2018 NanoScientific Symposium

Scanning Probe Microscopy (SPM)

September 19-20, 2018 • SUNY Polytechnic Institute, Albany, NY

PROGRAM

NanoFab South

DAY 1 Wednesday Sept. 19, 2018

Sponsored by Park Systems NANOscientific

Morning Session - Program Chair: Dr. Rigoberto Advincula, Case Western Reserve University, Cleveland, OH

08:00 - 08:30 am	Welcome (Keibock Lee, Park Systems President)
08:30 - 09:00 am	Dr. Rigoberto Advincula

"Functional Graphene Oxide (GO) Templated Patterning and Anti-Microbial Properties"

Graphene (G), Graphene Oxide (GO), and Reduced Graphene Oxide (rGO) have had an explosive growth in their applications ranging from electronic devices to biomedical applications. The use of lithographic and non-lithographic patterning methods have enabled the unique applications of such materials in electronics, display devices, flexible electronics, sensors, etc.. This talk will highlight the preparation of patterned surfaces via templating and photo masking shows the versatility of GO electrochemistry and photochemistry in unique film applications. We also demonstrate their use in improving anti-microbial properties against known classes of pathogens. The use of silver nanoparticles and other metal particles for antimicrobials has been the dominant additive for coatings, textiles, and other devices. Here we demonstrate the use of GO and rGO additives for anti-microbial activity such as E. Coli and B. subtilis including mitigation biofilm formation on a host of substrates. These properties were observed on solution preparation, coatings, and electrodes that have been modified by polymer-GO composites including preparation as fibers. Modification of graphene oxide further provides chemical functionality that is able to capture heavy metals for separations processes.

FEATURED SPEAKERS

09:00 - 09:30 am	Dr. Alain Diebold, SUNY Polytechnic Institute, Interim Dean of the College of NanoscaleScience; Empire Innovation Professor of Nanoscale Science; Executive Director, Center for Nanoscale Metrology

"Measurement Challenges arising from New Semiconductor Materials and Structures for Integrated Circuits"

09:30 - 10:00 am	Dr. Gwo Ching Wang, Rensselaer Polytechnic Institute (RPI), Travelstead Institute Chair, Physics, Applied Physics & Astronomy

"Ultrathin layered materials studied by AFM and MFM"

Atomic force microscopy has proven records to examine surface morphology, layer spacing, thickness and roughness of various materials. In this talk applications using AFM and MFM to examine strain and magnetic properties of ultrathin materials will be presented. Halide perovskite MAPbBr3 is an emerging thinner flake due to the soft Halide perovskite and the strain relaxes in the thicker flake to form holes. This is supported by significant strong blue shift of PL (2.44 eV) as the flake thickness decreases from bulk value (2.31 eV) [1]. Thickness dependent Photoluminescence shift is related to the change of electronic band structure resultant from the material under strain. For the transition metal dichalcogenides VS2 it is predicted by density function theory to have room temperature magnetic moment in ultrathin regime and it has potential implementation in spintronics circuits and quantum computing devices. In collaboration with Park Scientific, the optical image (Fig. 2a), AFM image (Fig. 2b) and the dependence of MFM phase contrast (Fig. 2c) on sample-tip distance were collected at lift heights (L) from 20 nm to 50 nm (Figs. 2d-h). Qualitatively, a decrease in the interfacial contrast with an increase in L was observed (Fig. 2i). The exponential decay of MFM phase shift with an increase in lift height likewise indicates an exponential decrease in attractive force between the tip and sample, consistent with what one would expect for a magnetic interaction. The observation of MFM phase signal reveals the existence of ferromagnetism in ultrathin VS2 consistent with density functional theory calculations.

10:00 - 10:30 am | **Phil Kaszuba, Global Foundries Senior Member of Technical Staff and lead engineer in their Scanning Probe Microscopy (SPM) laboratory**

"Meeting the Challenges in Analyzing State-of-the-art Semiconductor Devices Using Scanning Probe Microscopy"

In the late 1980s, the Scanning Probe Microscope (SPM) in its infancy was a complex, esoteric analytical instrument that had seen limited use in the semiconductor industry. The SPM rapidly evolved into a mainstream analytical instrument in the early 1990s when companies like IBM and Intel boasted of their state of the art 0.5µm planar technologies. Proving itself with its unprecedented ability to "see" features on semiconductor devices like never before, the SPM quickly became established as a workhorse instrument in semiconductor device analysis. Early use was confined primarily to analytical laboratories; followed by a rapid progression into semiconductor device manufacturing lines for metrology applications.

The semiconductor industry has continually progressed, aggressively advancing the state of the art, which at present, is at full production of 3-dimensional devices, e.g., FinFETs at a critical dimension of 14nm. Analytical instrumentation has also, through necessity evolved to support the rapid advancement of the industry and the SPM has played an increasingly critical, supportive role in the development of new technologies, the monitoring of manufacturing processes, and the failure analysis of nanoscale semiconductor devices. A discussion of the challenges in performing critical analyses using SPM will be presented along with some recent results.

10:30 - 11:00 am | **Dr. Yiping Zhao, Professor, Department of Physics and Astronomy; Director, Nanoscale Science and Engineering Center, The University of Georgia**

"When glancing angle deposition meets with colloidal lithography … "

The combination of colloidal lithography and glancing angle deposition can facilitate a new powerful fabrication technique – shadow sphere lithography, which can greatly expand the variety and complexity of nanostructures fabricated using colloidal monolayer template. In this talk, I will discuss how to control the vapor flux and the colloidal template to design different kinds of three-dimensional optical metamaterials and two-dimensional metasurfaces."

11:00 - 11:15 am | **Morning Break**

11:15 - 11:45 am | **Dr. Ye Tao,Rowland Institute at Harvard**

"Learning in Fundamental Atomistic Processes Using Suspended Silicon Nanowires"

Nanowires made of silicon are an emblem of the rise of nanotechnology and the emergence of a range of sensing modalities. In particular, the fields of chemical sensing and ultrasensitive force detection are two sub-fields that saw tremendous development in the past decade. In this talk, I will discuss two examples in which the mechanical and electrical properties of suspended single-crystal silicon nanowires are used to monitor chemical processes happening at the surface. In particular, we discover a new kinetic behavior in a solid-solid interface charge transfer reaction that is consistent with a microscopic model based on continuous interface inhomogeneities.

11:45 - 12:15 pm | **Dr. John A Marohn, Professor& Director of Undergraduate Studies, Department of Chemistry and Chemical BiologyMember, Field of Materials Science & Engineering, Cornell University**

"Advances in Electric Force Microscopy: (1) Sub-cycle Changes in Photocapacitance in Organic Photovoltaics, (2) Anomalous Light-induced Conductivity in Lead-Halide Perovskites, and (3) a Unified Lagrangian-Mechanics Theory of Scanning-Probe Electrical Measurements"

Electric force microscopy (EFM) and Kelvin probe force microscopy have revealed an enormous amount of useful information about semiconductor materials by enabling measurements of charge generation, injection, transport, and trapping with high spatial resolution. To test theories of charge generation and recombination, however, one also needs to follow sample properties with high temporal resolution. Light-induced charge generation and recombination is typically studied using nanosecond-resolution time resolved microwave conductivity, but the technique has no spatial resolution. (1) Ginger and coworkers introduced time-resolved EFM (tr-EFM), in which transient photocapacitance is followed by observing the cantilever's oscillation frequency with microsecond temporal resolution, and showed that the photocapacitance charging rate measured by tr-EFM was proportional to the external quantum efficiency in benchmark organic photovoltaic systems. (2,3) For charging rates faster than half a cantilever oscillation period (e.g., 1.5 microseconds), however, the demodulated cantilever frequency cannot be clearly interpreted because the cantilever's oscillation spectrum violates the requirements of Bedrosian's product theorem for analytic signals.(4) We introduce a new method for measuring photocapacitance transients with a scanning-probe microscope that sidesteps this seemingly fundamental limit.

12:10 - 01:30 pm | **LUNCH**

Afternoon Session - Program Chair: Dr. Gwo Ching Wang, RPI

01:30 - 02:00 pm | **Dr. Jiahua Zhu PhD, University of Akron, Associate Professor, Department of Chemical and Biomolecular Engineering**

"Quantitative Thermal Conductivity Analysis with Scanning Thermal Microscopy"

As the development of the electronic and semiconductor industries quickens, thermal management in micro-devices becomes increasingly important. Among the various available thermal characterization technologies, scanning thermal microscopy (SThM) has the unique capability to probe thermal properties down to nanoscale because of its excellent spatial resolution. Currently, relative mapping of thermal conduction properties can be achieved, while a quantitative data analysis method is still not available to acquire absolute thermal conductivity. The main challenge is from the unpredictable heat flux across thermal tip/sample surface interface, which makes the thermal analysis very difficult. The heat flux can be affected by a variety of factors such as roughness, hardness, tip/surface contacting pressure, thermal conductivity of sample, etc. All these factors need to be considered to understand the heat transport across the contacting interface, which can be described as thermal contact resistance (TCR). Once TCR can be quantified, the heat transport from tip to sample surface can be systematically analyzed. So far, it remains a great challenge to characterize TCR not only because it is affected by many factors but also because the interplay of these factors is still not yet clear. Constructing TCR and SThM models and applying post-calibration could be a feasible strategy to correlate probe current and sample thermal conductivity.

In our group, a mathematical model was developed to describe TCR by considering the following parameters: probe current, sample thermal conductivity, sample surface roughness, sample surface slope and sample micro-hardness. Another two constants were also employed in this model: thermal tip radius and loading force of thermal tip during scanning. This model was derived based on the heat transfer mechanism between two solid surfaces. Based on the working principle of SThM with conductivity contrast mode, two mathematical models (linear for smooth surface and non-linear for rough surface) were developed to predict thermal conductivity with probe current reading. By combing TCR model and SThM measurement, the quantification of thermal conductivity becomes possible.

02:00 - 02:30 pm	Dr. Nancy A. Burnham,Associate Professor of Physics & Associate Professor of Biomedical Engineering, Worcester Polytechnic Institute

"The Complex Polymers Beneath Your Feet"

from reservoirs [2]. Engineered nanoparticles [3] are being developed to better understand fluid flow within conventional reservoirs, which could lead to increased recovery if their adhesion to rock walls can be minimized [4]. Moreover, in unconventional reservoirs the challenge of efficient oil recovery is dependent on the pore system of the kerogen, which is the main component of organic matter, along with the minerals that compose the rock matrix. It represents nanomaterial in the subsurface, the elastic modulus of which has been recorded as 10 GPa [5], while the remaining rock matrix can be up to ten times stiffer. Eventually, kerogen produces bitumen and finally oil. After extraction and refining it becomes the asphalt binder upon which you and I walk and drive. Both kerogen and asphalt binder ("bitumen") can be thought of as complex polymers whose fascinating topography and chemo-mechanical properties are not well understood [5,6].In the case of asphalt binder, the challenge is to relate its complex chemistry to the durability of its long-term mechanical behavior in use as roads. Interestingly, however, room-temperature evolution of microstructures over a period of a few weeks was recently observed [7].In this talk, we will describe our contributions to addressing these societal problems by means of atomic-force microscopy. Better understanding of the source materials, the behavior of engineered nanoparticles within reservoirs, and a resulting every-day infrastructural material should lead to both more efficient fossil-fuel recovery and moredurablewalkways beneath your feet.

02:30 - 02:45 pm	Afternoon Break

ORAL PRESENTATIONS

02:45 - 03:00 pm	Yu Xiang, RPI "2D Materials in Real and Reciprocal Spaces: Complimentary AFM and RHEED Studies"
03:00 - 03:15 pm	Xin Sun, SUNY "van der Waals epitaxy of antimony on single-crystalline graphene"
03:15 - 03:30 pm	Zonghuan Lu, RPI, "Quasi van der Waals epitaxy of copper thin film on monolayer graphene buffer"
03:30 - 03:45 pm	Kai Trepka, Harvard "Position-Specific Attachment of Nanoscale Samples"
03:45 - 04:00 pm	Yifan Li, University of Akron "Investigation of "Artifact" Phenomenon in Scanning Thermal Microscopy (SThM)"
04:00 - 04:15 pm	Lucile Sheridan, Global Foundries "Die-Level AFM-based Fault Isolation on Bulk and SOI Fin-FET Devices for Advanced Semiconductor Nodes"
04:15 - 04:30 pm	Calder Miller, Rowland Institute at Harvard "A Suspended Graphene Sample Stage for Magnetic Resonance Force Microscopy"
04:30 pm	Closing Remarks: Keibock Lee, Park Systems

05:00 - 07:00 pm	Cocktail Reception

NanoFab East

DAY 2 Thursday Sept. 20, 2018, Park AFM Demo and Workshop

11:00 - 11:15 am	Networking Breakfast

10:00 - 11:00 am	Introduction to AFM
11:00 - 12:00 pm	Advanced Methods

12:00 - 01:00 pm	LUNCH

01:00 - 05:00 pm	Hands-on/Practical applications