3rd Edition of Webinar on Nanotechnology

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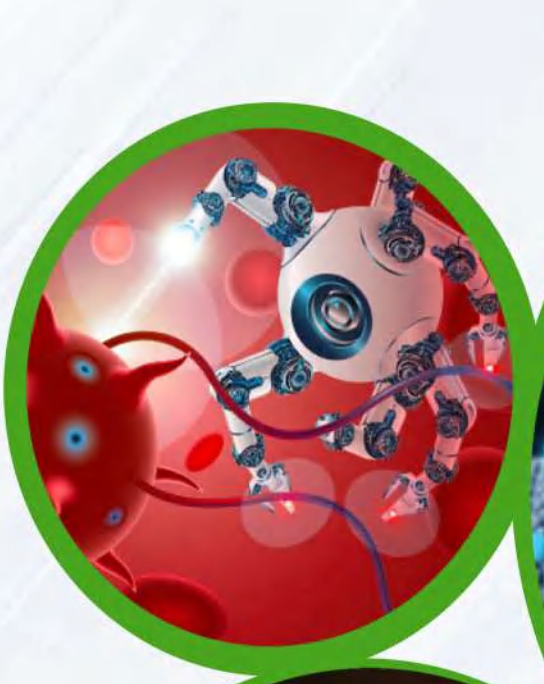

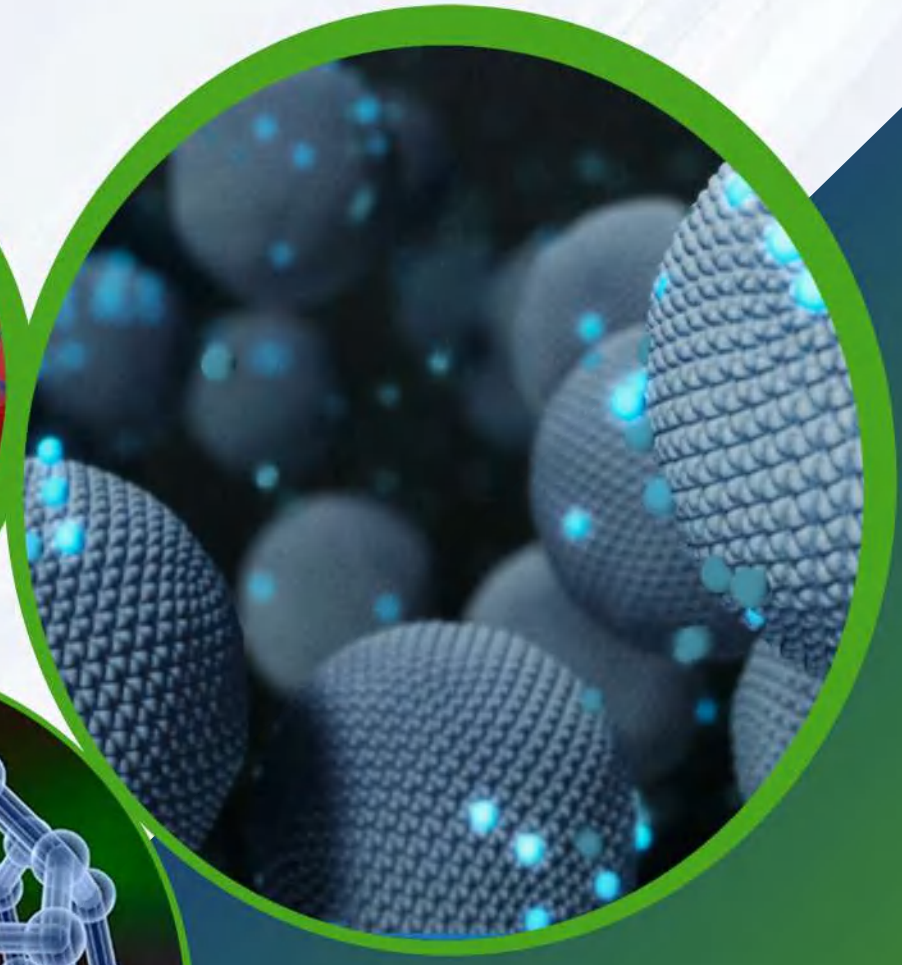

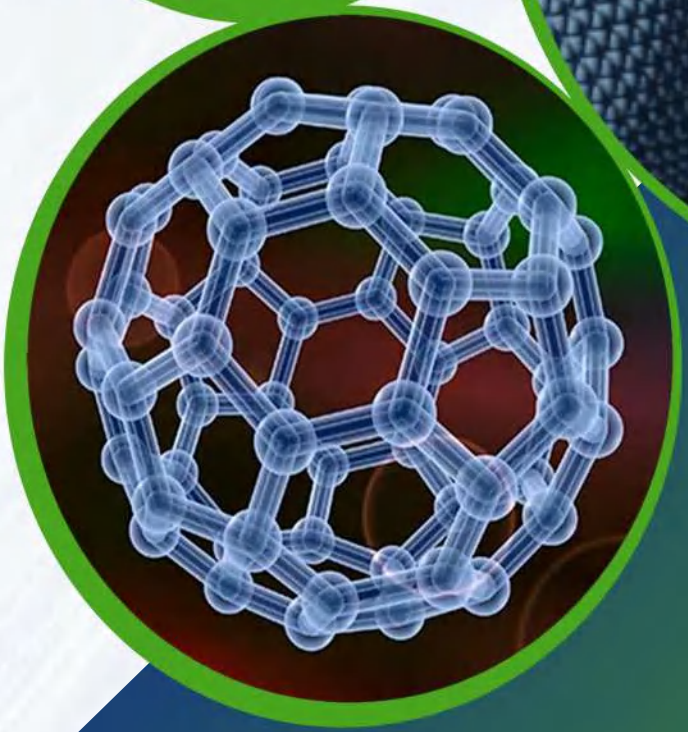

August 02-03, 2021

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Marco Raabe

JSPS & Humboldt Fellow, Max Planck Institute for Polymer Research, Germany

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Professor, Stevens Institute of Technology, USA

Kuei-Hsien Chen

Distinguished Research Fellow and Director, Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan

Stephen E. Saddow

Professor, University of South Florida, USA

Andrew T. S. Wee

Professor, Department of Physics, National University of Singapore, Singapore

Stephanie Willerth

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Gerhard Klimeck

Professor, Network for Computational Nanotechnology, Purdue University, USA

Stela Canulescu

Head, Photovoltaic Materials and Systems group, Department of Photonics Engineering, Technical University of Denmark, Denmark

Chi Hwan Lee

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Jean Duhamel

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Wenwan Zhong

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**Post Doctorate,
Condensed matter physics, Institute of Physics,
The National Autonomous University of México,
Mexico**

Angela Wittmann

**Postdoctoral fellow,
Massachusetts Institute of Technology, USA**

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DAY 1

August 02, Monday

Nanomedicine | Nanomedicine and Nano Drug Delivery Systems | Nanotechnology in Medical Diagnosis

Title: Utilizing multi-organ human on a chip systems to predict in vivo outcomes for efficacy and toxicity

James J Hickman, Founding Director, NanoScience Technology Center, NanoScience Technology Center, USA

Abstract

The utilization of multi-organ human-on-a-chip or body-on-a-chip systems for toxicology and efficacy, that ultimately should lead to personalized medicine applications, is a topic that has received much attention recently for drug discovery and subsequent regulatory approval. Hesperos has been constructing these systems with up to 6 organs and have demonstrated long term (>28 days) evaluation of drugs and compounds, that have shown similar response to results seen from clinical data or reports in the literature. Application of these systems for ALS, Alzheimer's, rare diseases, diabetes and cardiac and skeletal muscle mechanistic toxicity will be reviewed. The development of an in vitro PDPK modeling that predicts in vivo results will also be presented. The system utilizes platform screens from functional readouts. Hesperos has received Phase II and Phase IIB SBIR grants from NCATS to apply Advanced Manufacturing Technologies and automation to these systems in collaboration with NIST in addition to support form pharmaceutical and cosmetic companies. This talk will also give results of six workshops held at NIH to explore what is needed for validation and qualification of these new systems.

Biography

James J. Hickman is the Founding Director of the NanoScience Technology Center and a Professor of Nanoscience Technology, Chemistry, Biomolecular Science, Material Science and Electrical Engineering at the University of Central Florida. Previously, he was the Hunter Endowed Chair in the Bioengineering Department at Clemson University. Dr. Hickman has a Ph.D. from MIT in Chemistry. For the past thirty years, he has been studying the interaction of biological species with modified surfaces, first in industry and in then in academia. He has worked at NSF and DARPA in the area of biological computation. He is also the founder and current Chief Scientist of a biotechnology company, Hesperos, that is focusing on cell-based systems for drug discovery and toxicity. He has 159 publications and 20 book chapters, in addition to 29 issued patents. He is a Fellow of the American Institute of Medical and Biomedical Engineers (2004), the American Vacuum Society (2007) International Academy of Nanobiotechnology (2019) and the National Academy of Inventors (2020).

Title: Raman Signal Enhancement and Delineation of Cancer Cell Lines Using Au Nanoparticles

Rina Tannenbaum, Full professor, Department of Materials Science and Chemical Engineering, Stony Brook University, USA

Abstract

We use surface enhanced Raman scattering (SERS), a novel non-destructive and sensitive imaging modality, for the exploration of the structure and chemical composition of biological materials and probe its efficacy as a tool for the delineation of cancer tissue, histological analysis of biopsies, in vivo detection of tumors and intraoperative imaging. This work deals with the development of a comprehensive Raman imaging platform by measuring the SERS spectra of healthy, benign, and cancer cells at given spatial intervals over the whole area of the tissue of interest, keeping a precise correlation between the location of the measurement and the resulting spectrum. The selective imaging of the tumor is based on the selection of relevant and unique Raman bands and their intensities as a function of sampling location. Based on this information, 2D and 3D images of the relevant tumors may be constructed using novel and unique imaging techniques. In order to gain confidence in the accuracy and reliability of this novel technique, validation by independent alternative methods will be required. For this purpose, we selected breast cancer as a model system and focus on the correlation between documented and measurable metabolic compounds associated with this cancer and the tissue imaging data obtained with SERS Raman. In this work we investigated the surface plasmon resonance and surface-enhancing Raman capabilities of various morphological permutations of star-like Au nanoparticles. The morphological variations were achieved by changing the synthesis temperature and were confirmed with multiple characterization techniques. These variations yielded a novel particle geometry that has quasi-fractal branches. The relative enhancement factors of these nanoparticles as signal enhancers in surface-enhanced Raman spectroscopy has been shown to be closely correlated to the extent of branching and particle size of the Au nanostructures.

Biography

Dr. Tannenbaum is originally from Israel where she received a B.Sc. in chemistry and physics from the Hebrew University, an M.Sc. in physical chemistry from the Weizmann Institute of Science. and a D.Sc in chemical engineering from the Swiss Federal Institute of Technology in Zürich. She is a full professor in the Department of Materials Science and Chemical Engineering and a member of the Stony Brook Cancer Center at Stony Brook University in New York. To date she has published over 200 peer-reviewed articles, reviews and refereed conference proceedings. She is the recipient of numerous awards such as the best paper award in the 1st International Conference on Applied Physics (2003), the Sigma Xi best thesis advisor award (2004), the MRS Fall 2006 Meeting outstanding paper award (2007), 1st prize in the SAIC best paper competition (2007, 2010 and 2012) and best paper award in the 6th Symposium of Frontiers in Polymers (2019). She is a member of the Advisory Board of several professional journals, on the steering and program committees of numerous professional meetings and a frequent keynote and plenary speaker at national and international conferences. Dr. Tannenbaum's areas of interest are soft condensed matter and complex fluids, biomedical applications of Raman spectroscopy, nanocomposites from renewable resources, biomaterials for bone implants and tissue engineering, bio-adhesion, nanofluids, bio-nanostructures and nanoplatforms for cancer diagnostic and targeted drug delivery.

Title: Measuring physical properties of lipid-based nanoparticles for RNA delivery with multidetector asymmetric flow field flow fractionation (MD-AF4)

Fanny Caputo, Researcher, Department of Biotechnology and Nanomedicine, SINTEF Industry, Trondheim, Norway

Abstract

Asymmetric-flow field-flow fractionation (AF4) has been recognized as an invaluable tool for the characterisation of nano-enabled therapeutics and vaccines. To apply MD-AF4 in the pharmaceutical setting, robust and high-quality standard operating procedures (SOPs) needs to be developed, tailored on specific sample properties, and according to identifies parameters necessary to validate methods. We will describe how a unique international collaboration led to the development of robust SOPs for the characterisation of liposomal products and lipid-based nanoparticles for RNA delivery (LNP-RNA). Examples of how MD-AF4 methodologies have been validated and used for the analysis of key quality attributes, such as particle size, shape, stability, particle concentration, aggregation and drug loading will be described. MD-AF4 is used as a successful example to describe the pathway from SOPs to standardisation and how the work done on liposomal products can open a fast track for the development of methods for LNP-RNA.

Biography

Dr. Fanny Caputo is a researcher at SINTEF (Norway) since 2019, and previously working in CEA France. Her main interest lies in the physical-chemical assessment of nanomaterials and nanopharmaceuticals for safety and quality assessment and in the standardization of characterization methods for regulatory purposes. She is the chair of the safety and characterization WG of the Nanomedicine European Technology platform and active member of the ASTM E 56 where she is contributing to the first standard test methods on MD-AF4 for testing of liposomal products.

Title: Nanotraps for the containment and clearance of SARS-CoV-2

Jun Huang, Assistant Professor, Pritzker School of Molecular Engineering, University of Chicago, USA

Abstract

SARS-CoV-2 enters host cells through its viral spike protein binding to angiotensin-converting enzyme 2 (ACE2) receptors on the host cells. Here, we show that functionalized nanoparticles, termed "Nanotraps," completely inhibited SARS-CoV-2 infection by blocking the interaction between the spike protein of SARS-CoV-2 and the ACE2 of host cells. The liposomal-based Nanotrap surfaces were functionalized with either recombinant ACE2 proteins or anti-SARS-CoV-2 neutralizing antibodies and phagocytosis-specific phosphatidylserines. The Nanotraps effectively captured SARS-CoV-2 and completely blocked SARS-CoV-2 infection to ACE2-expressing human cell lines and primary lung cells; the phospha tidylserine triggered subsequent phagocytosis of the virus-bound, biodegradable Nanotraps by macrophages, leading to the clearance of pseudotyped and authentic virus in vitro. Furthermore, the Nanotraps demonstrated an excellent biosafety profile in vitro and in vivo. Finally, the Nanotraps inhibited pseudotyped SARS-CoV-2 infection in live human lungs in an ex vivo lung perfusion system. In summary, Nanotraps represent a new nanomedicine for the inhibition of SARS-CoV-2 infection.

Biography

Jun Huang is an assistant professor of the Pritzker School of Molecular Engineering, Committee on Cancer Biology, Committee on Immunology, and the Graduate Program in Biophysical Sciences of the University of Chicago. His lab performs basic and translational research with the objective of developing effective vaccines and cell immunotherapies for the treatment of cancer, infection, and autoimmunity. He carries out basic immunological research, focusing on molecular mechanisms of T cell recognition and signaling at the single-molecule level. He performs systems immunology, studying the development, differentiation, and metabolism of T cells at the single-cell level. He engineers CAR-T cells, aiming at the treatment of cancer and autoimmunity. He develops new biomaterials, enabling the detection, profiling, and manipulation of T cells and other immune cells for diagnosis and treatment.

Title: Designing targeted drug delivery system using a high-throughput nanosensor

Hung-Jen Wu, Associate Professor, Artie McFerrin Department of Chemical Engineering, Texas A&M University, USA

Abstract

The dynamic process of binding protein onto a biological membrane, driven by a series of binding domains, brings a protein to an active site for regulation of protein function. Because of the fluidic nature of the cell membranes, receptors on cell membranes can freely diffuse on the two-dimensional surface, eventually leading to multivalent interactions with proteins. Such two-dimensional motion assists weak-affinity ligands to participate in protein binding processes, even though the affinities of these ligands are almost undetectable in conventional assays. A new detection tool is urgently needed to discover those ligands to enhance the efficiency of the targeted drug delivery system. We have developed a nanocube sensor coupled with a computer simulation to quantitatively explore the multivalent protein binding. The nanocube sensor is surrounded by lipid bilayers that possess the same physical and chemical properties as cell membranes. This biomimetic surface then enables the label-free detection of protein bindings by observing the absorption spectra shift of localized surface plasmon resonance (LSPR) peak. This biosensor works with standard laboratory plate reader for high-throughput binding kinetic analysis. We have successfully discovered the intrinsic hetero-multivalent binding mechanism in biological membrane. Based on our new discovery of multivalency principle, a novel strategy of targeted drug delivery will be presented for combating drug-resistance pathogens.

Biography

Dr. Wu received his B.S. (1998) and M.S. (2000) in Chemical Engineering from the National Cheng-Kung University, Taiwan. He received his Ph.D. in Chemical Engineering from Texas A&M University in 2006, working on developing advanced microscopy techniques. (advisor: Prof. M. A. Bevan) From 2007 to 2011, he worked as a Postdoctoral Fellow at the University of California, Berkeley. (advisor: Prof. J. T. Groves) During the postdoctoral training, he focused on studying the properties of biological membrane. Between 2011 and 2013, Dr. Hung-Jen Wu was appointed as a Research Associate in the Nanomedicine Department at the Houston Methodist Research Institute, and was involved in developing diagnostic tools for infectious diseases. Dr. Wu joined Chemical Engineering department at Texas A&M University in 2013 and became an Associate Professor in 2020. Dr. Wu's research primarily focuses on the development of biosensors and their applications in glycobiology and infectious diseases.

Title: Novel Breath Acetone Sensor Based On 1d/2d Nanocomposite For Diabetes Prevention And Monitoring

Danling Wang, Assistant Professor, Department of Electrical and Computer Engineering, North Dakota State University, USA

Abstract

Acetone existing in human breath is an effective biomarker of diabetes, which can be used for the early diagnosis and daily monitoring of diabetes. Comparing to the conventional method of monitoring the blood glucose level in blood, detection of breath acetone provides a non-invasive, accurate, convenient, and inexpensive method of diabetes diagnosis and monitoring. Recently, we has developed a new breath acetone sensor based on a novel nanocomposite made by 1- dimensional nanorods, K2W7O22 (KWO) and 2-dimensional Ti3C2 MXene. The lowest detection limit of this sensor to breath acetone can be down to 0.2 parts-per-million (ppm) which is much less than 0.76 ppm, the key threshold to distinguish health person and high-risk of diabetes person. More importantly, the 1D/2D KWO/Ti3C2 nanocomposite based sensor shows excellent selectivity to acetone, great tolerance to water vapor, and can operate at room temperature. This success of this research offers a new sensing technology for disease early detection and health monitoring noninvasively.

Biography

Dr. Danling Wang is an Assistant Professor of the Department of Electrical and Computer Engineering at North Dakota State University. She is the principle investigator of NEWS (Nano-Electronic Wearable Sensors) lab. She earned dual Ph.D. in Electrical Engineering from University of Washington and Optical Physics from Peking University. Her research focuses on investigation of nanomaterial based sensor devices for applications in explosive detector in industry and military, breath analyzer for early stage disease diagnosis. Since 2016, Dr. Wang and her team have published more than 15 peer-reviewed journal papers, more than 10 invited conference presentation. The research of breath acetone sensor has gained lots of attention and secured more than 200,000 grants within 4 years.

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Nanomaterials | Nanomaterials for Energy and Environmental Applications | Graphene and Applications of 2D Materials | Nanomaterials Characterizations and Devices | Nanomaterials and Nanocomposites

Title: Exploring the Limits of Magnetism in Two-Dimensional Materials

Elton J. G. Santos, Reader, Theoretical and Computational Condensed Matter Physics, The University of Edinburgh, UK

Abstract

Dr Santos received his PhD in 2011 from the Danish Technical University with a European Honour. Then, he moved to Harvard University as a John A. Paulson Postdoctoral Fellow to undertake research on energy materials and method developments. He moved to Stanford University in 2013 as an assistant scientist to investigate novel functional devices. Dr Santos started his research group in 2015 at Queen's University (QUB) in the UK as a full Lecturer. At QUB, he took a leading role on the research of two-dimensional materials and energy efficient processes with several high-impact contributions. Dr Santos is one of the recipients of the 2020 Charles Hatchett Award for his investigations on Nb-based catalysts. He moved in 2020 to The University of Edinburgh as a Reader in Theoretical and Computational Condensed Matter Physics. He is part of the Higgs Centre for Theoretical Physics within the School of Physics and Astronomy. He is an EPSRC Fellow on 2D magnetic materials.

Biography

Dr Santos received his PhD in 2011 from the Danish Technical University with a European Honour. Then, he moved to Harvard University as a John A. Paulson Postdoctoral Fellow to undertake research on energy materials and method developments. He moved to Stanford University in 2013 as an assistant scientist to investigate novel functional devices. Dr Santos started his research group in 2015 at Queen's University (QUB) in the UK as a full Lecturer. At QUB, he took a leading role on the research of two-dimensional materials and energy efficient processes with several high-impact contributions. Dr Santos is one of the recipients of the 2020 Charles Hatchett Award for his investigations on Nb-based catalysts. He moved in 2020 to The University of Edinburgh as a Reader in Theoretical and Computational Condensed Matter Physics. He is part of the Higgs Centre for Theoretical Physics within the School of Physics and Astronomy. He is an EPSRC Fellow on 2D magnetic materials.

Title: Energtic nanoaluminum with innovative polymer capping systems

Paul A. Jelliss, Associate Professor, Department of Chemistry, Saint Louis University, USA

Abstract

Reactive metals include alkali and alkaline earth metals as well as certain late transition metals and p-block metals like zinc and aluminum, respectively. These metals, in their bulk form, are valued for their high energy content, but their energetic value can be further enhanced by reducing their structures to the nanoscale, which increases the ratio of surface atoms to those in the interior. However, a significant challenge encountered when synthesizing reactive metal nanoparticles is the passivation and stabilization of their surfaces without oxidizing metal atoms many layers down into the nanoparticle. Such oxidation can greatly reduce the energy value of the nanomaterial. Using bottom-up approaches such as catalyzed decomposition of molecular precursors, or top-down methods such as electrical explosion of wires (EEW), we have demonstrated that reactive metal nanoparticles can by synthesized and capped without significant detrimental surface oxidation using organic agents such as epoxides and alkenes. We are able to carefully exploit the reactivity of the metal nanoparticle surfaces to polymerize these molecules and create a protective organic polymer cap. With the advent of 'shelf-stable' nanoaluminum, an une pected challenge has arisen; kinetic stability has been rendered sufficient to significantly hinder subsequent reaction with oxygen and/or water, which may be required for propellant, explosive, or other energy-release applications. Thus we have developed capping schemes incorporating environmentally-responsive organic materials, whose degradation can be triggered by specific stimuli, such as UV light or thermal activation. We have also investigated the use of hollow polymer capsules and metal-organic frameworks (MOFs) to entrap nascent aluminum nanoparticles resulting in novel energetic nanocomposite materials.

Biography

Dr. Jelliss obtained his BSc (Chemistry) and his PhD (Chemistry) from the University of Bristol. His PhD research was based on the synthesis, characterization, and reactions of gold carborane complexes. He is currently an Associate Professor in the Department of Chemistry at St Louis University, having joined the faculty in 2000. Although he maintains interests in organometallic chemistry, for the last decade he has carried out extensive research with reactive metal nanoparticles.

Title: Anisotropic properties of bio-inspired nanocomposite materials

Oliver Félix, CNRS - Institut Charles Sadron, Université de Strasbourg, Strasbourg, France

Abstract

The remarkable properties of natural composite materials (e.g. plant cell wall, animal exoskeleton) have attracted a wealth of research to understand their structure-properties relations at all length scales and to design novel materials with superior performance. However, while nature masters the organization of anisotropic nano-objects like nanocelluloses into complex superstructures, the development of synthetic nanocomposite materials with complex and precisely controlled architectures (e.g. helical) has proven to be difficult due to the lack of suitable approaches for their preparation. With respect to the preparation of multimaterial thin films with a high level of control over the spatial positioning of their constituents, Layer-by-Layer (LbL) assembly [1] has gained its merits as a simple and highly versatile nanofabrication method. While the sequence of components in layered multimaterial films can be very well controlled by LbL-assembly, tuning of the in-plane anisotropy has not yet been achieved. Recently, we have introduced a method called "Grazing Incidence Spraying" for the in-plane alignment of anisotropic nanoparticles (cellulose nanofibrils, metallic nanowires and nanorods, ...) on large areas [2]. Its combination with the LbL-approach permits to extend it toward the preparation of complex (e.g. helical) multilayer films in which the composition and orientation can be controlled independently in each layer. The talk will illustrate some of our recent results on the design of complex bio-inspired nanostructured materials combining hard anisotropic elements like cellulose nanofibrils with soft polymer building blocks. The preparation of such thin films will be presented and their optical and mechanical properties will be discussed as function of the film composition and geometry [3,4].

[1]. Decher, G. Science, 1997, 277, 1232-1237
[2].Blell, R. et al. ACS Nano 2017, 11, 84–94.
[3].Merindol, R. et al. ACS Nano, 2015, 9, 1127 - 1136.
[4].Merindol, R. et al. ACS Nano 2020, 14, 16525-16534.

Biography

Dr. Olivier Félix completed in 1999 his PhD degree in Chemistry at Université Louis Pasteur (Strasbourg, France). After a post-doctoral fellowship at University of Twente (Enschede, Netherlands), he has integrated in 2000 the French National Center for Scientific Research (CNRS) as researcher in the team of Professor G. Decher at Institut Charles Sadron (Strasbourg, France). His research activities focus on the fabrication of multifunctional multimaterial coatings/films using the so-called Layer-by-Layer (LbL) technique. Since 2010 he has developed a new research activity based on the assembly of hybrid nanostructured materials with exceptional mechanical properties and interesting optical properties. In the meantime, he has contributed to the development of a new and versatile method, grazing incidence spraying (GIS), for the controlled in-plane alignment of anisotropic objects at solid interfaces. The latter combined with the LbL-assembly technique is used to prepare bio-inspired nanocomposites with complex superstructures.

Title: Development of carbon nanofiber aggregate sensing technology for sustainable resilience of civil infrastructures to multi-hazards

Yi-Lung Mo, Professor, University of Houston, USA

Abstract

Multi-hazards such as natural hazards (floods, earthquakes, severe storms and wild land fires) or man-made disasters (nuclear disaster, oil spills and terrorist attacks) lead to substantial damage on critical civil infrastructures and communities and have social, economic and environmental consequences. The immediate impacts on multi-hazards include loss of human life and damage to infrastructures. Multi-hazard mitigation for civil infrastructures forms a vital input in disaster management, design of development strategies and emergency response forecasting. In this lecture we will present how to develop a robust and cost-effective real-time carbon nanofiber aggregate (CNFA) sensor system that can be embedded at civil infrastructures for damage detection during events such as earthquakes, nuclear disasters and missile attacks, and for water level monitoring in civil infrastructures during flooding. A real-time multi-hazard alert software system will also be developed to monitor the data generated by the CNFA sensors and produce proper alerts when hazardous events are detected. The CNFA acts as a strain sensor. The stresses in the critical regions of civil infrastructures due to natural or man-made haz ards can be determined by taking into account the strains developed on the surface of the CNFA. This strain produces an equivalent stress in the CNFA that can be derived from its electrical resistance variation. The CNFA sensor system determines the stresses and strains in civil infrastructures and transmits the information to immediately provide real-time information to decision makers. We will also develop a predictive computational modeling platform, which incorporates various couplings between mechanical, electrical and thermal effects and provides accurate coupled response (e.g., displacement, stress, temperature, electrical field, impedance frequency) of civil infrastructures.

Biography

Dr. Y.L. Mo, F.ASCE, F.ACI, F.Humboldt, F.IAAM, is John and Rebecca Moores Professor at the Civil and Environmental Engineering Department, University of Houston (UH), Houston, Texas. Dr. Mo's technical interests are multi-resolution distributed analytical simulations, nano-scale material and large-scale infrastructure testing, and field investigations of the response of complex structures, on which he has more than 500 research publications, including 274 referred journal papers, many conference, keynote and prestige lectures, research reports, books and book chapters, magazine articles and earthquake field mission reports. In the past several years, Dr. Mo has focused on smart material research, especially application of carbon nanofiber material for sustainable resilience of civil infrastructure subjected to multi-hazards.

Title: Enhanced Energy Transfer from Nitrogen-Vacancy Centers to Three-Dimensional Graphene Heterostructures by Laser Nanoshaping

Jing Liu, Assistant Professor, Department of Physics, Indiana University-Purdue University, USA

Abstract

Graphene is an extensively studied two-dimensional (2D) material and has earlier been used to tailor the emission behavior of proximal light emitters by controlling the energy flow to modulate the related relaxation rates, with demonstrated potential in fields of bio-sensing and photovoltaics. The good interface between emitters and the 2D materials are important to efficiently modulate the photon emission behavior. However, seamless integration of the quantum light emitter and these atomically thin materials is challenging due to fabrication limitation. In this paper, we report the utilization of laser nanoshaping approaches to "wrap" the atomically thin graphene on the X-Y facets of the nanodiamond particles. Compared with the 2D layout, the 3D integration enhanced the energy transfer by 45%. Furthermore, we found that the energy transfer efficiency of NV centers to the 3D graphene could reach a maximum value of 80% over a long distance (~ 25 nm), under intense laser excitation. Our analysis indicates that the photon-generated carrier density of graphene enhances the non-radiative decay rate of NV centers. Besides contributing new insight on the fundamentals of interactions between graphene and quantum emitters, the effort undertaken furthermore holds tremendous promise in developing the graphene based nano-cavities for various applications ranging from sensing, to photovoltaics, to lasing, and to quantum communications.

Biography

Dr. Liu obtained the BS (Physics) from Nanjing University, MS (Optics) from Chinese Academy of Science, and the PhD (Biological Engineering) from Purdue University. His PhD research was developing nonlinear microscopes for the label-free imaging of single molecules in the nanoscale. He has been focusing on the nanoscale light-matter interactions for decade. His current research focus is to develop scalable and modulated quantum photon sources for quantum communication and bioimaging.

Title: Bilayer graphene grown in Frank van der Merwe mode and its machine-learning-assisted characterization

Haozhe Wang, Postdoctoral Associate, Massachusetts Institute of Technology, USA

Abstract

Bilayer graphene is now a rising star for the discoveries of unconventional physics. While the number of exciting physical phenomena observed in bilayer graphene increases, a big gap persists in transforming these discoveries into useful applications, owing to the small-scale samples obtained via top-down approach. We realized a layer-by-layer (that is, Frank-van der Merwe) growth mode in large-scale bilayer graphene, with no island impurities, which is unprecedented in any van der Waals-stacked materials. This is important because it ensures the purity, quality and homogeneity of any thin films. Owing to counter-intuitive growth principle in chemical vapor deposition graphene, we proposed a new physical quantity, named "interface adhesive energy", that can be used to predict the growth mode. We show, through first-principle calculations, this new physical quantity is tunable. We have thus realized the classical Frank-van der Merwe growth mode in graphene.

The characterization of graphene is a historical problem. Since the first report of graphene, researchers have been showing a few characterization images and spectrum of a material, based on random sampling. The situation became ambiguous for large-scale sample, when massive data involved. We have invented a machine-learning-assisted Raman analysis tool for precise characterization of stacking order and layer number of our graphene grown in Frank van der Merwe mode.

Biography

Dr. Haozhe Wang obtained his Bachelor's degree in Materials Science and Engineering from Shanghai Jiao Tong University and his Ph.D. degree from Massachusetts Institute of Technology (MIT) in Electrical Engineering and Computer Science. He is currently working as a Postdoctoral Associate at MIT. Dr. Wang's research is about nanoscale materials and their applications in advanced electronics. Dr. Wang has published various papers in prestigious journals such as Matter, Nature Communications, ACS Nano, etc. He is a recipient of the MIT Quantum Hackathon Creativity Award, the MIT Ho-Ching and Han-Ching Fund award.

Title: Controlling epitaxial growth of wafer-scale transition metal dichalcogenides by MOCVD

Tanushree H. Choudhury, Assistant Professor, Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology, India

Abstract

Monolayer transition metal dichalcogenides (TMDs) possess a range of intriguing optical and electronic properties including direct bandgap, high exciton binding energies, valley polarization. Our research is aimed at the development of an epitaxial growth technology for layered dichalcogenides, like that which exists for III-V and other compound semiconductors, based on metalorganic chemical vapor deposition (MOCVD). This approach provides a high overpressure of chalcogen species needed to maintain stable growth at elevated temperature and excellent control of the precursor partial pressures to achieve monolayer growth over large area wafers. Our initial studies have focused on the epitaxial growth of binary TMD monolayers including MoS2, WS2, WSe2 and MoSe2 using metal hexacarbonyl and hydride chalcogen precursors to deposit on 2" sapphire substrates in a cold-wall CVD reactor. Hydride chalcogens precursors allow for deposition of stoichiometric TMDs with a higher lateral growth rate. A multi-step precursor modulation growth method was developed to independently control nucleation density and the lateral growth rate of monolayer domains on the substrate. This approach also enables measurement of metal-species surface diffusivity and domain growth rate as a function of growth conditions providing insight into the fundamental mechanisms of monolayer growth. Using this approach, uniform, coalesced monolayer and few-layer TMD films were obtained on 2" sapphire substrates at growth rates on the order of ~1 monolayer/30 min. In-plane X-ray diffraction demonstrates that the films are epitaxially oriented with respect to the sapphire with narrow X-ray full-width-at-half-maximum indicating minimal rotational misorientation of domains within the basal plane. Controlling the growth temperature and chalcogen flux was crucial in establishing an epitaxial relation. Nuclei localization at the terrace edges, in addition to the underlying substrate, imposes a single orientation. Dark-field transmission electron microscopy of transferred WS2 monolayers shows ~95% single orientation coverage with minimal bilayer and inversion domains. WS2 single-crystal transferred films also show narrow exciton linewidths (~31 meV) and negligible defect-related emission at 80 K. The key features observed during the growth of WS2, MoS2 and WSe2 will be discussed.

Biography

Tanushree H. Choudhury received her Ph.D. in Materials Science from Materials Research Centre, Indian Institute of Science, Bangalore. In 2021 she joined the Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology Bombay as an Assistant Professor. Prior to that she was in the 2D Crystal Consortium- Materials Innovation Platform at Pennsylvania State where she worked on wafer scale growth of epitaxial TMDs using metal organic chemical vapor deposition. Her research focuses on understanding fundamental mechanisms of crystal growth and epitaxy of TMDs and the effect of defects on nucleation of TMDs.

Title: Towards control at the nanoscale: Coated nanodiamonds as intracellular heaters and temperature sensors

Marco Raabe, JSPS & Humboldt Fellow, Max Planck Institute for Polymer Research, Germany

Abstract

Nanodiamonds present an all-carbon-based nanomaterial with promising abilities in both bioimaging and nanoscale sensing. As nanodiamonds are naturally transparent without further optical properties, they owe their fluorescence to optical defect centers in the carbon lattice. For the most part, nitrogen vacancy (NV) centers have been studied previously, where their high photostability has enable the use of nanodiamonds as imaging probes for various techniques. Other than imaging, negatively charged NV centers (NV^-) possess opto-magnetic properties which allow sensing of temperature, single spins, and pH with a high sensibility at the nanoscale. However, the chemically complex surface of nanodiamonds and their tendency to aggregate in physiological buffer solutions, has led to limited applications. In this study, we lifted this hurdle by developing a new coating strategy which covers the surface of nanodiamonds and thus prevents aggregation. To this end, we absorbed hyperbranched polyethylenimine onto the nanodiamond surface and employed form-arm PEG chains as crosslinkers to form a nanogel shell. To endow these coated nanodiamonds with a heating function, we adsorbed the photothermal agent indocyanine green onto the nanogel. These nanodiamond–ICG constructs showed a photothermal effect after irradiation with an infrared laser. To explore this further, we proved that, after the construct was taken up by a human cervical carcinoma cell line (HeLa), we spatially induced cell death by applying the infrared laser. Most importantly, the nanodiamonds enabled us to sense the change of the intracellular temperature during the photothermal effect at the nanoscale and correlate this change to the macroscale temperature measurement. This gave us new insights into the local temperature and its influence on cell viability. Through this approach we can gain more details of temperature-driven biological processes at the nanoscale

Biography

Dr. Marco Raabe obtained both his BSc (Biochemistry) and MSc (Biochemistry) from Ulm University. For his PhD (Chemistry) he moved to the Max Planck Institute for Polymer Research. His PhD research was based on the functionalization and application of fluorescent nanodiamonds as imaging tools. During his postdoctoral research he worked on intracellular nanoscale sensing using nanodiamonds. Recently, he was awarded with a postdoctoral fellowship of the Japan Society for the Promotion of Science (JSPS). Furthermore, since December 2020 he is a member of the Humboldt Foundation. Currently, he is working at the Kyoto University in the group of Professor Itaru Hamachi as a JSPS&Humboldt Fellow. His area of interest is the engineering of the cell-surface to equip cells with new functions and to create living materials. He has published various papers in peer reviewed journals including Nano Letters, Small, Advanced Therapeutics, and ChemMedChem.

Title: Microfluidic supported structured polymer nanoparticles and their controlled assemblies

Nikunjkumar R. Visaveliya, Postdoctoral Researcher, City College of New York, USA

Abstract

Labeling through fluorescent materials are increasingly advantageous for in vivo and in vitro imaging applications for diagnostic and theranostic purposes. A wide range of various fluorescent organic dyes is routinely utilizing for various labeling purposes due to their easy use, low cost, and availability of full emission wavelength range. However, organic dyes are very sensitive to their surrounding in which they rapidly degrade either chemically or photochemically. To avoid the concern of degradability, inorganic nanoparticles (quantum dots) are highly versatile and photostable. However, quantum dots are relatively toxic to biological systems, and hence their widespread and safe uses are a concern. Alternatively, dye-doped polymer particles are promising for labeling and imaging due to their properties that overcome limitations of photodegradation as well as toxicity. In this work, various experimental strategies for the nanoscale and microscale fluorescent polymer particles have been developed to bind the fluorophores inside the matrix covalently or non-covalently, as well as at the surface through direct adsorption or based on bio-conjugation. On the other hand, surface-enhanced Raman spectroscopy (SERS) is one of the most powerful analytical techniques in which significant field enhancement can be realized upon adsorption of molecules (analytes) on the surface of metal nanostructure that allow detection (sensing) of analytes efficiently. A key element is SERS substrate that needs to be equipped with plenty of plasmonic hotspots with relatively roughened metallic surface. Despite many SERS substrates are routinely utilizing, there is still room and hence search is continuing for the dynamic substrates that reveal extraordinary SERS signal outcomes. Polymers can provide the platform to meet such requirements by sys tematically depositing metal nanostructures at the surface. Here, the development of the polymer-metal composite particles at nanometer and micrometer length scales, and their applications as sensor particles for SERS sensing are presented.

Biography

Dr. Nikunjkumar R. Visaveliya studied Chemistry at Sardar Patel University in India. He obtained his doctoral degree from the Technical University of Ilmenau, Germany where he performed research on microfluidic syntheses of multifunctional polymer and composite nano/microparticles for sensing and labeling applications. Currently, he is a postdoctoral researcher at the City College of New York, USA. His research interests are microfluidics and interfacial/functional nanomaterials for biomedical, energy, catalysis, sensing, and labeling applications.

Title: Spectrally selective mid-IR light detection based on hybrid nanopatterned graphene and vanadium oxide heterostructure operating close to room temperature

Michael N. Leuenberger, Professor, NanoScience Technology Center and Department of Physics, University of Central Florida, USA

Abstract

We present the model of an ultrasensitive mid-infrared (mid-IR) photodetector consisting of a hybrid heterostructure made of nanopatterned graphene (NPG) and vanadium dioxide (VO2) which exhibits a large responsivity of R ⊠ 105 V/W, a detectivity exceeding D* 1010 Jones, and a sensitivity in terms of noise-equivalent power NEP 10 fW/Hz1/2 close to room temperature by taking advantage of the phase change of a thin VO2 film. Our proposed photodetector can reach an absorption of nearly 100% in monolayer graphene due to localized surface plasmons (LSPs) around the patterned circular holes. The geometry of the nanopattern and an electrostatic gate potential can be used to tune the absorption peak in the mid-IR regime between 3 and 12 μm. After the photon absorption by the LSPs in the NPG sheet, the phase change of VO2 from insulating to metallic phase is triggered, resulting in a current through the VO2 sheet due to the applied bias voltage Vb. The response time is about 1 ms, shorter than the detection times of current VO2 bolometers. Using a gradient thickness of the VO2 layer, a linear dependence between input power Pinc of the incident light and the photocurrent Iph is achieved. Our envisioned mid-IR photodetector reaches detectivities of cryogenically cooled HgCdTe photodetectors and sensitivities larger than VO2 microbolometers while operating close to room temperature.

Biography

Dr. Leuenberger is a Professor of Theoretical Condensed Matter Physics in the NanoScience Technology Center, Dept. of Physics, and College of Optics and Photonics at the University of Central Florida working in the fields of quantum optics, 3D and 2D semiconductor heterostructures, graphene, 3D topological insulators, and magnetic systems. Besides his strong track record in quantum information science (Nature, PRL, PRB, Nano Lett, etc.), he gained broad expertise in developing multiscale models of photodetectors, transistors, LEDs, and thermal emitters made of 2D materials including defects (Nature Comm., Scientific Reports, PRB, etc.).

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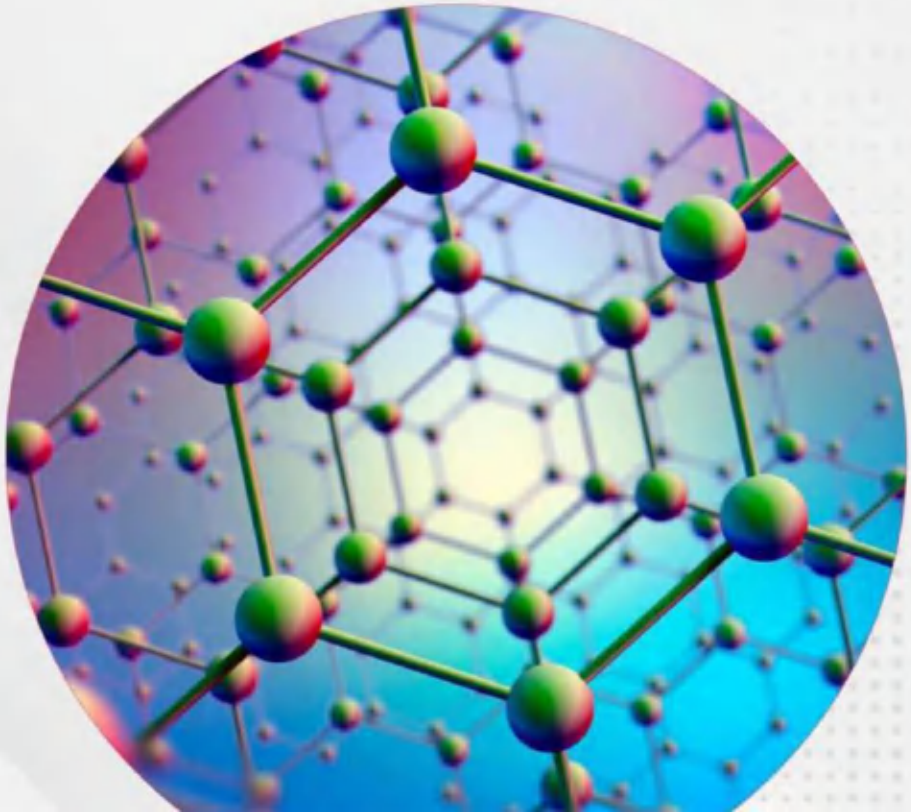

Title: Low-dimensional Nano-materials for Photo-catalytic CO2 Reduction and the Mechanistic Studies using in situ Spectroscopies

Li-Chyong Chen, Director, Center for Condensed Matter Sciences, National Taiwan University, Taipei, Taiwan

Abstract

Photo-catalytic CO2 conversion to hydrocarbon fuels, which makes solar energy harvesting and CO2 reduction reaction (CO2RR) simultaneously, is a killing two birds with one stone approach to solving the energy and environmental problems. However, challenges are the low photon-tofuel conversion efficiency of the photo-catalysts and lack of the product selectivity. Here, four cases in low-dimensional nano-materials for CO2RR will be illustrated: (i) the carbon-doped SnS2 nanosheets [Nature Comm. 9, 169 (2018)] and carbon-implanted SnS2 thin films [Nano Energy 72, 104717 (2020)]; (ii) hydrogenated Ni nanocluster-modified black TiO2 w/wo KSCNmodification [Small 14, 1702928 (2018), ACS Appl. Mater. & Inter. 11, 25186 (2019)]; (iii) MoS2 few layers with defects controlled by plasma; and (iv) direct Z-scheme ZnS/ZnIn2S4 heterostructures, comprising cubic ZnS nanocrystals on hexagonal ZnIn2S4 (ZIS) nanosheets. Vibrational spectroscopies, including Raman and Fourier transform infrared spectroscopy (FTIR), along with various electronic spectroscopies such as X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS), are employed to probe the light-matterambient interactions. For instance, in-situ dark current and Raman spectroscopy measurements are used to monitor the catalyst surface affinity toward the CO2 molecule. Whereas, diffusereflectance FTIR is used to explore the CO2 and related intermediate species adsorbed on the catalyst during photo-catalytic CO2RR. Moreover, XAS and XPS can be used to monitor the electronic charge transfer behaviors. The role and interplay of the defects, surface modifications to the hosting materials, and their effects on the adsorption of CO2 and subsequent CO2RR, as well as the adsorbate-catalyst surface interactions during CO2RR will be discussed.

Biography

Dr. Li-Chyong Chen received her B.S. in Physics from National Taiwan University (NTU) in 1981, and Ph.D. in Applied Physics from Harvard University in 1989. Afterwards, she worked at the Materials Research Center in General Electric Corporate R&D, USA, before she joined the Center for Condensed Matter Sciences (CCMS) at NTU. Li-Chyong was the Director of CCMS and is now the Director of the Center of Atomic Initiative for New Materials. Her group is specialized in the growth of low-dimensional nanomaterials and their applications for energy, optoelectronics, and sensing. Till date she has 16 patents, 16 review articles and over 422 papers, with >17,484 citations and an H-index of 66. Li-Chyong is a Fellow of the Materials Research Society in USA, and a Laureate of the 22nd Khwarizmi International Award. She received twice Outstanding Research Award by Ministry of Science and Technology, and Academic Award by Ministry of Education.

Title: Ferromagnetism in Transition Metal Dichalcogenides

Eui Hyeok Yang, Professor, Stevens Institute of Technology, USA

Abstract

I will present the chemical vapor deposition-growth, doping, and magnetism of two-dimensional (2D) transition metal dichalcogenides (TMDs). While the lack of bandgap is a serious limitation for graphene use in electronic devices, reports have shown up-and-coming prospects of using TMDs in electronics and optoelectronics because of their unique properties, which complement graphene. In particular, 2D atomic crystals exhibiting magnetic properties provide an ideal platform for exploring new physical phenomena in the 2D limit, representing a substantial shift in the ability to control and investigate nanoscale phases. Experimental studies have shown doping of dissimilar atoms into TMDs to create 2D dilute magnetic semiconductors, which are promising candidates for spintronics applications. However, the success of these previous attempts was limited, resulting in either a Curie temperature well below room temperature or lacking scalability for practical integration into devices. Our work demonstrates a 2D dilute magnetic semiconductor at room temperature via an in situ synthesis and characterization of Fe-doped TMD monolayers. We simultaneously achieve the substitutional doping of Fe and the growth of MoS2 and WS2 monolayers and show that Fe incorporates substitutionally into Mo and W lattice sites and probes ferromagnetism in Fe:MoS2 at room temperature. This new class of van der Waals ferromagnets finds critical applications, including on-chip magnetic manipulation of quantum states or spintronics.

Biography

Dr. EH Yang is a Professor of the Mechanical Engineering Department at Stevens Institute of Technology. The first to receive a MEMS Ph.D. in South Korea, he joined Stevens in 2006 following tenure as a senior member of the engineering staff at NASA Jet Propulsion Laboratory, where he was awarded, among other honors, the Lew Allen Award for Excellence in 2003. Through the Stevens Micro Device Laboratory, he facilitated student research and hands-on education in emerging nanotechnologies and spearheaded Stevens' first undergraduate nanotechnology research training program. Dr. Yang has secured more than 35 federal grants and contracts totaling approximately $8.5 million, including funding from the National Science Foundation, Air Force Office of Scientific Research, National Reconnaissance Office, US Army, and NASA. Dr. Yang's professional service credits include editorial board positions for several journals, including Scientific Reports and IEEE Sensors Journal. Dr. Yang was a featured Track Plenary Speaker at ASME International Mechanical Engineering Congress and Exposition (IMECE) in 2018. He received the Award for Research Excellence at Stevens in 2019 and the IEEE Technical Achievement Award (Advanced Career) from the IEEE Sensors Council in 2020. Dr. Yang is a Fellow of the National Academy of Inventors. He is also a Fellow of the American Society of Mechanical Engineers.

Title: Carbon doped SnS2 Thin Film and Powder for Artificial Photosynthesis

Kuei-Hsien Chen, Distinguished Research Fellow and Director, Inst. of Atomic and Molecular Sciences, Academia Sinica, Taiwan

Abstract

Solar photoreduction of CO2 to produce value added hydrocarbons is highly desirable to tackle environmental and energy issues. Despite the great improvement in the efficiency and cost of solar cells, the efficiency in artificial photosynthesis is much lower than the >15% of solar cells. Recent progress in 2D chalcogenides with tunable bandgap and layer numbers offers great opportunity for the investigation in this field. In this work, thin film and powder SnS2 have been synthesized for the study. Hydrothermal synthesis of carbon-containing SnS2 exhibits a highly active photocatalytic conversion of CO2 to selective hydrocarbons under visible-light irradiation. Overall, the carbon doping in the SnS2 nanostructure plays a key role and significantly enhance the visible light photocatalytic activity with a photochemical quantum efficiency above 0.7%. Meanwhile, Thin film SnS2 has been grown for the mechanism study. By carbon-ion implantation of the thin film, we observed enhanced CO2 reduction under solar illumination. Other FTIR, Raman, NMR, BET, SECM, and synchrotron based facilities including APXPS and XAS have been used to investigate this issue.

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Biography

Dr. Kuei-Hsien Chen obtained his BS degree from Electrical Engineering, NTU and his MS and Ph.D. degrees from Applied Science, Harvard University in 1989. He worked on CVD diamond synthesis at General Electric R&D Center till 1992 before he joined the Institute of Atomic and Molecular Sciences (IAMS), Academia Sinica in 1993. He is currently the Distinguished Research Fellow and Director of IAMS, and adjunct research fellow in the Center for Condensed Matter Sciences (CCMS) in NTU. He works on the synthesis and applications of advanced materials, particularly on their energy applications including electrocatalysis, photovoltaic, thermoelectricity, and solar fuels. Dr. Chen has published more than 400 papers and holds 12 patents with more than 17,000 citations and an h-index of 66.

Title: Silicon carbide for advanced in-vivo medical devices

Stephen E. Saddow, Professor, University of South Florida, USA

Abstract

Silicon carbide (SiC) was discovered in 1891 and first saw use as an industrial material due to its hardness and wear resistance. In the 20th century a wide and variety of applications were explored due of its unique electrical and thermal properties, and it was the first light emitting diode (LED) (blue) in 1907. During the semiconductor revolution, it found application in electronics due to its high-temperature and high-voltage breakdown properties. In 1989 the first commercial blue LED was marketed using 6H-SiC, one of the many solid-state forms of silicon carbide. Today it is one of the main power electronics material systems and has found wide-spread use in electric switching applications such as electric vehicles and energy converters. In recent years there has been increased attention on SiC as a viable material for biomedical applications. Of particular interest in this review is its potential for application as a long-term implantable device for healthcare applications. SiC forms in single-crystalline, polycrystalline and amorphous forms and, while it displays ceramic-like properties, is also a wide-band gap semiconductor whereby controlled impurity doping can be used to achieve material resistivity from the semi-insulating to semi-me tallic range. Numerous nanostructures have been synthesized using SiC such as nanowires, nanoparticles and nanodots. The amorphous phase is an excellent insulator which can be conformally deposited to serve as both an insulating layer as well as a biocompatible, high-durability layer for numerous implantable devices. These material properties allow the biomedical device designer to take advantage of its excellent biological, chemical, mechanical and electrical properties and realize wearable and implantable devices that display superior biological response and reliability. In addition, its potential for integration as system on a chip and those applications where SiC is used as an active material make it a suitable substrate for micro-device fabrication. This review highlights the critical properties of SiC for application as implantable biomedical devices and reviews recent work reported on using SiC as an active or passive material in biotransducers and neural implants.

Biography

Dr. Stephen E. Saddow received his doctorate in electrical engineering from the University of Maryland at College Park in 1993 and is currently Professor in the Department of Electrical Engineering and Professor in the Department of Medical Engineering at the University of South Florida (USF), Tampa, FL. He also is currently Collaborating Scientist at the Italian Synchrotron Light Source (Elettra, Beamline BEAR); and a Guest Researcher at the National Cancer Institute. He was elected Fellow of the AIMBE for seminal contributions to the field of Silicon Carbide (SiC) Biomedical Technology, significantly advancing in vivo biomedical devices and systems. Dr. Saddow is a Senior Member of the IEEE and National Academy of Inventors and holds more than 15 Patents, mostly on SiC biomedical device technology.

Title: Defects in Two-Dimensional Transition-Metal Dichalcogenides

Andrew T. S. Wee, Professor, Department of Physics, National University of Singapore, Singapore

Abstract

Atomic defects are ubiquitous in a wide range of 2D transition-metal dichalcogenides (TMDs). They could be intrinsic, formed during the initial sample growth, or created by post-processing. Many properties, including optical, electrical, and chemical properties, can be significantly modulated, and potentially invoke applicable functionalities utilized in many applications. Hence, controlling chalcogen atomic defects provides an alternative avenue for engineering a wide range of physical and chemical properties of 2D TMDs [1].

This talk focuses on defects in 2D TMD van der Waals magnets, which if they exist would be ideal atomically thin building blocks for 2D spintronics [2]. Theories have predicted intrinsic magnetism in 2D VX_2, such as vanadium diselenide and vanadium ditelluride. Bonilla et al. reported strong room-temperature ferromagnetism in 1T-VSe_2 monolayers on van der Waals substrates [3]. We show however, that 2D 1T-VSe_2 is not intrinsically ferromagnetic, but displays evidence of spin frustration [4]. Nevertheless, a magnetic transition in 2D VSe_2 is induced at the contamination-free interface between Co and VSe_2 via interface hybridization [5]. Promotion of ferromagnetism in 2D VSe_2 is accompanied by antiferromagnetic coupling to Co and a reduction in the spin moment of Co. Consistent results are obtained for 2D VTe_2 [6]. In particular, we demonstrate that the reconstructed VSe_2 monolayer with Se-deficient line defects displays room-temperature ferromagnetism under X-ray magnetic circular dichroism and magnetic force microscopy, consistent with the DFT calculations [7]. This work possibly resolves the controversy on whether monolayer VSe_2 is intrinsically ferromagnetic, and highlights the importance of controlling surface defects in 2D TMDs.

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Biography

Andrew Wee is a Class of '62 Professor of Physics, and Vice President (University and Global Relations) at the National University of Singapore (NUS). His research interests are in surface and nanoscale science, scanning tunneling microscopy (STM) and synchrotron radiation studies of the molecule-substrate interface, graphene and related 2D materials. He was a Commonwealth Fellow as well as a Rhodes Scholar at the University of Oxford, where he received his received his DPhil (1990). He holds a Bachelor of Arts (Honours) in Physics (1994) as well as a Masters degree from the University of Cambridge. He is an Associate Editor of the journal ACS Nano, and serves or has served on several other journal editorial boards.

Title: 3D bioprinting neural tissues

Stephanie Willerth, Full Professor, Biomedical Engineering, University of Victoria, Canada

Abstract

3D bioprinting can create living human tissues on demand based on specifications contained in a digital file. Such highly customized, physiologically-relevant 3D human tissue models can screen potential drug candidates as an alternative to expensive pre-clinical animal testing. The Willerth lab has developed a novel fibrin-based bioink for bioprinting neural tissues derived from human induced pluripotent stem cells (hiPSCs), which can become any cell type found in the body. Here I will discuss the latest work from our group detailing the composition of our 3D bioprinted tissues and our new spin-off company - Axolotl Biosciences.

Biography

Dr. Willerth, a Full Professor in Biomedical Engineering, holds a Canada Research Chair in Biomedical Engineering at the University of Victoria where she has dual appointments in the Department of Mechanical Engineering and the Division of Medical Sciences. She also holds an appointment with the School of Biomedical Engineering at the University of British Columbia. She serves as the Acting Director of the Centre for Biomedical Research and the Biomedical Engineering undergraduate program at the University of Victoria. She is an active member of the steering committee of the B.C. Regenerative Medicine Initiative and the Stem Cell Network. She also serves as a staff scientist at Creative Destruction Lab. She also was the President of the Canadian Biomaterials Society- serving a three-year term as President-Elect then President and Past President from 2017-2019. She recently founded the start-up company - Axolotl Biosciences.

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Title: NEMO5, a Parallel, Multiscale, Multiphysics Nanoelectronics Modeling Tool

Gerhard Klimeck, Professor, Network for Computational Nanotechnology, Purdue University, USA

Abstract

The downscaling of electronic devices has reached the range where the number of atoms in critical dimensions is countable, geometries are formed in three dimensions and new materials are being introduced. Under these conditions one can argue that the overall geometry constitutes a new material that cannot be found as such in nature. The interactions of electronic, photons, and lattice vibrations are now governed by these new material properties and longer-range interaction mechanisms such as strain and gate fields. The Nanoelectronic Modeling tool suite NEMO5 is aimed to comprehend the critical multi-scale, multi-physics phenomena and deliver results to engineers, scientists, and students through efficient computational approaches. NEMO5's general software framework easily includes any kind of atomistic model and is, insofar, able to compute atomistic strain, electronics band structures, charge density, current and potential, Schrödinger eigenvalues and wave-functions, phonon spectra, and non-equilibrium Green functions (NEGF) transport for a large variety of semiconductor materials and the software is entirely parallelized. We believe that such modeling capability is not available in any other modeling tool at this time.

The NEMO modeling framework has been used to understand a variety of different device and materials concepts that will be critically important in the sub 10nm device regime. Some examples are bandstructure in Si nanowires as a function of crystal direction and strain. Interface roughness and alloy disorder scattering are modeled in the framework through an explicit atomistic representation. Gate tunneling can be modeled explicitly through quantum mechanical transport and designs can be obtained in which a good Si-based transistor is possible at 5nm gate lengths. Current developments include the explicit modeling of the metal-semiconductor interfaces, the series resistance loss and the thermal transport in nano-scale devices. Some recent examples are explorations for band-to-band tunneling transistors (BTBT) in realistic geometries in III-V, BTBT in III-N, and new 2D materials.

Biography

Gerhard Klimeck is the Reilly Director of the Center for Predictive Materials and Devices (c-PRIMED) and the Network for Computational Nanotechnology (NCN) and a Professor of Electrical and Computer Engineering at Purdue University. He guides the technical developments and strategies of nanoHUB.org which annually serves over 300,000 users worldwide with on-line simulation, tutorials, and seminars.

He was previously with NASA/JPL and Texas Instruments leading the Nanoelectronic Modeling Tool development (NEMO). His work is documented in over 500 peer-reviewed journal and proceedings articles resulting in over 20,000 citations and a citation h-index of 68 on Google Scholar. He is a fellow of the IEEE, APS, IOP, AAAS, and Alexander von Humboldt.

Title: Intrinsic Defects in MoS2 Grown by Pulsed Laser Deposition: From Monolayers to Bilayers

Stela Canulescu, Head, Photovoltaic Materials and Systems group, Department of Photonics Engineering, Technical University of Denmark, Denmark

Abstract

Pulsed laser deposition (PLD) is a powerful method for the growth of two-dimensional (2D) transition metal dichalcogenides (TMDs) into van der Waals heterostructures. However, despite significant progress, the defects in 2D TMDs grown by PLD remain largely unknown and yet to be explored. In this paper, we will combine atomic resolution images and first-principles calculations to reveal the atomic structure of defects, grains, and grain boundaries in mono- and multilayer TMDs grown by PLD. We will show that sulfur vacancies and MoS antisites are the predominant point defects in monolayer MoS2. We predict that the aforementioned point defects are thermodynamically favorable under a Mo-rich/S-poor environment. The MoS2 monolayers feature nanometer size grains connected by a high density of grain boundaries. In particular, the coalescence of nanometer grainsresults in the formation of 180° mirror twin boundaries consisting of distinct 4- and 8-membered rings. We show that PLD synthesis of bilayer MoS2 results in various structural symmetries, including AA and AB, but moiré patterns with various stacking angles. Moreover, we report on the experimental demonstration of an electron beam-driven transition between the AB and AA stacking orientations in bilayer MoS2. These results provide a detailed insight into the atomic structure of monolayer MoS2 and the role of the grain boundaries on the growth of bilayer MoS2, which has importance for future applications in optoelectronics.

Biography

Dr. Stela Canulescu obtained his BSc (Physics) from the University of Bucharest and her PhD from the ETH Zurich. She is currently Head of the Photovoltaic Materials and Systems group at the Department of Photonics Engineering, technical University of Denmark. Her areas of interest are thin film kesterite solar cells and 2D materials. She has published various papers in peer-reviewed journals, such as Solar Energy Materials and Solar Cells, ACS Applied Materials and Interfaces and ACS Nano.

Title: Sticker-like Electronics (Sticktronics) for Wearable Health Monitoring

Chi Hwan Lee, Associate Professor, Purdue University, USA

Abstract

Advanced materials engineering and processing technologies provide means to realize a range of ultra-thin, flexible and stretchable bio-integrated electronics, opening up a new prospect in many biomedical devices and technologies. The mechanical flexibility and stretchability allow the devices to intimately integrate with biological systems such as biological cells, organs, and skins at their length scale. The embedded semiconducting nanomaterials provide the functionalities that can monitor the clinically useful bio-signals with sufficient spatial and temporal controls. This presentation will introduce two different kinds of novel transfer printing methods by exploiting controlled 'cracks' that enable the physical separation of diverse bio-electronics from their original fabrication silicon wafer, thereby can be utilized in many wearable and implantable biomedical applications. Conformal skin-mountable sensors and cell- or tissue-injectable silicon nano-needles will be discussed to show the representative applications in wearable healthcare monitoring and intracellular/intratissue drug delivery. Discussions about the results of detailed experimental and theoretical studies will be followed to reveal the essential attributes of the materials, mechanics, fabrication processes, and system configurations.

Biography

Dr. Chi Hwan Lee is the Lesli A. Geddes Associate Professor of Biomedical Engineering and Associate Professor of Mechanical Engineering at Purdue University. Prior to joining Purdue in 2015, he was a postdoctoral research associate in Department of Materials Science and Engineering at University of Illinois at Urbana-Champaign. He received M.S. and Ph.D. degrees in Mechanical Engineering from Stanford University in 2009 and 2013, respectively. His scholarly efforts are dedicated to addressing unmet clinical needs using novel yet simple wearable devices with a clear path towards translation to produce measur able clinical and economic impacts. These wearable devices, which resemble sticker patches, can be easily integrated with the human body or biological cells and tissues at their length scale in a minimally invasive manner. The potential application of these devices is boundless ranging from artificial skin to drug delivery patch, and to tele-rehabilitation systems. He has published > 60 journal papers with the total citation of > 4,700 and h-index of 32. He has issued 4 U.S. patents, and > 6 utility (non-provisional) and > 20 provisional patents, leading him to spin off 3 startup companies. He has recently received the 2019 NIH Trailblazer Young Investigator Award, 2020 Purdue Faculty Award of Excellence for Early Career Research, and 2020 Purdue Focus Award.

Title: Excess Polymer in Single-Walled Carbon Nanotube Thin-Film Transistors: Its Removal Prior to Fabrication is Unnecessary

Benoît H. Lessard, Associate Professor, Department of Chemical and Biological Engineering, University of Ottawa, Canada

Abstract

Ultrapure semiconducting single-walled carbon nanotube (sc-SWNT) dispersions produced through conjugated polymer sorting are ideal candidates for the fabrication of solution-processed organic electronic devices on a commercial scale. Protocols for sorting and dispersing ultrapure sc-SWNTs with conjugated polymers for thin-film transistor (TFT) applications have been well refined. Conventional wisdom dictates that removal of excess unbound polymer through filtration or centrifugation is necessary to produce high-performance TFTs. However, this is time-consuming, wasteful, and resource-intensive. We challenge this paradigm and demonstrate that excess unbound polymer during semiconductor film fabrication is not necessarily detrimental to device performance. The following presentation will focus on the engineering of sc-SWNTs based electronic devices. The choice of conjugated wrapping polymer and its effect on film formation and the device performance leading to several emerging structure property relationships and a roadmap to high performance.

Biography

Benoît H. Lessard is a Tier 2 Canada Research Chair and Associate Professor in the Department of Chemical & Biological Engineering at University of Ottawa. Recipient of 2018 Ontario Early Researcher Award, 2015 Charles Polanyi Prize in Chemistry and 2018 J. Mater. Chem. C Emerging Researcher. Since 2008, Prof. Lessard has published 97 peer reviewed journal articles, 14 patent applications, 1 book chapter and presented his work over 90 times at international and national conferences. Prof. Lessard is co-founder of Ekidna Sensing inc, which is a spinoff company based on cannabinoid sensors. Prior to joining uOttawa, Prof. Lessard was NSERC Banting Fellow at the University of Toronto on organic electronics and obtained his PhD (2012) from McGill University in Polymer reaction engineering.

Title: Probing the Interior of Complex Polysaccharides at the Molecular Level by Pyrene Excimer Fluorescence (PEF)

Jean Duhamel, Full Professor, Institute for Polymer Research, Waterloo Institute for Nanotechnology, Canada

Abstract

The abundance, bioavailability, and biodegradability of polysaccharides make them ideal target for use as industrial feedstocks, particularly as plastics. Unfortunately, natural polysaccharides do not have the range of properties required for industrial plastics, thus requiring their chemical modification. However, to be effective, chemical modifications need to account for the structure of the polysaccharides, which is not always well-defined, as some polysaccharides of interest like glycogen or amylopectin are extremely large macromolecules several 10's of nm in size, whose highly branched interior and polydispersity complicate their characterization. This presentation will describe how the short range process of excimer formation between an excited and a ground-state pyrenyl label covalently attached onto a polysaccharide can be taken advantage of to yield quantitative information about the conformation of polysaccharides.

In these experiments, a pyrene dye is covalently attached onto the polysaccharide. Since pyrene excimer formation (PEF) occurs within ~ 5 nm, the rate of PEF is proportional to the local concentration [Py]loc of pyrene within a subvolume ~ 5 nm in diameter inside the polysaccharide, where [Py]loc is itself related to the local density of the polysaccharide. Analysis of the fluorescence decays acquired with the pyrene-labeled polysaccharides yields the number of anhydroglucose units (AGUs) confined within ~ 5 nm, which in turn provides information about the arrangement of internal helices in the polysaccharide interior. This methodology showed that in solution, amylopectin consists of clusters of helices, where the helices are separated by ~ 3 nm with the clusters being connected to each other via long oligosaccharide chains. In glycogen, another highly branched polysaccharide, the internal helices were experimentally found to be within ~ 2 nm from each other, as theoretically predicted by the Tier model. Consequently, these PEF-based experiments provide a useful means to probe the interior of complex polysaccharides at the molecular level.

Biography

Jean Duhamel obtained his PhD in Chemical Engineering in 1989 at the Institut National Polytechnique de Lorraine (France) with Dr. André where he learned about the fundamentals of fluorescence. From 1990 to 1993, he was a post-doctoral fellow with Prof. Winnik at the University of Toronto (Canada) where he applied fluorescence to study polymers in solution. In 1993, he moved to the University of Pennsylvania (USA) as a post-doctoral fellow to study oligonucleotides by fluorescence anisotropy with Prof. Ponzy Lu. In 1996, he joined the University of Waterloo, where he is now full professor. At Waterloo, his research focused on applying pyrene excimer fluorescence to characterize the internal dynamics and structure of macromolecules in solution. His key contribution was the development of new mathematical models that enabled the interpretation of these experiments to obtain truly novel information about a variety of different polymer systems.

Title: Complex Interactions between Nanomaterials and Biomolecules Elucidated with Advanced Analytical Tools

Wenwan Zhong, Professor, Department of Chemistry, University of California, USA

Abstract

Engineered nanomaterials (ENMs) support the growth of new and competitive technologies in the fields of energy production and biomedical science. The rapidly increasing production and applications of ENMs calls for interdisciplinary research to assess the biological impacts from ENMs and discover the fundamental factors that contribute to such impacts. My research group actively develops analytical tools to elucidate the complex interaction among ENMs, biomolecules, and biological systems. Our focus is on the biocorona formed on ENMs present in biofluids because of molecular adsorption on ENM surface. The physicochemical properties of ENMs strongly affect the formation of the biocorona, which subsequently mediates the interaction between ENMs and the biological system, making it important to study the formation and composition of biocorona, as well as their impacts on the biological behaviors of ENMs. We developed a series of analytical techniques for measurement of the binding affinity of proteins to ENMs; exploration of the interaction between a large number of proteins and ENMs in a high-throughput manner; study of the dynamics of corona formation; and investigation of the binding sites of ENMs on various proteins as well as the ENM-induced conformational changes in proteins. Recently, we developed a machine learning method for prediction of protein corona formation in biomatrices using novel descriptors other than the physicochemical properties of the ENMs to improve the prediction accuracy. These works have revealed the importance of ENM surface property on the affinity and kinetics of protein interaction; disclosed the contribution of protein characteristics to adsorption on ENMs; and compared protein and lipid corona formation in different biological fluids, including serum, tears, and lung fluid. We believe the advanced analytical tools we have developed for detailed characterization of the biocorona on ENMs can help to gain more knowledge to decipher the corona-mediated biological responses to ENMs.

Biography

Dr. Wenwan Zhong is a Professor of Chemistry at University of California, Riverside. She obtained her B.S. from University of Science and Technology of China, and Ph.D. from Iowa State University. Her research is devoted to developing innovative analytical techniques to advance our understanding on how biomolecules function and to improve disease diagnosis and treatment. Her group combines synthetic receptors, functional nucleic acids, and nanomaterials, with analytical techniques like flow cytometry, open-channel separation, optical spectroscopy, and mass spectrometry, for the discovery and analysis of biomarkers. Her group is also interested in developing analytical techniques for the study of nano-bio interface.

Title: Charge Transfer and Exciton dynamics at hybrid organic-2D interfaces

Wai-Lun Chan, Associate Professor,
Department of Physics and Astronomy,
University of Kansas, USA

Abstract

Monolayer transition metal dichalcogenide crystals (TMDCs) can be functionalized by organic molecules to form organic-2D hybrids, which are useful for many energy and sensing applications. For light harvesting applications, processes such as excited-state charge transfer (CT) and exciton dissociation at the organic-2D interface control the overall optical-to-electrical conversion efficiency at these hybrids. In this talk, I will summarize our recent efforts in understanding microscopic mechanisms that affect the CT and exciton dissociation dynamics at organic-TMDC interfaces. Specifically, we recently found that the difference in the potential energy landscape in both lateral and vertical directions near the interface can result in distinct behaviors for two very similar interfaces. For example, effective charge separation is observed at zinc phthalocyanine (ZnPc)/monolayer-MoS_2, but triplet exciton formation is observed at ZnPc/bulk-MoS_2. Moreover, it is found that the dimensionality of the electron wave function and the interfacial energy level offset can affect the CT rate at organic/TMDC interfaces by more than ~20 times.

Biography

Dr. Chan obtained his BSc degree (Physics/Materials Science) from the Chinese University of Hong Kong and his PhD degree (Materials Science) from Brown University. After two postdoctoral trainings at the University of Illinois at Urbana-Champaign and at the University of Texas at Austin, Dr. Chan started his independent research group at the University of Kansas (KU). Currently, he is an associate professor at KU. Dr. Chan is a recipient of the National Science Foundation (NSF) CAREER award (2014), and the MRS graduate student award (2006). His current research interest is on understanding the electron and exciton dynamics in a range of materials such as organic semiconductors, 2D materials, and hybrid halide perovskites.

Title: Nanoscale Ferroelectric Characterization with Advanced Multi-Frequency Scanning Probe Microscopies

Kaiyang Zeng, Associate Professor, Department of Mechanical Engineering, National University of Singapore, Singapore

Abstract

Piezoresponse Force Microscopy (PFM) has been widely used to characterize nanoscale ferroelectric properties since 1990s. However, the intensive study of the conventional PFM has revealed a growing number of concerns and limitations which are largely challenging its validity and application. This study will show two new developments to significantly improve the nanoscale ferroelectric measurement,, i.e., the Heterodyne Megasonic Piezoresponse Force Microscopy (HM-PFM) and Non-Contact Heterodyne Electrostrain Force Microscopy (NC-HEsFM). HM-PFM is based on the conventional instrument architecture of PFM, but uniquely uses 106 to 108 Hz high-frequency excitation and heterodyne method to measure the piezoelectric strain at nanoscale. It is found that HM-PFM can unambiguously provide standard ferroelectric domain and hysteresis loop measurements, and an effective domain characterization with excitation frequency up to ~110 MHz has been demonstrated. Most importantly, owing to the high-frequency and heterodyne scheme, the contributions from both electrostatic force and electrochemical strain can be significantly minimized in the HM-PFM measurements. Furthermore, a special technique, named difference-frequency piezoresponse frequency spectrum (DFPFS) measurement, is developed on HM-PFM and a tinct DFPFS characteristic is observed on the materials with piezoelectricity.

NC-HEsFM utilizes a newly-designed force sensor and heterodyne detection scheme to measure the nanoscale piezoelectric strain, and for the first time, achieves non-contact, electrostatic force minimized ferroelectric characterization. NC-HEsFM can perform ideal and high-resolution ferroelectric domain mapping, standard ferroelectric hysteresis loop measurement and controllable domain manipulation, and at the same time, operate on multiple high eigenmodes. NC-HEsFM also significantly minimize electrostatic force effect. Meanwhile, the application of the new force sensor makes NC-HEsFM highly compatible for high-vacuum and low-temperature environments, thus combining the advantages of non-contact operation and electrostatic force minimization, NC-HEsFM is expected to reach the ultimate goal of atomically resolved ferroelectric characterization.

Biography

Dr. Kaiyang Zeng is currently Associate Professor and deputy head (Graduate programme) of Department of Mechanical Engineering, National University of Singapore (NUS). He obtained his BSc (Ceramic Materials) from Hunan University, China and his PhD (Materials Science and Engineering) from the Royal Institute of Technology (KTH), Sweden. He was previously worked at the Institute of Materials Research and Engineering (IMRE), Singapore as senior research scientist before joint NUS in 2004. He currently lectures numbers of courses at NUS, including "Fracture and Fatigue of Materials" for Graduate Students, and "Fundamental of Materials Science and Engineering" for undergraduate students. At NUS, his main research area includes development of Scanning Probe Microscopy (SPM) based techniques, multifield coupling of advanced materials, deep-date analysis for SPM images, and in-situ SPM characterization of advanced functional materials. He has published more than 200 papers in peer reviewed international journals.

Title: Non-linear Damping Phenomena in Palladium Nano-mechanical resonators

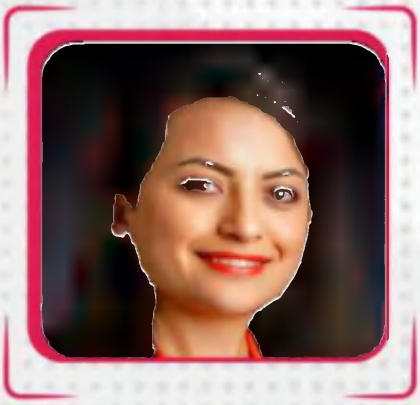
Ananth Venkatesan, Department of Physical Sciences, Indian Institute of Science Education and Research, India

Abstract

Non-linearity is ubiquitous in nanomechanical systems due to the conducive aspect ratio of devices like length to thickness or width. Newtonian damping that is linearly proportional to the velocity has been successful in describing several linear and non-linear oscillatory systems. A non-Newtonian non-linear damping term of the form F = -hx2v has been observed in several nanomechanical systems fabricated out of various materials like graphene drums, Carbon nanotubes and Diamond beams. In this work we describe non-linear damping observed in sub-micron Palladium beams when driven to regimes of Duffing non-linearity. Both the Duffing non-linearity and the non-linear damping are found to be enhanced in beams exposed to low pressures of H2. The non-linear damping shows a linear drop with increase in temperature from T~110 mK to ~1 K. Such a temperature dependence at low temperatures is reported for the first time in nanomechanical systems. A non-linear analogue of the Akhiezer mechanism seems to be the most plausible mechanism. This mechanism is plausible as phonon bounce rates across the device are slower than the resonant frequency of the beam.

Biography

Dr. Ananth Venkatesan obtained his PhD in Physics under Prof Sergey Kravchenko at Northeastern University, Boston. His thesis work was on measuring magnetization of strongly correlated 2D electrons. Since his PhD and second Post-Doc at Univ of Nottingham he has been working on a variety of mesoscopic devices. His research group at IISER, Mohali, India works on a variety of mesoscopic devices at low temperatures. Special focus is on low temperature dissipation phenomena in metallic nanomechanical resonators and novel 2D electron devices. The present work was published in Nano Lett. 2021, 21, 7, 2975-2981



Title: Continuous Nature Factory and Characterization of One-dimensional (1D) Silver and Palladium Nanostructures

Shohreh Hemmati, Assistant Professor, School of Chemical Engineering, Oklahoma State University, USA

Abstract

One-dimensional (1D) metal nanostructures synthesis with precise control over size and morphology is an essential way to tune their properties for practical applications in surface plasmonic, chemical/biological sensing, antimicrobial surfaces, high-performance catalysis, and transparent conductive films (TCFs) manufacturing, to name a few. Nowadays, green noble metal nanoparticle synthesis processes utilizing natural precursors are of great interest because of their advantages as the cost effective, facile, less harmful, and sustainable technologies compared to the physical and chemical synthesis methods. However, these new techniques should be optimized not only in terms of scale-up capability, but also in aspects of product quality and performance.

Our group taking different approaches for the synthesis of 1D metal nanostructures towards their green, sustainable, and continuous synthesis to overcome challenges in their physical and chemical batch synthesis methods. This presentation will include three main parts as 1) large-scale manufacturing of functionalized silver nanowire transparent conducting films; 2) protein engineering and processing of plant viral templates for controlled palladium nanorod synthesis; and 3) millifluidic, green, and sustainable synthesis of 1D silver and palladium nanostructures using tannic acid and L-ascorbic acid, respectively. Each part will also provide a fundamental understanding behind the synthesis process using different characterization techniques such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDXS), and Ultraviolet–visible spectroscopy (UV-vis) as well as the kinetic studies to propose the reaction mechanism behind theses novel synthesis processes.

Biography

Dr. Shohreh Hemmati is an Assistant Professor of Chemical Engineering at Oklahoma State University (OSU). She was a Postdoc at Purdue University before joining OSU in 2018. Dr. Hemmati received her Ph.D. in Chemical Engineering in 2016 from the University of New Hampshire. She obtained an M.S. in Energy Engineering in 2009 from Sharif University of Technology (Tehran, Iran), and from 2009-2012, she worked for the Sharif Energy Research Institute as a Research Scientist. She received her B.S. in Chemical Engineering in 2006 from Arak University (Arak, Iran). Dr. Hemmati's research interests are on green nanotechnology and nanomanufacturing. More specifically, she is working on metal nanostructures synthesis, with focuses on their green and sustainable synthesis using the millifluidic techniques to be integrated with artificial intelligence (AI) for the ultimate goal of precise control over their size and morphology. Dr. Hemmati's research is mostly funded by the National Science Foundation (NSF).

Title: Nanoscale visualization of temperature distribution on bundles of carbon nanotubes

Hiromu Hamasaki, Postdoctoral Fellow, Department of Mechanical Engineering, Osaka University, Japan

Abstract

Thermal management based on nanomaterials is a fascinating topic because of their unique and excellent thermal properties. For one, carbon nanotubes show extremely high thermal conductivity; it is an order of magnitude higher than highly thermal-conductive metals such as copper. However, assemblies of the carbon nanotubes have poorer thermal conductivity than individual ones. Generally, assemblies of nanomaterials show different thermal properties from individual nanomaterials. This is mainly due to numerous, various and nontrivial boundaries in the assemblies. Although we can comprehend average properties of the boundaries based on the measurements of macroscopic specimens, it is difficult to see what is happening at the microscopic boundaries. Here, we have conducted visualization experiments of temperature distribution in a transmission electron microscope by utilizing phase transition of metal nanoparticles. In our study, temperature distribution of bundled carbon nanotubes is investigated. The experimental results are validated by finite element analysis, and it show colossal difference of thermal conductivity between intra-nanotube and inter-nanotube transport. Our methodology can aid in visualizing nanoscale thermal transport that is not restricted to carbon nanotubes.

Biography

Dr. Hiromu Hamasaki obtained his PhD (Engineering) from the University of Tokyo in 2019. Currently, he is a postdoctoral fellow at Osaka university, Japan. His area of interest is carbon nanotubes, heat transfer and electron microscopy.

Title: Optofluidics and its applications

Anna Pyayt, Associate Professor, Department of Chemical, Biological and Materials Engineering, University of South Florida, USA

Abstract

Opto-fluidics is a field focused on manipulating fluids with light for a variety of applications. Here we present our findings on several new regimes of opto-fluidic manipulation that can be engineered using careful design of micro-currents. We theoretically optimize these regimes using COMSOL Multiphysics™ and present three sets of simulations and corresponding opto-fluidic experiments. We theoretically and experimentally demonstrate that optically controlled micro-currents can be used to capture and move around variety of microscopic objects ranging from cells and nanowires to whole live worms. We also show that optofluidic manipulation can be used for improved biomedical instrumentation and diagnostic devices.

Biography

Dr. Anna Pyayt is an Associate Professor at the University of South Florida. She is the head of the Innovative Biomedical Instruments and Systems (IBIS) lab. Dr. Pyayt joined USF after being an NSF Computer Innovation Fellow and Postdoctoral Fellow at Stanford University. She earned her dual Ph.D. in Electrical Engineering and Nanotechnology from the University of Washington. Some of her research was published in Nature Photonics and Nature Nanotechnology, highlighted in Science and Nature. She designed and developed many innovative systems and instruments including Telescopic Pixel display technology that was created in collaboration with Microsoft Research. She was also the first scientist to demonstrate a novel optical interconnect between a photonic and multiple plasmonic waveguides enabling fabrication of new Biomedical nano-chips (published in Nature Nanotechnology). Her project on Mobile ELISA point-of-care system for biomedical testing was chosen by Elsevier among thousands of papers for international news coverage.

Title: Thermodynamically stable, spray-coated nanoparticle solar selective absorbers with >94% optical-to-thermal conversion efficiency at 750°C

Jifeng Liu, Associate Professor, Thayer School of Engineering, Dartmouth College, USA

Abstract

Concentrated solar power (CSP) systems offer a great advantage over photovoltaics in overcoming the solar electricity intermittency issue because it can produce electricity using stored thermal energy at night. Generation 3 (Gen3) CSP systems require a high operation temperature ≥750°C to increase the power-cycle efficiency beyond 50%, exceeding that of the best research photovoltaic cells so far (~47%). However, such a high operation temperature poses a notable challenge to high temperature materials. A critical challenge is the lack of solar selective absorbers that demonstrate both high optical-to-thermal energy conversion efficiency ηtherm approaching 95% and long-term thermal stability at >750°C in air. Existing solar absorbers either have limited ηtherm≤89% or deteriorate significantly within 500h at 750°C; some of these also require costly vacuum deposition for stringent thickness control. In this paper, we present low-cost, highly scalable spray-coated transition metal oxide nanoparticle (NP) pigmented solar selective coatings on various types of Inconel alloy tube sections that are thermodynamically stable at 750-800°C in air, maintaining ηtherm>94.4% under a solar concentration ratio of C=1000 after 60 simulated day-night cycles between 750°C and 25°C. Such a high efficiency is achieved by optimizing the d-band optical absorption spectra of transition metal ions, engineering their valences and stoichiometry for maximal absorption in the solar spectral regime and minimal thermal emittance losses in the infrared regime at the same time. We were also able to maintain or even slightly increase the efficiency when operating at 750°C in air by engineering the interdiffusion of transition metal ions between the coating and the Inconel substrate to our advantage. These results indicate that the transition metal oxide nanoparticle solar selective coatings not only provide higher efficiency, but also greatly enhanced the thermal stability for future generations of high-efficiency CSP systems.

Biography

Dr. Jifeng Liu received the B.S. and M. S. degrees in materials science and engineering from Tsinghua University, Beijing, China, and the Ph.D. degree in materials science and engineering from the Massachusetts Institute of Technology. He is currently an Associate Professor and the Materials Science and Engineering Program Lead at the Thayer School of Engineering, Dartmouth College. His major research field is photonic materials and devices, including integrated photonics for ultralow energy photonic datalinks as well as nanomaterials and nanostructures for photodetectors, image sensors, modulators and solar energy harvesting. He has authored or coauthored more than 90 peer-reviewed journal papers, more than 60 conferences papers, and six book chapters, which have been cited over 11,000 times according to Google Scholar. Dr. Liu has also been granted 15 U.S. patents related to nanophotonic materials and devices. He is a recipient of NSF CAREER Award, a Fellow of the Optical Society of America (OSA), and a Senior Member of the Institute of Electrical and Electronics Engineers (IEEE).

Title: Simple One Step Synthesis of Dual Emissive Heteroatom Doped Carbon Dots for Acetone sensing in Commercial Products and Cr (VI) reduction

Naveen Kumar Reddy Bogireddy, Post Doctorate, Condensed matter physics, Institute of Physics, The National Autonomous University of México, Mexico

Abstract

In this work, highly stable and sustainable dual emissive heteroatom doped carbon dots (DECDs) have been synthesized under optimized conditions, characterized and applied as nano optical sensor for acetone, chromium (VI) and iron (III). The as-prepared DECDs exhibit comparable PL intensities when excited at 254 nm, covering the entire visible spectrum with a flat band signal. The stability was tested up to 48,000 s continuous excitation under Xenon flash lamp, saline solution, pH and temperature. As-prepared DECDs demonstrated an excellent fluorometric-based selectivity towards Acetone, Cr (VI) and Fe (III) which are important toxic pollutants from natural disasters like forest fires and volcanic gases, and processing of plastics, cleaning, house hold products industries and waste water. The selectivity of the nanoprobes has been tested over 28 different analytes. Further, the optical sensing of acetone was tested in commercial products and direct reduction of Cr (VI) to Cr (III) in spiked tap water samples under ambient conditions.

Biography

Dr. Naveen Kumar Reddy Bogireddy obtained his Masters in Nano Technology at Vellore Institute of Technology (VIT) University, India and his PhD (Applied Sciences and Engineering) from the Autonomous State University of Morelos (UAEM), Mexico. He is previously worked in MeRITs Engineering college as assistant professor, Andhra Pradesh, India. His PhD research was based on the heterogeneous catalytic reduction of several industrial organic contaminants with major focus on developing new reusable and eco-friendly catalysts which were tested in the catalysis and sensing applications. He currently doing post doc at condensed matter physics, Institute of Physics, The National Autonomous University of México (UNAM), México. His area of interest is nanomaterials for Energy and Environmental Applications. He has published various papers in peer reviewed journals including Chemical Engineering Journal, Journal of Hazardous Materials, Catalysis Today etc.

Title: Tuning spin injection at hybrid molecule magnet interfaces by molecular design

Angela Wittmann, Postdoctoral fellow,
Massachusetts Institute of Technology, USA

Abstract

Organic semiconductors have recently been found to have a comparably large spin diffusion time and length [1]. This makes them ideal candidates for spintronic devices. However, spin injection and transport properties in organic semiconductors have yet to be fully understood The efficiency of spin injection from a ferromagnetic material into an adjacent non-magnetic material is given by the spin mixing conductance geff. It can be quantified by measuring the linewidth broadening of the ferromagnetic resonance (FMR) absorption of the ferromagnet due to an increase in Gilbert damping caused by spin injection into the adjacent non-magnetic material. Here, we use this technique to systematically study spin injection from a metallic ferromagnet permalloy, Ni80Fe20, into dinaphtho[2,3-b:2,3-f]thieno[3,2-b]thiophene (DNTT), one of the best performing small molecule organic semiconductors to date. The unique tunability of organic materials by molecular design allows us to study the impact of interfacial properties on the spin injection efficiency systematically. We show that both, spin injection efficiency at the interface as well as the spin diffusion length in the molecule can be tuned sensitively by the interfacial molecular structure and side chain substitution of the molecule [2].

[1] S. Watanabe*, K. Ando* et al., Nature Physics, 10, 308–313 (2014)
[2] A. Wittmann et al., Physical Review Letters, 124, 027204 (2020)

Biography

Dr. Angela Wittmann received her BSc in Physics from the Swiss Federal Institute of Technology (ETH Zurich) and a Ph.D. in Physics from the University of Cambridge (UK) in 2019. She is currently a postdoctoral fellow at the Massachusetts Institute of Technology (USA) in the group of Prof. Geoffrey Beach at the Materials Research Laboratory. Her research explores the control of the spin degree of freedom and spin dynamics in unconventional condensed matter materials such as organic semiconductors and antiferromagnets. Using different experimental techniques, including magneto-transport measurements and x-ray imaging, she aims to tackle the challenges posed by today's vast amount of data by developing novel ultrafast and robust spin-based memory technologies.

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