State-of-the-art Nanofabrication
Fundamentals and Advanced Applications

Tuesday, May 29, 2018
8:30 am – 3:30 pm

The popular EIPBN Short Courses will take place on Tuesday, May 29th, 2019. This all-day event features 5 lectures given by leading authorities in each field. This is a perfect opportunity to further your knowledge of nanofabrication processes and applications while interacting in a classroom setting with experts in their field.

Space is limited! Please register early to secure your spot.

Session Chairs:
Stefano Cabrini, Molecular Foundry - Lawrence Berkeley National Laboratory
Weilun Chao, Center for X-ray Optics - Lawrence Berkeley National Laboratory

8:30 am
Welcome and Introduction

8:45 am
Emerging Hardware for Neuromorphic Computing – Qiangfei Xia ; Department of Electrical and Computer Engineering, University of Massachusetts

9:45 am
Nanofabrication Techniques for Processing 2D Materials and Devices – Xiaogan Liang, Department of Mechanical Engineering, University of Michigan

10:45 am COFFEE BREAK

11:00 am
Materials for Advanced Lithgraphy – Greg Wallraff, IBM Almaden Research Center

12:00 pm – 1:30 pm Lunch

1:30 pm
Pattern transfer technology for nanofabrication - Ming Lu, Brookhaven National Laboratory

2:30 pm
Update on EUV Lithography – Patrick Naulleau, Director, Center for X-ray Optics, Lawrence Berkeley National Laboratory

Abstracts

Emerging Hardware for Neuromorphic Computing: It becomes increasingly difficult to improve the speed-energy efficiency of traditional digital processors because of limitations in transistor scaling and the von Neumann architecture. To address this issue, computing systems inspired by the extremely high energy efficiency of the brain offer an attractive solution. In this short course, I will first introduce a few emerging devices using resistance as the state variable, including phase change memory (PCM), memristor/resistance switch (RRAM), magnetoresistance switch (MRAM) and ferroelectric tunnel junction (FTJ). I will then address how these devices can be integrated into large arrays to implement artificial neural networks for machine learning applications. Finally, I will discuss a few novel concepts, in particular devices that can faithfully emulate bio-realistic synaptic and neuronal functions as building blocks for spiking neural networks.

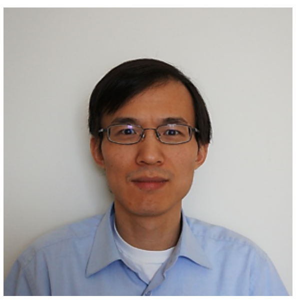
Nanofabrication Techniques for Processing 2D Materials and Devices: This short course presentation introduces the recent progress in development of top-down nanofabrication and nanomanufacturing techniques for processing 2D materials into functional devices. Emerging 2D materials, such as graphene and transition metal dichalcogenides (TMDCs), provide attractive electronic, photonic, chemical, and mechanical properties, and potentially enable new devices applications in the fields such as biosensing and clinical diagnosis, artificial intelligent (AI) systems, and energy harvesting. However, the current state-of-the-art semiconductor manufacturing processes, such as resist-based lithography and plasma-based feature etching, are not suitable for mass production of 2D-material-based commercial devices. In this presentation, I will briefly talk about the current scientific and technical challenges involved in manufacturing of 2D materials and devices as well as the recent exploration works seeking to develop non-traditional lithography approaches that could address such challenges.

Materials for Lithography: This short course will describe the development and applications of chemically amplified resists from the beginnings of deep ultraviolent lithography to today's EUV resists. Emphasis will be on the properties and chemistry of these materials and how resist design determines lithographic performance. Included will be a discussion of alternative patterning technologies such as multiple patterning, DSA and nanoimprint. New inorganic resist materials and the special challenges facing the development of EUV resists for the sub 7 nm nodes will be addressed.

Pattern transfer technology for nanofabrication: Pattern transfer, in terms of micro/nanofabrication, refers to the process which transfer the patterns generated from lithography processes to substrate or other materials. This introductory course will provide an overview of both subtractive and additive pattern transfer techniques, including dry etch, wet etch, lift-off and electrochemical deposition. The focus will be on those working in the sub-100-nm critical dimension region. I will use x-ray zone plate fabrication in the case study to compare all these techniques.

Update on EUV Lithography: EUV Lithography will soon be replacing DUV immersion lithography in high volume production. With numerous 0.33 numerical aperture (NA) tools in the field, EUV has proven itself as technically extremely capable, yet availability remains a gating item for the insertion of EUV into high volume production. On the research and development front, the activity in EUV has now in large part shifted over to high numerical aperture (NA ≥ 0.5) EUV. High NA significantly stresses several current challenges and brings with it fundamentally new challenges. The most significant new challenge arises from angular bandwidth limitations of the mask multilayer requiring the use of anamorphic optics, or new multilayer material systems. The most significant extended challenge revolves around stochastics in photoresist materials and exposure processes. This tutorial will include a general introduction to EUV technology, a brief overview of the current commercialization status, and a description of the major challenges facing the extendibility of EUV highlighting new research facilities and activities focused on addressing these emerging challenges.

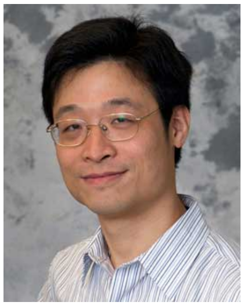
Speaker Biography



Qiangfei Xia - Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, MA 01003 Dr. Xia is a professor of Electrical & Computer Engineering at UMass Amherst and head of the Nanodevices and Integrated Systems Lab (http://nano.ecs.umass.edu). He received his Ph.D. in Electrical Engineering in 2007 from Princeton University, and spent three years at the Hewlett-Packard Laboratories before joining UMass. Dr. Xia's research interests include beyond-CMOS devices, integrated systems and enabling technologies, with applications in machine intelligence, reconfigurable RF systems and hardware security. He is a recipient of DARPA Young Faculty Award, NSF CAREER Award, and the Barbara H. and Joseph I. Goldstein Outstanding Junior Faculty Award.

Dr. Xiaogan Liang is currently working as a Associate Professor at The Mechanical Engineering Department of University of Michigan (UM) : http://nnl.engin.umich.edu/. Before joining UM, Dr. Liang was a Staff Scientist working at The Molecular Foundry, Lawrence Berkeley National Laboratory. His current research interests are focused on nanomanufacturing and microsystem integration, nanoelectronics and optoelectronics based on low-dimensional nanostructures, biosensors, and flyer/microdrone sensors. Dr. Liang has coauthored 62 journal publications and 46 conference presentations, has given 29 invited presentations, and has 5 US patents. Dr. Liang is the recipient of NSF CAREER Award, and he is the member of Sigma Xi, IEEE, and ASME. Dr. Liang obtained a BS in Physics from Peking University, a MS in Condensed Matter Physics from Institue of Semiconductors, Chinese Academy of Sciences, and a Ph.D. in Electrical Engineering from Princeton University.

Gregory Wallraff is a staff scientist at the IBM Almaden Research Center in San Jose, CA. He joined IBM in 1987 after receiving a PhD in Physical Organic Chemistry from the University of Utah. Since then he has worked several areas of technology with a focus on photoresists for semiconductor manufacturing. He has 120 publications and 39 patents



Ming Lu - Ming Lu is a staff scientist in the Center for Functional Nanomaterials of Brookhaven National Laboratory, a U.S. Department of Energy user facility. His research focuses on the exploration of new methods and new materials for nanofabrication, especially for photonics and x-ray microscopy applications. He received his B. S. and M. S. in Physics and Condensed Matter Physics, respectively, from Fudan University, China and Ph.D. in Physics from Stony Brook University, and was an adjunct assistant professor in the department of mechanical engineering of Stony Brook University.

Patrick Naulleau received his B.S. and M.S. degrees in electrical engineering from the Rochester Institute of Technology, Rochester, NY, in 1991 and 1993, respectively. He received his Ph.D. in electrical engineering from the University of Michigan, Ann Arbor in 1997 specializing in optical signal processing and coherence theory. In 1997 Dr. Naulleau joined Berkeley Lab on the EUV LLC program building the world's first EUV scanner. From June 2005 through March 2008, Dr. Naulleau additionally joined the faculty at the University at Albany, SUNY as Associate Professor, also concentrating in the area of EUV lithography. In April 2010 Dr. Naulleau took the position of Director of the Center for X-ray Optic at Lawrence Berkeley National Laboratory. Dr. Naulleau has over 300 publications as well as 19 Patents and is a Fellow of OSA and SPIE.