise 3D locations.

Most current doping techniques rely on planar rigid substrates. Molecular monolayer doping (MLD) is presented as an alternative doping method with the capability to produce ultrashallow junctions with low sheet resistances for planar and non-planar structures. MLD relies on the formation of a self-assembled monolayer of a dopant containing compound which is annealed to diffuse dopants into the substrate, forming an ultra-shallow junction with a high surface concentration. A low-cost reaction chamber for MLD is developed using materials that are commonly found in chemistry stockrooms and local home goods stores. Basic exemplar devices such as MESA etched diodes are fabricated. Patternability of MLD is demonstrated using thin oxide as the mask and successfully fabricating n-MOSFETs. The talk will present the process design of MLD in a university fab with a sight on high volume manufacturing capability of MLD. It is envisioned that MLD will transform selective doping the way Atomic Layer Deposition (ALD) has done for thin dielectric and barrier layers.

Author: Santosh Kurinec (Rochester Institute of Technology, USA)

Santosh K. Kurinec is a Professor of Electrical & Microelectronic Engineering at Rochester Institute of Technology (RIT). She received Ph.D degree in Physics from University of Delhi, India. She was Post doc at University of Florida and faculty at Florida State University before joining RIT. She is a Fellow of IEEE, Member APS, The New York Academy of Sciences. She received the 2012 IEEE Technical Field Award and was inducted in the 2018 Women in Technology Hall of Fame. Her current research activities include nonvolatile memory, photovoltaics, advanced integrated circuit materials and processes.

Nanomaterial Based Pressure Sensor for Sphygmographic Pulse Pattern Analysis

Wen Li

Session: Materials and Devices IV, T1-T1, 10/16/2018 10:30

Abstract

Without X-ray computed tomography or stethoscope, Traditional Chinese Medicine (TCM) relies on inspection, auscultation/olfaction, inquiring, and palpation for medical diagnosis. We will present an intelligent "palpation robotic hand" (PRH) that uses 3 fingers, which are integrated with silicon and graphene-based pressure sensor arrays, to acquire temporal and 3D spatial pulse information from human wrists, and uses AI-based algorithms to classify arterial pulse patterns of patients. The technical specification of the PRH is to digitize and recognize at least 28 fundamental types of sphygmographic pulse patterns described by TCM doctors in the past few hundred years, and correlate these patterns to disease diagnosis.

Author: Wen J Li (City University of Hong Kong)

Wen J. Li is Chair Professor of Biomedical Engineering at the City University of Hong Kong (CityU). He was with The Chinese University of Hong Kong (1997-2011), NASA/CalTech Jet Propulsion Laboratory (1995-1997), and The Aerospace Corporation (1987-1994) before joining CityU. His academic honors include IEEE Fellow, ASME Fellow, and 100 Talents of the Chinese Academy of Sciences (中科院百人計劃). He served as the President of the IEEE Nanotechnology Council (2016 and 2017) and is currently VP of Academic Affairs (honorary) of the Shenzhen Academy of Robotics. He has co-founded Sengital Ltd. (Hong Kong) and Bewis Sensing LLC. (China), which are commercializing MEMS-based sensing systems worldwide. Prof. Li was educated at the University of Southern California (BSAE ‘87; MSAE ‘89) and the University of California, Los Angeles (PhD ‘97, Aerospace Engineering). His current research interest includes intelligent cyber physical sensors and AI for biomedical applications.

Solution-processed Perovskite Optoelectronics

Lih Y. Lin

Session: Materials and Devices III, T1-M3, 10/15/2018 15:30

Abstract

Solution-processed nanomaterials offer a promising route to overcome the grand challenge of integrated light sources on Si and flexible substrates due to their wide fabrication compatibility, but they have not achieved satisfactory performance in both efficiency and stability. In recent years, metal halide perovskites have emerged as a highly promising newcomer among photonic materials. They exhibit high charge mobility, sharp optical absorption edges and high absorption coefficients comparable to GaAs, as well as an unusual defect tolerance. The materials were first applied to photovoltaics and resulted in record certified research solar cell power conversion efficiencies > 22% in less than four years. The outstanding performance suggests their promise for light-emitting and other photodetection applications, and many research efforts have been made in this field. In this talk, we present and discuss our work on perovskite quantum dot (QD) vertical cavity lasers with low threshold (0.39 uJ/cm2), LEDs with high stability, broad-band hybrid phototransistor with high sensitivity, and solar cells with enhanced charge mobility through QD surface modification.

Authors: Lih Lin and Chen Zou (University of Washington, USA)

Silicon Nanotechnology for Biomolecule Sensing
Jan Linnros

Session: Properties / Fabrication I, T2-M1, 10/15/2018 10:30

Abstract

Silicon microfabrication technologies, which has enabled the integration of billions of transistors on a single chip for use in computers or in mobile phones, are now reaching dimensions of only a few nanometers - almost the size of biomolecules. Nano-scaled devices therefore enable sensing of proteins or DNA at very low concentration in a liquid solution, sometimes down to the single molecule level. At the same time, integration of hundreds of such sensors on a single chip properly functionalized with different antibodies would allow a full palette of different proteins or DNA strands to be sensed targeting a particular medical situation or diagnosis. In this talk I will review three different chip-based sensors which we have explored in various collaborative projects: (i) Nanowire (or nanoribbon) sensors. This is an electrical sensor working essentially as a MOS transistor with an open gate, onto which antibodies have been immobilized, sensing the charge of hybridizing proteins or DNA. (ii) Electro-kinetic capillary sensor. This uses a capillary with functionalized inner surface. By flowing the electrolyte solution through the capillary, an electrokinetic potential is generated which changes upon binding of target molecules. (iii) Finally, a membrane with nanopores has been used for translocating DNA strands labelled with fluorophores. This is an optical technique that allows single molecule detection where the throughput can be relatively large due to parallel DNA translocation in a large array of nanopores. Results and applications of these techniques will be reviewed.

Authors: Jan Linnros (Royal Instutute of Technology - KTH, Sweden); Apurba Dev, Ilya Sychugov, Miao Zhang, Amelie Eriksson Karlström and Sara Cavallaro (Royal Institute of Technology - KTH, Sweden)

Jan Linnros received his Ph.D. in Physics from Chalmers University of Technology (Göteborg, Sweden) in 1986. After a post-doc at Bell Labs, Murray Hill, he joined the Swedish Institute of Microelectronics in Stockholm. In 1993 he accepted a research position at Royal Institute of Technology and was appointed full professor in 2001 where he is now heading the Photonics research unit. He is an active teacher in Nanoelectronics/Nanotechnology and has supervised some 15 PhD students. He has published ~250 scientific papers and has given ~50 invited talks (also plenary at NMDC 2016). He is also a cofounder of a company ‘Scint-X’ developing an imaging X-ray detector and of the company ‘Spin-Y’ developing an electron-spin filter.
Current research interests include: Silicon nanostructures such as Si quantum dots, nanowires for biomolecule sensing, nanopores for studies of single-molecule translocation etc. A main scientific break-through has been PL spectroscopy of individual silicon quantum dots.

'Protein-adsorption Problem' Revealed by Using Plasma Deposited AgNPs-based Nanocomposites

Kremena Makasheva

Session: Properties / Fabrication I, T2-M1, 10/15/2018 10:30

Abstract

Describing the 'protein-adsorption problem' remains an active field of research due to its importance for various biomedical applications. Protein adsorption on solid surfaces represents the conditioning step of micro-organism adhesion and future biofilm formation. Alternatively, nanomaterials and specifically nanocomposite thin layers became indispensable building blocks in bioanalytical devices, since they clearly enhance their performances in terms of sensitivity and detection limits. In order to properly design their structural, optical and electrical properties, rational engineering of their architectures is mandatory. It traces the transition from material level of development to system level of applications. In this work we exploit the multifunctionality of silver nanoparticles (AgNPs) as plasmonic antenna when embedded in thin SiO2 layers and as biocide agents because of their strong toxicity towards micro-organisms to reveal the 'protein-adsorption problem'. It focuses on conformational changes of proteins after adsorption and emphasizes the importance to evaluate the protein adhesion to bioactivated surfaces. The substantial role played by the competitive adsorption of different proteins has been considered by weighting the contribution of each constituent. This opens new perspectives for building up a more realistic scenario towards protein behaviour in intermixed proteins/proteins systems, micro-organisms and more complex organizations, such as proteins/micro-organisms hybrid systems.

Authors: Kremena Makasheva (LAPLACE, CNRS, University of Toulouse, France); Marvine Soumbo, Adriana Scarangella, Christina Villeneuve-Faure, Laurine Martocq (LAPLACE, Université de Toulouse, France); Gaetan Laroche (Université Laval, Canada); Adnen Mlayah (CEMES-CNRS, University of Toulouse, France); Caroline Bonafos (CEMES-CNRS, France); Marie-Carmen Monje and Christine Roques (LGC, University of Toulouse, France)

Kremena Makasheva works on plasma deposition of nanostructured thin layers for biomedical, optical and electrical engineering applications in LAPLACE laboratory, Toulouse, France. She entered the CNRS in 2010, Materials and Plasma Processing group in LAPLACE. She obtained PhD degree in 2002 for her work on electrical gas discharges sustained by surface waves at Sofia University, Bulgaria. In 2003 she joint the Groupe de physique des plasmas at Université de Montréal to work on atmospheric pressure surface wave discharges, especially on contraction phenomenon. In 2007 she moved to Toulouse, France, LAPLACE laboratory, to work on modeling microdischarges and microwave plasmas. In 2009 she started working on plasma deposition. Her research in LAPLACE is now directed to the study of reactive plasmas and to the design, characterization and application of plasma deposited nanocomposites materials. In 2016 she served as General Chair of the 11th IEEE NMDC of the IEEE Nanotechnology Council.

Ethics in Nano Education, but First the Ethics of Nano Education

Cyrus Mody

Session: Panel Session - Nanotechnology Education Worldwide, P1-M4, 10/15/2018 19:30

Abstract

Discussions of the ethics or social implications of nanotechnology almost always focus on products (and occasionally manufacturing or experimental processes) which are nano-enabled and/or contain nanomaterials. These discussions are important, but they miss that (literally) the most visible part of nanotechnology involves the reorganization of education at all levels but especially in universities and community colleges. In general, institutions which have "nano" in their names have spent the 21st century advocating for more interdisciplinary, market-oriented, hands-on forms of education. Both the benefits and the costs of these educational innovations should be at the center of discussions of the societal implications of nanotechnology. Education is the means by which societies reproduce; thus education is always sensitive and frequently contested. In this paper I survey the long history of activism and political debate which informs the educational innovations associated with nanotechnology, including the innovation of bringing ethics training into nano education. I argue that ethics does belong in nano education, but to understand why we first need to analyze the ethics of nano education.

Author: Cyrus Mody (Maastricht University, The Netherlands)

Cyrus Mody is Professor and Chair in the History of Science, Technology, and Innovation. He has written two books on the history of nanotechnology: Instrumental Community: Probe Microscopy and the Path to Nanotechnology (MIT, 2011) and The Long Arm of Moore's Law: Microelectronics and American Science (2017). Both books deal in part with nano-education; Mody also has practical experience in the area, having co-taught Nanotechnology: Content and Context three times at Rice University. He is currently editor-in-chief of Engineering Studies, a journal dedicated to critical approaches to engineers and engineering, including nanotechnology and/or engineering education

Nanotech/Science Education at a Research University

Peter Moeck

Session: Nanotech Education, T4-M1, 10/15/2018 10:30 AM

Abstract

Besides mentioning typical class room activities such as the didactic use of 3D printed models and discussing the course contents in general terms, this author summarizes the experiences and insights he gained from teaching courses on "nanotech" for over a decade at both the undergraduate and the graduate student levels at a research university. A distinction is made between advanced courses that can be classified as some kind of workforce training and 300 level undergraduate courses that are mainly concerned with the development of critical thinking skills.

Author: Peter Moeck (Portland State University, Portland/Oregon, USA)

Some Considerations Regarding the Modeling and Characterization of Bulk CMOS Devices for High-Frequency Applications

Roberto Murphy

Session: Special Applications I, T3-M1, 10/15/2018 10:30

Abstract

The evolution of integrated-circuit fabrication processes have translated into higher operating frequencies for bulk CMOS devices, making more complex circuits possible. The designer, however, needs precise and accurate models to simulate circuits with confidence before they go to the fab. In this talk, some relevant aspects of the characterization and modeling of CMOS devices are addressed. These include showing how most of the parameters commonly determined from DC curves can be readily obtained from RF measurements, thus making DC curve fitting unnecessary. Then, complete characterization and modeling routines are presented, which cover substrate and geometry effects, as well as the frequency dependence of several model parameters. Some thoughts regarding simulation tools close the presentation.

Authors: Roberto S Murphy and Reydezel Torres-Torres (INAOE, Mexico)

Roberto S. Murphy-Arteaga (M΄92, SM΄02) received his B.Sc. degree in Physics from St. John's University, Minnesota, and the Ph.D. from the National Institute for Research on Astrophysics, Optics and Electronics (INAOE), in México. He has published more than 140 articles and is the author of a text book on Electromagnetic Theory. Dr. Murphy's research interests are the physics, modeling and characterization of the MOS Transistor for high frequency applications. He is a Senior Member of IEEE; a Distinguished Lecturer of the Electron Devices Society; belongs to the Mexican Academy of Sciences; and to the Mexican National System of Researchers (SNI).

Self-Heating in Devices Based on 2D and Phase-Change Materials

Eric Pop

Session: Special Session II, T4-M3, 10/15/2018 15:30

Abstract

This talk will describe measurements and simulations of self-heating in transistors based on atomically thin "2D" devices, which represent an extreme case of SOI-like thermal confinement. The talk will also discuss the energy-efficiency limits of phase-change memory, another device type where self-heating plays a crucial role in its operation. These results help us understand the limits of operation, as well as how to engineer more energy-efficient nanoscale electronics.

Author: Eric Pop (Stanford University, USA)

Nanostructures for Enabling Implantable Bioelectronic Systems

Raj Pulugurtha

Session: Properties / Fabrication III, T2-M3, 10/15/2018 15:30

Abstract

Nanomaterials and nanostructures will play a critical role in addressing the challenges associated with the realization of implantable neuroelectronic systems that interface with the nervous system. Current packaging approaches deal with large enclosures with leads and connectors that are not scalable to address the need for scalable, compliant and high-channel density nerve interfaces in ultra-thin or flexible form-factors. This paper will describe high-density and scalable feedthrough approaches that can achieve up to 400 channels/mm2 with recent advances in 3D packaging technologies with flexible glass substrates that are laminated or coated with ultra-thin biocompatible polymer films such as LCP or parylene. The adhesion of metal traces to such nonpolar or hydrophobic polymers has been a major challenge. New innovations in engineered metal-polymer interfaces to create nanostructured inorganic-organic hybrid interlayers are shown to improve the metal-polymer adhesion. Power harvesting and storage with embedded power components as flex high-density nanostructured capacitor and battery layers is another key building block to realize such systems. Nanolayered film coatings are being explored to achieve hermetic but conformal barriers that can eliminate the diffusion of moisture or ions into the electronics. Low-temperature sealing with laser-assisted fusion of nanometallic structures can further address the challenges with hermeticity. This paper will review these recent advances in nanostructures for realizing implantable bioelectronics systems.

Authors: Raj Pulugurtha (Florida International University, USA); Robert Spurney, Shreya Dwarakanath, Rao Tummala, and Kathaperumal Mohanalingam (Georgia Institute of Technology, USA)

Dr. P. M. Raj's expertise is in packaging of electronic and bioelectronic systems, power-supply and wireless component integration in flex and rigid packages, and biocompatible and hermetic packaging with high-density feedthroughs. He is an is an Associate Professor with BME and ECE at FIU and Adjunct Professor with the Georgia Institute of Technology, ECE Department and Packaging Research Center. He co-lead several technical thrusts in electronic packaging, working with the whole electronic ecosystem. His research led to 310 publications. His papers received more than 25 best-paper awards. He is the Associate Editor for IEEE CPMT transactions and IEEE Nanotechnology magazine, and the Co-Chair for the IEEE nanopackaging technical committee. He received BS (1993, Indian Institute of Technology, Kanpur), ME (1995, Indian Institute of Science, Bangalore) and PhD (1999, Rutgers University, New Jersey)

A Guided Safari Through the Properties of over 1000 2D Materials Revealed by Data Mining Techniques

Evan Reed

Session: Special Session IV, T4-T2, 10/16/2018 13:30

Abstract

Two-dimensional materials and weakly bonded layered materials exhibit potentially advantageous properties as thin electronic materials, but research has been largely focused on only a couple of dozen types. We have utilized data mining approaches to elucidate over 1000 2D materials and several hundred 3D materials consisting of van der Waals bonded 1D subcomponents, or molecular wires. I will provide a guided tour of the spectrum of properties of these materials that are of interest for electronic applications. We find that hundreds of these 2D materials have the potential to exhibit observable piezoelectric effects, representing a new class of piezoelectrics. Another subset of these materials has the potential to exhibit structural changes under a variety of external stimuli including electrostatic gating. I will discuss calculations of phase diagrams, some experimental results, and potential phase change applications for these materials.

Authors: Evan Reed, Gowoon Cheon and Daniel Rehn (Stanford University, USA)

Power and Reliability Challenges in IoT Nanoelectronics
Ricardo Reis Session: Nanotech / Nanostructures III, T2-T3, 10/16/2018 15:30

Abstract

The increasing number of devices connected to the internet is providing the concept of Internet of Things, that together with Internet of Health, Internet of People and Internet of Something is constructing the Internet of Everything (IoE). There is also an overlapping between IoT and CPS (Cyber Physical Systems) that have as components not only electronic ones, but also mechanical components, optical components, organic components, chemical components, etc. A keyword in IoT is optimization, mainly power optimization. Power optimization must be done in all levels of design abstraction, and at physical level it is related to the number of transistors. Also, many systems are critical ones, like in Internet of Heath, where reliability is a major issue. Most of the circuits designed nowadays use much more transistors than it is needed. The increasing leakage power and routing issues are an important reason to optimize the number of transistors, as leakage power is related to the number of transistors. Also, the replacement of a set of basic gates by a complex gate reduces the number of connections to be implemented using metal layers as well the number of contact/vias. The reduction of the number of connections to be implemented using metal layers helps to improve routing and also helps to improve reliability. To cope with this goal, it is needed to provide tools to automatically generate the layout of any transistor network.

Author: Ricardo A L Reis (Universidade Federal do Rio Grande do Sul, Brazil)

Current/voltage Fluctuations in Nanodevices: From Thermal and Shot Noise to Quantum Optics

Bertrand Reulet

Session: Special Session III, T4-T1, 10/16/2018 10:30

Abstract

Current and voltage fluctuations or "noise" are ubiquitous in nanodevices. Among fundamental sources of such noise are thermal noise, due to the random thermal fluctuations of charge carriers, and shot noise, due to the discreteness of their charge. When a small device is cooled down to extremely low temperature, charge transport is described by quantum mechanics, which has direct visible consequences on noise. We will describe experiments that show how quantum mechanics directly influences current fluctuations, namely as time correlations between successive attempts for the electrons to cross a sample. We will show that at very low temperature and voltage bias, current fluctuations in the microwave domain are dominated by the so-called vacuum fluctuations or zero point motion of the carriers, and that shot noise can be managed to go below vacuum fluctuations, a phenomenon similar to "vacuum squeezing" usually discussed in quantum optics.

Author: Bertrand Reulet (Université de Sherbrooke, Canada)

Biosourced Electroactive Materials Towards Green Electronics

Clara Santato

Session: Properties / Fabrication III, T2-M3, 10/15/2018 15:30

Abstract

Melanin (from the Greek μέλας, mélas, black) is a biopigment ubiquitous in flora and fauna, featuring broadband optical absorption, hydration-dependent electrical response, ion-binding affinity as well as antioxidative and radical-scavenging properties. In the human body, photoprotection in the skin and ion flux regulation in the brain are some biofunctional roles played by melanin. We will discuss the progress in melanin research that underpins emerging technologies in energy storage/conversion and bioelectronics. The melanin research aims at developing approaches to explore natural materials, well beyond melanin, which might serve as a prototype benign material for sustainable green technologies.

Authors: Clara Santato, Eduardo Di Mauro, Ri Xu, Abdelaziz Gouda and Manuel Reali
(Polytechnique Montreal, Canada)

Clara Santato is Full Professor in the Department of Engineering Physics at Polytechnique Montréal. She earned her PhD degree in chemistry ("Preparation and Characterization of Nanostructured WO3 Films as Photoanodes in Photoelectrochemical Devices") in 2001 from the Université de Genève and her MSc degree ("Electropolymerization and Photopolymerization of a Pyrrole-Substituted Ruthenium tris (bipyridyl) Complex") in chemistry in 1995 from Università degli Studi di Bologna. The experimental work was carried out in collaboration with Université J. Fourier. She was a (permanent) research scientist at the Institute for Nanostructured Materials, part of the Italian National Research Council, from 2001 to 2011, and a visiting scientist (2007–2010) at Cornell University, Department of Materials Science and Engineering (Malliaras Laboratory for Organic Electronics). In 2006, she was a visiting scientist with a cross-appointment between the Institut National de la Recherche Scientifique and McGill University (Chemistry), and in 2005, at Purdue University (Chemistry).

Santato's research focuses on semiconducting films and their interfaces with metal electrodes and electrolytes, for applications in transistors and energy conversion/storage, and has been recently recognized by her elevation to the Institute of Electrical and Electronics Engineers (IEEE) senior membership. With her group, she recently expanded her research interests to green electronic and energy-storage devices.

Santato is a member of the UNESCO MATECSS (Materials and Technologies for Energy Conversion, Saving and Storage) Chair. She serves as an associate editor of the Journal of Power Sources (Elsevier).

Recent Progress in High-Thermal Conductivity Materials Research

Li Shi

Session: Special Session I, T4-M2, 10/15/2018 13:30

Abstract

Pursuit of the extreme limit in materials properties including ultrahigh thermal conductivity remains at the frontier of science and technology. Materials with high thermal conductivity can help to enable effective thermal management methods for nanoelectronics. Recent first principles theoretical calculations have suggested exceptional thermal conductivity and different size dependences due to unique phonon band structures in both smooth and puckered two-dimensional layers and cubic boron arsenide that contains both light and heavy elements. Many of these theoretical predictions are investigated or validated in this work with the use of high-fidelity four-probe thermal transport measurements and Raman thermometry measurements

Author: Li Shi (University of Texas at Austin, USA)

Future and Emergent Materials and Devices for Resistive Switching

Georgios Sirakoulis

Session: Emerging II, T3-W3, 10/17/2018 15:30

Abstract

RRAMs are considered as the most promising devices for NVM and storage class memory applications at technology nodes below 20nm. In addition, due to their memristive properties pave the way for the realization of neuromorphic prototype circuits. In this article we will present the evolution of the resistive switching devices from the materials point of view. More specifically we will report on the switching mechanisms responsible for the change of resistance in two-terminal devices such as Metal-Insulator-Metal (MIM) or Metal-Insulator-Semiconductor (MIS). The majority of these devices are two-terminal MIM structures and use as insulator (active material) metal oxides are used. The present models considering the oxide and metal physical and chemical properties seem that can explain the observed resistive phenomena. The resistance switching phenomena are strongly related to the physical and the electro-chemical reactions governing the metal-insulator interfaces as well the bulk properties of the insulators. In this context, we will categorize the various insulators, mainly metal oxides, with respect to the switching phenomena they exhibit in combination with the metal (or semiconductor) electrodes used. A comprehensive review of the literature will be delivered, while the milestones in the evolution of materials and devices will be thoroughly discussed. In the same context, the taxonomy of the corresponding models will be presented and analysed in accordance to the devices' operation parameters and the attributing switching or memristive behavior of these devices. As an example, we can refer to the effect of humidity, which seems to play a crucial role in the reliability of RRAMs. Thus, the application of a hydrophobic material with poor diffusivity of metal ions will be preferable. In this direction we are investigating the resistance switching and memristive properties of silicon nitride; a well-known material in NVM technology and microelectronics. The fabrication and characterization of RRAM MIS single cells have been successfully demonstrated. The top-electrode is Cu while the bottom-electrode is heavily doped Si. The SET/RESET voltages as well as the operation current can be tuned by modification of the nitride's stoichiometry, affecting the formation of traps (Nitrogen Vacancies) in the bulk material. Also, we demonstrated that the formation of a thin oxynitride layer at the interface with the top-electrode enhance significantly the RRAM operational characteristics. The corresponding specific devices models will be discussed and presented thoroughly in terms of the attributing mechanisms, considered parameters, resulting complexity and efficiency to depict qualitatively and quantitatively the devices operation. Following, we will present overall the state-of-the-art in terms of materials and device performance and the corresponding models. Finally, the various integration approaches and the main issues in this area will be discussed.

Authors: Panagiotis Karakolis, Pascal Normand and Panagiotis Dimitrakis (NCSR Demokritos, Greece); Vasileios Ntinas, Iosif-Angelos Fyrigos, Ioannis Karafyllidis and Georgios Sirakoulis (Democritus University of Thrace, Greece)

2-Dimensional Materials a Journey Across Flatland
Raj Solanki
Session: Materials and Devices II, T1-M2, 10/15/2018 13:30

Abstract

The unique properties of graphene have drawn attention to other 2-dimensional (2D) materials, in particular metal chalcogenides, which can behave as metals, insulators, or semiconductors. Within each layer, the metal and chalcogenide atoms are held by covalent-ionic mixed bonds and the individual layers are held together by van der Waals bonds. Semiconductors composed of this structure are of particular interest for the fabrication of the future generation of field effect transistors (FETs) and optoelectronic devices since the film thickness of these materials can be a single or a few layers thick. Moreover, absence of dangling bonds allows for better electrostatic control of carrier transport; hence, they are ideal for downscaling of FETs. The ability to tune the direct band gap of many of these materials, by controlling their thickness, allows further flexibility for the design and fabrication of optoelectronic devices. To date, most of the research on these materials has been reported employing exfoliated films. We have been investigating growth of 2D films of these materials via atomic layer deposition (ALD) over large areas for practical applications. Our results to date and characteristics of the films grown via ALD will be presented and discussed.

Author: Raj Solanki (Portland State University, USA)

Raj Solanki is Professor in the Department of Physics and has a joint appointment in the Department of Electrical and Computer Engineering at Portland State University. His group was one the first to demonstrate use of lasers for thin film deposition and etch. Since then, his research has covered several aspects of optics and electronic materials and devices, including SOI technology, flat panel displays and bio-sensors. Current research in his lab includes 2D metal chalcogenides and multivalent battery technology.

Back to the Future How FinFETs and 3DIC are Making It Difficult for Emerging Nanotechnologies

Mircea Stan

Session: Modeling & Simulation II, T3-T2, 10/16/2018 13:30

Abstract

Reports of "Moore's Law" demise have been greatly exaggerated. Based on predictions made more than a decade ago, emerging technologies (molecular electronics, carbon nanotubes, graphene, spintronics, etc.) were supposed by now to have supplanted (at least in part) good old silicon CMOS. This talk will go over some of the reasons that hasn't happened yet - the semiconductor industry moving in the 3rd dimension both at the device level (FinFETs) and at the system level (3DIC).

Author: Mircea Stan (University of Virginia, USA)

Mircea R. Stan is a professor in the ECE Department at UVa, teaching and doing research in the areas of high-performance low-power VLSI, temperature-aware circuits and architecture, embedded systems, spintronics, and nanoelectronics. He leads the High-Performance Low-Power (HPLP) lab, is an associate director of the Center for Automata Processing (CAP) and an assistant director of the Center for Research in Intelligent Storage and Processing-in-Memory (CRISP). He received the 2018 Influential ISCA Paper Award, the NSF CAREER award and was a co-author on best paper awards at SELSE17, ISQED08, GLSVLSI06, ISCA03 and SHAMAN02 and IEEE Micro Top Picks in 2008 and 2003.

Carbon Nanotechnology for Lithium Ion Battery

Yonhua Tzeng

Session: Materials and Devices VIII, T1-W2, 10/17/2018 13:30

Abstract

Long-cycling-life lithium ion battery with a much higher charge storage capacity per unit weight and volume than state-of-the-art commercial products are needed for electric vehicles and many future high demanding applications. Silicon of the same weight is capable of storing electrical charges up to 10 times of that of commonly used graphite. But, the repetitive volume expansion and shrinkage of silicon may cause silicon to pulverize. Therefore, finding means of retaining the physical and functional integrity of silicon based anodes is important. Carbon nanotechnology is applied to help solve this problem. Nanoscale carbons such as graphene, carbon nanotube, nanodiamond, etc. were studied and shown to be promising. This talk will review various approaches having been reported for achieving good performance of silicon anodes and report carbon nanotechnology we developed for future lithium ion battery.

Author: Yonhua Tzeng (National Cheng Kung University, Taiwan)

A Unified Numerical Solver for Modeling Metastability and Reliability of CdTe Solar Cells

Dragica Vasileska

Session: Materials and Devices III, T1-M3, 10/15/2018 15:30

Abstract

The record efficiencies of thin-film CdTe technology are still ten absolute percent lower than the Shockley-Queisser limit. As short-circuit current density (JSC) is approaching the theoretical limit, both open-circuit voltage (VOC) and fill factor (FF) are far below the theoretical limits for most devices. Since VOC is a strong function of the doping concentration in the absorber layer, better understanding of doping mechanisms and defects formation is a must. Like most common dopants in px-CdTe, Copper (Cu) forms multiple species of defects including interstitial donors (Cui), substitutional acceptors on Cd site (CuCd) and tightly-bounded complexes such as Cui-CuCd and Cdi-CuCd. Resulting amount of uncompensated acceptor impurities is usually three or four orders of magnitude smaller than the total atomic Cu concentrations, which limits the VOC of Cu-doped CdTe solar cells significantly. Although total Cu concentration profiles can be measured by the secondary ion mass spectrometry (SIMS) technique, the concentration of different species of Cu (mainly Cui and CuCd) generally cannot be identified. Given this, gaining a better understanding of Cu migration in CdTe is of crucial importance in order to further enhance the performance of CdTe solar cells. Moreover, PV modules (multiple solar cells electrically connected) are expected to function properly for more than 25 years, in order to provide electricity at proper cost. However, due to the fast diffusion rates of Cu atoms, the gentle balance between mutually compensating Cu impurities could be subject to temporal changes causing metastabilities observed in CdTe solar cells, which also makes the predictive simulation of device performance more important. Thus, gaining a better understanding of mechanisms that govern formation and interactions between Cu-related defects is of crucial importance for further advancement of the CdTe photovoltaics.

Author: Dragica Vasileska (Arizona State University, USA)

Characterization of the Electrical Behaviour of Thin Dielectric Films at Nanoscale Using Methods Derived from Atomic Force Microscopy: Application to Plasma Deposited AgNPs-based Nanocomposites

Christina Villeneuve-Faure

Special Session VII, T4-W2, 10/17/2018 13:30

Abstract

Recent advances in the development of micro- and nano-devices call for application of thin nanocomposite dielectric films (thickness less than few tens of nanometers) with tuneable electrical properties. For optimization purposes, their behaviour under electrical stress needs to be probed at relevant scale (i.e. nanoscale). To that end electrical modes derived from Atomic Force Microscopy (AFM) appear the best methods due to their nanoscale resolution and non-destructive nature which permits in-situ characterization. Conductive AFM (C-AFM), Kelvin Probe Force Microscopy (KPFM) or Electrostatic Force Microscopy (EFM) have previously been exploited to determine leakage current in gate oxide, charge at oxide/semiconductor interface in MOS devices or dielectric permittivity in composite thick layer. In this work, the potentialities of electrical modes derived from AFM are presented. The samples under study consist of plasma processed thin dielectric silica layers with embedded silver nanoparticles (AgNPs). Their structure comprises a single AgNPs layer inserted at perfectly controlled distance from the SiO2 surface. Charges injection at local scale, using AFM tip, is investigated by KPFM and Electrostatic Force Distance Curve (EFDC) modes. The relative merit of each method in terms of resolution and sensitivity is discussed. Moreover, modulation of the local permittivity induced by the AgNPs is assessed by EFM.

Authors: Christina Villeneuve-Faure (LAPLACE, University of Toulouse, France); Kremena Makasheva (LAPLACE, CNRS, University of Toulouse, France); Cedric Djaou (Laplace, France); Laurent Boudou (LAPLACE, University of Toulouse, France); Gilbert Teyssedre (University of Toulouse & CNRS, LAPLACE & CNRS, Paul Sabatier University, France)

Advanced Nanoscale Magnetic Tunnel Junctions for Low Power Computing

Zhaohao Wang

Session: Materials and Devices I, T1-M1, 10/15/2018 10:30

Abstract

Nanoscale magnetic tunnel junction (MTJ) has become a competitive candidate for low power computing, and much progress was recently made. In this invited paper, we give an overview of our recent achievements in this topic. First, we present a MTJ with atom-thick tungsten spacer and bridging layer, which simultaneously shows the high perpendicular anisotropy, large tunnel magnetorisistance ratio, small resistance-area product, low write current density, and high robustness to annealing. Second, we propose a novel magnetic memory named NAND-SPIN addressing the drawbacks of the mainstream spin transfer torque and spin orbit torque based MTJs. Finally, we extend the MTJs to the neuromorphic application by creating skyrmions in the free layer during the magnetization switching.

Authors: Zhaohao Wang, Shouzhong Peng, Mengxing Wang, Xueying Zhang, Wenlong Cai, Jiaqi Zhou and Kaihua Cao (Beihang University, P.R. China); Weisheng Zhao (Beihang Universiy, P.R. China)

Pseudo-memcapacitive Neuro-transistor Based Capacitive Neural Network

Zhongrui Wang

Session: Modeling & Simulation III, T3-T3, 10/16/2018 15:30

Abstract

The unprecedented computing capability of artificial neural networks has shown great promise in realizing artificial cognition intelligence. Emerging hardware neuromorphic computing architectures call for novel electronic building blocks with bio-realistic learning protocols for energy efficient implementation of neural network algorithms, which is crucial for the era of big data and Internet of things. We developed the first volatile pseudo-memcapacitor to emulate the membrane potential of a biological neuron, exhibiting the stochastic temporal leaky integrate-and-fire and simultaneous dendritic spatial summation, due to analogues dynamics between Ag filaments and Na+/K+ ion channels at nanoscale dimension. The active operation of the neural functionalities has enabled sustainable signal propagation in multi-stage networks with passive synapses. Paired with non-volatile pseudo-memcapacitive synapses, Hebbian-like learning mechanism was implemented for the first time in a capacitive network, leading to the observed associative learning. An experimental prototype of fully integrated capacitive neural network with the Hebbian-like mechanism was used to classify inputs signals. The energy efficient capacitive system may suggest a novel bio-plausible routine for the hardware implementation of neuromorphic computing.

Authors: Zhongrui Wang, Mingyi Rao (University of Massachusetts, Amherst, USA); Jin-Woo Han (NASA, USA); Jiaming Zhang (Lam Research, USA); Huaqiang Wu (Tsinghua University, P.R. China); Qinru Qiu (Syracuse University, USA); R. Stanley Williams (Hewlett-Packard Laboratories, USA); Qiangfei Xia and Joshua Yang (University of Massachusetts, USA)

Dr. Zhongrui Wang is a post-doctoral research fellow with the Electrical and Computer Engineering Department of the University of Massachusetts Amherst. He worked with Prof. Joshua Yang and Prof. Qiangfei Xia on unconventional computing solutions using memristors. Prior to joining UMass, Dr. Zhongrui Wang obtained his Ph. D and B. Eng. in Electrical and Electronic Engineering from Nanyang Technological University of Singapore.

TEM Investigations for Nanomaterials Properties
Benedicte Warot-Fonrose
Session: Emerging I, T2-W2, 10/17/2018 13:30

Abstract

The properties of an assembly of nano-objects frequently allow to deduce the property of individual objects, however it is sometimes necessary to study a nano-object alone at the nanoscale. Transmission electron microscopy (TEM) is one of the suitable technique to get access to structural, chemical, magnetic or optical properties at the nanometer scale. For example, structural and magnetic transitions require the combination of several TEM techniques to elucidate the transition. Compounds such as FeRh or MnAs, which exhibit magnetic transitions close to ambient temperature from a ferromagnetic state to a zero global magnetization state (antiferromagnetic or paramagnetic), will be presented. Another example will concern the chemical composition of semiconductor devices where the optical properties can be modulated by the interface composition.

Author: Benedicte Warot-Fonrose (CEMES-CNRS, France)

Benedicte Warot-Fonrose is a CNRS researcher since 2004 and his research is devoted to the correlation between local structure and chemical composition with macroscopic properties, like magnetism or transport. He is a specialist in transmission electron microscopy and electron energy-loss spectroscopy. He developed these methods on various nanomaterials. Besides the utilization of up-to date microscopes, with aberration correctors, he also developed the EMCD technique (energy-loss magnetic chiral dichroism) to measure magnetic moments with the spatial resolution available in a TEM. Some recent experiments are devoted to “in situ” measurements, especially under electrical contacting and heating.

Materials and Devices for Wearable Healthcare from the Skin to Below the Skin

Sheng Xu

Session: Modeling & Simulation I, T3-M3, 10/15/2018 15:30

Abstract

Wearable electronic devices that can acquire vital signs from the human body represent an important trend for healthcare. Combined strategies of materials design and advanced microfabrication allow the integration of a variety of components and devices on a stretchable platform, resulting in systems with minimal constraints on the human body. We have demonstrated a skin-mounted multichannel health monitor that can sense local field potentials, temperature, strain, acceleration, and body orientation. Integrating ultrasonic transducers on this stretchable platform adds a third dimension to the detection range by launching ultrasound waves that reach well underneath the skin. The ultrasound waves allow capturing a wide range of dynamic events in deep tissues such as blood pressure in central arteries and veins. This technology holds profound implications for continuous and noninvasive sensing, diagnosis, and treatment of chronic diseases.

Author: Sheng Xu (University of California, San Diego, USA)

Sheng Xu is currently an assistant professor in the Department of Nano-engineering at UC San Diego. He received his B.S. in Chemistry and Molecular Engineering from Peking University in Beijing, China, and Ph.D. in Materials Science and Engineering at Georgia Institute of Technology. He worked as a postdoctoral research associate in Frederick Seitz Materials Research Laboratory at the University of Illinois at Urbana-Champaign, where he developed advanced stretchable electronic systems for healthcare and energy applications. His research group currently focuses on crystalline material growth for high-performance energy devices and bio-integrated electronics for human-machine interface and health monitoring. His research has been recognized by a series of awards, including the MIT Technology Review Top Innovators Under 35, NHLBI Technology Development Award, 3M Non-Tenured Faculty Award, the TSMC Research Gold Award, and the International Union of Pure and Applied Chemistry Prize for Young Chemists.

Conduction Current and Displacement Current Created in One Generator

Qing Zhang

Session: Materials and Devices VI, T1-W1, 10/17/2018 10:30

Abstract

Most of electric power for industry and our daily life is converted from mechanical power through a variety of types of electric generators. The working principles of these generators can be classified into three primary categories, i.e, electromagnetic induction, electrostatic induction and piezoelectric effect. Electromagnetic generators produce conduction current based on Faraday's law. In contrast, electrostatic generators and piezoelectric generators create displacement current under electrostatic induction and piezoelectric effect, respectively. In this talk, we present a new type of electric generators which could generate both conduction and displacement current. These generators can be simply constructed using a pair of semiconducting or/and metallic electrodes which possess distinct chemical potentials. When the two electrodes are brought in contact, electrons could diffuse from the high into the low chemical potential electrode. Once the two electrodes are being separated, the diffused electrons are then discharged to the external circuit and flow back to the high chemical potential electrode, converting the mechanical power to electrical power. With a small load resistance, both conduction and displacement currents are clearly seen in the contact-separation cycles. However, the conduction current dominates the total generated current under a load resistance larger than 1 Mohm for our present prototype generators.

Author: Qing Zhang (Nanyang Technological University, Singapore)

Qing Zhang is a professor and Director of Centre of Micro-/Nano-electronics in School of Electrical and Electronic Engineering, Nanyang Technological University (NTU), Singapore. His research interests cover nanomaterials and nano/micro-electronic devices, carbon/silicon based thin films, etc. His attention focuses on carbon nanotube and other 0-D, 1-D and 2-D nanostructure based devices and fundamentals, etc. He and his group members have studied functionalized carbon nanotubes for several types of sensors, (including NH3 gas sensors, nitrophenol sensors, organophosphate sensors and glucose sensors, etc), logic circuits and Li-ion batteries, etc. He has published more than 250 peer-review scientific papers in the fields of electronic materials, physics and devices for data processing, sensing and energy storage and harvesting.