Keynote: “Directing Self-Assembly and Defect Formation in Compound Semiconductors”

Lattice and atomic mismatch strain greatly impact the fundamental physics of thin-film growth. Our research group investigates aspects of these issues in III–V compound semiconductors, including the atomic surface structure, self-assembly of nanostructures, and defect formation. We also examine methods to direct self-assembly and defect formation by in situ patterning using focused ion beams (FIB). The atomic surface structure of compound semiconductors plays an important role in the growth of alloyed films, influencing both macroscopic properties, such as compositional uniformity and morphology, and microscopic atomic positions through ordering and surface segregation. Our scanning tunneling microscopy experiments demonstrate that many compound semi-conductor alloys exhibit multiple surface structures. Calculations show that the shape and distribution of the reconstruction domains are determined by elastic relaxation between them. We use Monte Carlo simulations to examine the effect of finite temperature on the free energy of surface reconstructions to determine the role of entropy on surface stoichiometry and atomic ordering. We are also studying in situ surface patterning as a route to controlling film growth, including the self-assembly of nanostructures and formation of strain-relieving defects. In this work we use a novel in vacuo FIB and growth system. Growth of InAs quantum dots on FIB-irradiated GaAs substrates shows that quantum dots nucleate exclusively at ion-induced holes. Photoluminescence studies show that FIB-induced quantum dots are optically active for ion doses less than a critical value. Lattice-mismatched films have been grown on blanket ion-irradiated and topographically patterned substrate regions in an effort to engineer defect formation.

Keynote speaker: Joanna Mirecki Millunchick

Joanna Millunchick is an associate professor of materials science and engineering at the University of Michigan and affiliate of the applied physics program and the Michigan Center for Theoretical Physics. She received a BS in physics in 1990 from DePaul University and a PhD in materials science and engineering in 1995 from Northwestern, where she held the General Electric Fellowship. Millunchick was a postdoctoral fellow at Sandia National Laboratories. Her general research interests involve manipulating matter and particles on the nanoscale to enable the design of new electronic materials for optoelectronic and microelectronic applications. In 2004 she spent a sabbatical at Northrop Grumman Corp. and the University of California, Los Angeles, where she worked on the characterization of GaN-based microelectronics using X-ray diffraction techniques. Millunchick teaches students from across the unversity and has conducted pedagogical research examining the efficacy of Internet-based resources in student learning. She has received an NSF Career Award and a Sloan Foundation Fellowship, among other awards.

26th Annual Hilliard Symposium

The John E. Hilliard Symposium is the Department of Materials Science and Engineering's annual capstone event, where we highlight the original research of senior graduate students. Now in its 26th year, the symposium encourages communication between the department and representatives of companies and agencies that support our work. It is also an opportunity to welcome back alumni who are in the audience.

John E. Hilliard, 1926–87

John E. Hilliard joined the Northwestern faculty in 1962 and taught here for the next quarter of a century. Born and educated in the United Kingdom, he received a PhD from the University of Liverpool. There followed a postdoctoral appointment at the Massachusetts Institute of Technology and six years at the General Electric Reseearch Laboratory before he came to Northwestern.

Professor Hilliard was an inspiring teacher for not only his students but also his colleagues and the wider metallurgical community. His work included four areas of research: the study of the thermodynamic and kinetic processes in inhomogeneous systems; the quantitative characterization of structure; the theoretical and experimental study of spinodal decomposition; and the synthesis and investigation of compositionally modulated films. The last two areas represent pioneering work cited with enormous frequency.

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McCormick

Northwestern Engineering

John E. Hilliard Symposium

May 14, 2009

9 a.m. to 5 p.m.

Transportation Center, 600 Foster Street

Northwestern University Evanston campus

Keynote speaker:

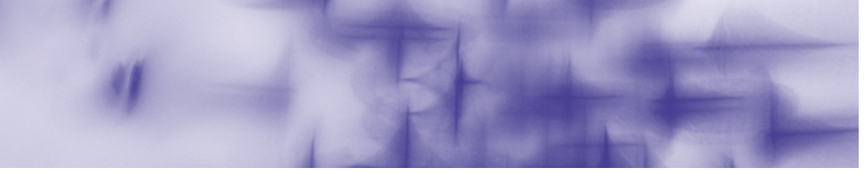
Joanna Mirecki Millunchick

Associate Professor of Materials Science and Engineering

University of Michigan, Ann Arbor

Robert R. McCormick School of Engineering and Applied Science
Northwestern University

Department of Materials Science and Engineering



Morning Schedule

9:30 –10:10 a.m. Keynote: “Directing Self-Assembly and Defect Formation in Compound Semiconductors,” Joanna Mirecki-Millunchick

10:10–10:30 a.m. Break

10:30–10:50 a.m. “Pyramidal Nanogratings: A Platform to Explore New Plasmonic Materials,” Hanwei Gao

10:50–11:10 a.m. “Triblock Copolymer Gels: Structure, Fracture Behavior, and Application In Ceramics,” Michelle Seitz

11:10–11:30 a.m. “Stresses and Phase Transformations in Plasma-Sprayed Environmental Barrier Coatings,” Bryan Harder

11:45 a.m Lunch at James L. Allen Center

Afternoon Schedule

2–2:20 p.m. “Characterization and Nanopatterning of Functional Organics on Hydrogen-Terminated Si(111),” Joshua Kellar

2:20–2:40 p.m. “Tailoring the Physical Properties of Polymers via Solid-State Processing and Production of Nanocomposites,” Cynthia Pierre

2:40–3 p.m. “Atom-Probe Analysis of Semiconductor Nanowires: Toward Understanding the Incorporation of Dopants,” Daniel Perea

3–3:20 p.m. “Bioinspired Interfacial Modification for Designer Polymer Nanocomposites,” Lesley Hamming

3:20–3:40 p.m. Break

3:40–4 p.m. “Atomic-Scale CharacterizatIon of Molecular Chains on Si(100):H,” Michael Walsh

4–4:20 p.m. “Effects of Tantalum on the Phase Decomposition of a Model Ni-Al-Cr Superalloy on a Nanoscale,” Chris Booth-Morrison

4:20–4:40 p.m. “Local Electrical and Dielectric Properties of Nanocrystalline Solid-Oxide Fuel Cell Electrolytes,” Nicola Perry

PhD Student Speakers

Chris Booth-Morrison obtained a BS degree in metallurgical engineering from McGill University. Working with David Seidman at Northwestern, he studies the kinetic pathways of γ/γ' phase transformation in model Ni-Al-Cr superalloys using atom-probe tomography in concert with first-principles calculations and Monte Carlo and thermodynamic simulations. This work is done in collaboration with Ronald D. Noebe of NASA.

Hanwei Gao received a BS in physics in 2004 from the University of Science and Technology of China and then joined Teri Odom’s group at Northwestern, focusing on plasmonic crystals. He received the Materials Research Science and Engineering Center Fellowship in 2007.

Lesley Hamming graduated from Northwestern with honors in mechanical engineering. As an undergraduate she researched carbon nanotube-polymer composites with Catherine Brinson and has worked with Brinson and Phillip Messersmith during her graduate study, for which she was awarded NSF and Northwestern University Presidential Fellowships. Her research won a poster award at the spring 2007 Materials Research Society meeting. She helped build a summer internship program at nanotechnology companies for high school students.

Bryan Harder graduated from Northwestern in 2004 with a BS in materials science and engineering. His undergraduate and graduate research studies have focused on aspects of alternative energy applications. These include transparent conducting oxides used in solar cells, hydrogen separation membranes, and fuel cells. His PhD research, advised by Katherine Faber, has focused on protecting materials used in high-efficiency natural gas burning turbine engines used for generating electricity.

Joshua Kellar received a BS from Georgetown University, where he majored in physics and English. He received an MA in creative writing from Boston University and worked for three years at the Federation of American Scientists before coming to Northwestern. Advised by Mark Hersam, Kellar is working on novel techniques to pattern organic molecules on silicon surfaces.

Daniel Perea graduated in 2003 with a BS in chemistry from the University of California, Riverside, and then produced and sold single-walled carbon nanotubes for Carbon Solutions, Inc. He is a fifth-year graduate student in Lincoln Lauhon’s research group. His research focuses on the use of atom-probe tomography to map the three-dimensional dopant distribution in individual semiconductor nanowires to understand how the optical and electronic properties can be engineered by the controlled incorporation of dopants.

Nicola Perry received a BS in materials science and a BA in French studies with high honors from Rice University. There she researched carbon nanotube–ceramic nanocomposites. Now in her fourth year at Northwestern, she is advised by Thomas Mason. She works in the interdisciplinary Department of Energy fuel cell group to study nanostructured ceramics that could help lower the operating temperature of solid-oxide fuel cells. She received an NSF graduate research fellowship and an American Society of Materials Chicago chapter poster award and was selected to NSF’s Fostering U.S.-Australian Research Collaborations in Materials program.

Cynthia Pierre obtained a BS from Princeton University in 2003. There she received the Tau Beta Pi Prize and a Gates Millennium Scholarship, which also funded four years of doctoral study at Northwestern. Under the guidance of John Torkelson, she is working on the production and characterization of polymer nanocomposites using solid-state shear pulverization. She was awarded a Selected Professions Fellowship from the American Association of University Women and the Dow Sustainability Innovation Challenge for her work to improve recycling of polyethylene terephthalate (PET). She will begin her career at Dow Chemical Company in July.

Michelle Seitz obtained a BS in materials science and engineering with a minor in literature from the Massachusetts Institute of Technology. Coadvised by Katherine Faber and Kenneth Shull, she is working on the structure-property relationships in model polymer gels to better understand the linear, nonlinear, and fracture behavior of soft materials as well as how these materials can be used in the processing of ceramics. Her awards include an NSF Graduate Fellowship, Cabell Fellowship, Alan Gent Distinguished Student Paper Award, and Peebles Award for Graduate Research in Adhesion Science, and she was a finalist for the 2009 Frank J. Padden Jr. Award for Excellence in Polymer Physics Graduate Research from the American Polymer Society Polymers Division.

Michael Walsh received a BS in physics from Creighton University in 1999. He is in Mark Hersam’s research group, working on the construction of an ultrahigh-vacuum scanning tunneling microscope that he has used to study the electronic and chemical properties of self-assembled organic nanostructures on silicon.