

Registration Form

U.S. professors, postdocs, and graduate students
(See other side for NSF Fellowships).

Name: _____

Title: _____

Address: _____

City: _____ State: _____

Zip Code: _____ Country: _____

E-mail: _____

Affiliation (will be printed on your name tag)

Phone: (____) _____

Institute Mission

- To identify and promote important areas of nanotechnology, and to create new areas of focus which will augment current nanotechnology research and development by universities, industries and government.
- To train future and practicing engineers, scientists and educators in the emerging areas of nanotechnology, nano-engineering, nano-mechanics, and nano-materials.
- To exchange new ideas, disseminate knowledge and provide valuable networking opportunities for researchers and leaders in the field.

Course Description

Modern technological society is increasingly concerned with high performance materials, and in achieving good efficiency in energy conversion, communications, computation, and chemical processing. This is evidenced by the high demand of microelectronics, and they have become an integral part of our lives nowadays – computers, cell phones, iPods, automobiles, aerospace systems, and biomedical systems all consist of these ever-shrinking microelectronics. The advances in microelectronics technologies have brought and will continue to bring convenience to our daily lives, enhance health and safety, and help to make major scientific discoveries among many other advantages. The market demand for and applications of microelectronics are expanding rapidly ranging from consumer electronics to industry, homeland security, medical science, aerospace applications and so on, making great synergy with the existing technology.

In the last decade, various aspects of nanotechnology have been actively investigated to achieve specific goals in materials, medicine, electronics, and energy production. By dexterous manipulation of molecules, innovative concepts of materials and devices have been proposed and developed. Such molecular manufacturing requires rigorous

understanding of the fundamental science underlying molecular structures and its applications to artificial manipulation of molecules in order to achieve specific functions with high efficiency. Upon the completion of such functional materials at the molecular level, the interface from nanoscale to micro- and macro- scale should be provided to lead the novel nanomaterials to a real marketplace.

This short course will cover topics from atomic-level handling to molecular level manufacturing and, ultimately to final applications. Major research and development in nanotechnology will be reviewed through the talks. Professor Mark Hersam will discuss atomic level manipulation by scanning probe microscopy. High resolution lithography can lead to modification of surface properties at the atomic level, which potentially benefit storage devices of extremely high density. Professor Hersam will also provide an introduction to the properties and processing of carbon nanotubes. In particular, a scalable and industrially viable strategy for producing monodisperse carbon nanotubes that was recently invented in the Hersam Laboratory will be featured. As a fundamental building block toward multi-functional materials, nanoscale porous materials are discussed by Professor Don Ellis. The materials can be used for selective separation of molecules and molecular sensors. Requirements for regulation of mass and charge transport at the ion/electron level, in gas phase, and for molecular separations, catalysis, and sensing provide a set of 'chemical criteria' for design. Requirements for device stability and useful operational lifetime will impose possibly conflicting 'physical criteria.' Another important method for producing nano-scale structures is via thin film deposition. These can be in the form of nano-layered structures or self-assembled three dimensional structures. Professor Barnett will introduce the basics of thin film deposition methods, nucleation and structure, and properties. Properties to be discussed will include mechanical, electrical, and electrochemical, the latter relevant to thin and thick films in solid oxide fuel cells.

Upon the synthesis of novel materials, the characterization and manipulation of such materials with high accuracy will be a major challenge. This will be addressed by Professor Wing Kam Liu with modeling and simulation using the newly developed Immersed Electrokinetic Finite Element Method (IEFEM) coupled with multiscale physics to treat a complex multi-body interaction problem that contains deformable objects, ions, and fluids. The ions in the aforementioned problem complicate the situation by affecting the flow regime and distribution of the charges upon imposing an electric

field. The solution to this problem has important implications in micro/nano fluidic devices for bioengineering and medical applications. By using unique multiscale simulation tools, the handling of various nano-/bio- materials is mainly discussed with future prospects. The interface between nanomaterials and micro- or macro-scale devices requires intermediate nanostructures as a platform, which is achieved by nanomanufacturing steps. Nanoscale fabrication methods will be discussed by Professor Jae-Hyun Chung. Top-down methods in nanoscale science are reviewed with recently developed nanomanufacturing methods. On the other hand, bottom-up approaches assembling nanomaterials are introduced with new directions to designing nanoscale devices.

As future applications, micro/nanofluidic devices will be discussed with critical challenges by Professor Arun Majumdar. The scaling issues in energy production and fluids and heat transfer are discussed with emphasis on nanoscale fluidic phenomena and devices. These are relevant for processes such as energy-efficient separation of fuels. Nanoscale fluidic phenomena are also relevant for energy storage devices such as batteries. Furthermore, nanofluidics is important in analyzing and processing biological molecules. Nanoscale heat and charge transport are important in many energy applications such as thermoelectric refrigeration and power generation. A fundamental understanding of how chemical bonding and nanostructures influence transport is critical for these applications. Professor Majumdar will introduce the subject from macroscopic concepts and then highlight the differences in both science and engineering at the micro/nanoscales.

Program Outline

L: (lecture)

Mon 9:00-12:00

L1: Introduction to lithography (Dr. Hersam)

L2: Scanning probe microscopy (Dr. Hersam)

L3: Scanning probe lithography (Dr. Hersam)

Mon 1:00-4:00pm

L4: Introduction to carbon nanotubes (Dr. Hersam)

L5: Advanced processing of carbon nanotubes (Dr. Hersam)

L6: General principles of simulation: (Dr. Ellis)

Coupling of first-principles theory, experimental data, and simplified parameterized models

Tue 9:00-12:00

L7: Model building: 1. Macromolecular filters and nanoreactors (Dr. Ellis)

L8: Model building: 2. Multilayer structures for multifunctionality: from OLEDs to catalysts to bioactive films (Dr. Ellis)

L9: Model building: 3. Design of a robust solid oxide electrolyte (Dr. Ellis)

Tue 1:00-4:00

L10: Modeling: Electrokinetic assembly and manipulation (Dr. Liu)

L11: Application to biomaterials (Dr. Liu)

L12: Application to cell dynamics (Dr. Liu)

Wed 9:00-12:00

L13: Introduction to thin film processing (Dr. Barnett)

L14: Thin film nucleation and structure (Dr. Barnett)

L15: Properties of thin films (Dr. Barnett)

Wed 1:00-4:00pm

L16: Top-down vs. Bottom-up approaches (Dr. Chung)

L17: Nanomanufacturing (Top-down) (Dr. Chung)

L18: Nanomanufacturing (Bottom-up) (Dr. Chung)

Thu 9:00-12:00

L19: Scaling issues in micro/nanofluidics and their applications (Dr. Majumdar)

L20: Heat transport in nanoscales (Dr. Majumdar)

L21: Applications in thermoelectric energy conversion (Dr. Majumdar)

Thu 1:00-4:00

L22: Introduction to solid oxide fuel cells (Dr. Barnett)

L23: Solid oxide fuel cell nano- and micro-structure effects (Dr. Barnett)

L24: Fuel cell modeling (Drs. Ellis and Liu)

Course Credit and Pre-requisites

The total number of contact hours for the four-day program is 24, and 2.4 CEUs. There are certain pre-requisites for each topic. In order to maximize the learning experience, we will provide complete course materials to students prior to the class. Pre-requisite material will be reviewed briefly at the beginning of each course.

Instructors

Dr. Scott A. Barnett is a Professor in the Materials Science and Engineering department at Northwestern University. He is also founder of Functional Coating Technology LLC. After receiving his Ph.D. in Metallurgy from the University of Illinois at Urbana-Champaign in 1982, he held postdoctoral appointments at the University of Illinois and Linkoping University (Sweden). He took his present position at Northwestern in 1986. His research focuses on thin films and coatings produced by ion-assisted deposition, physical vapor deposition, and colloidal deposition methods. His

materials focus is on nano-layered nitride hard coatings, transparent conducting oxide thin films, and solid oxide fuel cells. Dr. Barnett has published over 160 papers in peer-reviewed journals, has 11 issued patents, and has been an invited speaker at many national and international conferences. In 1986 he was awarded the ONR Young Investigator Award, and in 1998 was honored as a Fellow of the American Vacuum Society.

Dr. Jae-Hyun Chung an Assistant Professor of Mechanical Engineering at University of Washington received his B.S. in 1995 and M.S. in 1997 from Sungkyunkwan University in Korea; his Ph.D. in 2004 from Northwestern University. He is interested in MEMS/Nanotechnology area, and in particular of the manufacturing of micro/nano structures. Examples of the research area are electric field guided molecular assembly and nanoscale structure fabrication using the shadow effect. He is also interested in the applications of such micro/nano structures. The applications include bio/chemical sensors using nanochannels, nanofibrils, and nanowires. In 2004, he received Samsung Electronics Humantech Thesis Award.

Dr. Donald E. Ellis, Professor of Physics & Chemistry at Northwestern University, and member of NU's Materials Research Center, and Institute of Environmental Catalysis. He received his B.S.(1961), M.S.(1964), and Ph.D.(1966) degrees from MIT, spending two years on the Physics faculty at Univ. of Fla. before joining Northwestern. Don is a Fellow of the American Physical Society, and member of the American Chemical Society, Materials Research Society, and Brazilian Physics Society; awards received include Sloan Fellowship, Fulbright Scholar (Netherlands), Nordita Visiting Prof.(Sweden), NAS/USSR Exchange Scholar, Fulbright Scholar (Brazil). He is currently Visiting Professor at Centro Brasileiro de Pesquisas Fisicas. Don works in the cross-disciplinary Materials Theory area with current emphasis on bioceramics, macromolecular and nanoparticulate structures, electroceramics, and catalytically active interface and surface systems. Atomistic simulations and Density Functional electronic structure analyses, in conjunction with experimental collaborations form the foundation of the materials design and analysis effort of the Ellis group and collaborators.

Dr. Mark C. Hersam is currently a Professor of Materials Science and Engineering at Northwestern University. His research interests include single molecule devices, nanofabrication, scanning probe microscopy, semiconductor surfaces, and carbon nanotubes. Since joining Northwestern University, Dr. Hersam has received several awards including the Beckman Young Investigator Award (2001), NSF CAREER Award (2001), ARO Young Investigator Award (2005), ONR Young Investigator Award (2005), Sloan Research Fellowship (2005), Presidential Early Career Award for Scientists and Engineers (2005), TMS Robert Lansing Hardy Award (2006), and AVS Peter Mark Award (2006). Dr. Hersam completed his Ph.D. in Electrical Engineering from the University of Illinois at Urbana-Champaign in 2000 under the support of a NSF Graduate Fellowship and an IBM Distinguished Fellowship. In 1997, Dr. Hersam received his M.Phil. in Microelectronic Engineering and Semiconductor Physics from the University of Cambridge (UK) under the support of a British Marshall Scholarship. Prior to graduate school, Dr. Hersam graduated with Highest Honors from the University of Illinois at Urbana-Champaign in 1996 with a B.S.

in Electrical Engineering. Besides his educational training, Dr. Hersam has also been employed by Argonne National Laboratory and IBM where he performed research on surface acoustic wave sensors and carbon nanotubes respectively.

Dr. Wing Kam Liu, Walter P. Murphy Professor of Mechanical Engineering at Northwestern University and Director of NSF Summer Institute on Nano Mechanics and Materials, received his B.S. from the University of Illinois at Chicago in 1976; his M.S. in 1977 and Ph.D. in 1981 both from Caltech. His research activities include concurrent and hierarchical bridging scale methods for computational mechanics, in particular, nano mechanics and materials, and multi-scale analysis. Selected Liu's honors include the Gustus L. Larson Memorial Award, the Pi Tau Sigma Gold Medal and the Melville Medal, all from ASME; the Thomas J. Jaeger Prize by the International Association for Structural Mechanics in Reactor Technology, and the SAE Ralph R. Teetor Educational Award, the Computational Structural Mechanics Award and Computational Mechanics Award from USACM and IACM, respectively. Liu serves on both the executive committee of the ASME applied mechanics division and the International Association for Computational Mechanics. He was the past president of USACM. Liu is cited by Institute for Scientific Information (ISI) as one of the most highly cited, influential researchers in Engineering, and an original member, highly cited researchers database.

Dr. Arun Majumdar received a B.Tech in Mechanical Engineering from the Indian Institute of Technology, Bombay (IIT-B) in 1985, and a PhD in Mechanical Engineering from the University of California, Berkeley in 1989, for research conducted in the laboratory of Professor Chang-Lin Tien. After being on the faculty of Arizona State University (1989-92) and University of California, Santa Barbara (1992-96), he began his faculty appointment in the Department of Mechanical Engineering at the University of California, Berkeley. He currently holds the Almy and Agnes Maynard Chair Professorship in the College of Engineering. In addition to his faculty appointment, Professor Majumdar serves as the Chair of the Berkeley Nanosciences and Nanoengineering Institute. He is also a member of the Nanotechnology Technical Advisory Group to the President's Council of Advisors on Science and Technology (PCAST). He served as the founding chair of the ASME Nanotechnology Institute, and is currently a member of the Council of Materials Science and Engineering at the Department of Energy and the Advisory Committee of the National Science Foundation's Engineering Directorate. Professor Majumdar is a recipient of the Institute Silver Medal (IIT-B) (1985), NSF Young Investigator Award (1992-97), ASME Melville Medal (1992), Gustus Larson Memorial Award of the ASME (2001), Distinguished Alumni Award from IIT-B (2002), and ASME Heat Transfer Memorial Award (2006). Professor Majumdar's research interests are in the broad area of mechanics and transport in nanostructured materials. Of particular current interest are phonon dynamics and transport in low-dimensional materials, materials and devices for thermoelectric energy conversion, transport and reactions in confined liquids (nanofluidics), chemomechanics of small and macromolecules with applications in chem/biosensing, and nanoscale imaging.

NSF Fellowships

NSF fellowships are available to professors, postdocs and Ph.D. candidates from US universities. The fellowship consists of full tuition plus a travel allowance if applicable. Please see web site for application forms. In addition, please submit a two-page vita in NSF format and a 200-word statement indicating why the short course will help your career by **April 1, 2007**.

Registration

Mail in the completed registration form with check or money order by **June 1, 2007**.

Make check or money order payable to:

Northwestern University

Send to:

Northwestern University, Dept. of Mechanical Engineering,
2145 Sheridan Rd., TECH B224, Evanston, IL 60208

Attn: Wing Kam Liu

Fees

The registration fee for the short course is: \$2,000.

An additional \$200 fee will be added to late registrations received after July 1, 2007. Register by May 1, 2007 and receive a 20% discount. The fee includes continental breakfast, coffee breaks, and lunch each day plus a Reception Dinner on Monday and a Banquet Dinner on Thursday as well as all presentation materials, lecture notes and appropriate review papers.

Location

The course will be held at Northwestern University.

Accommodations

A block of rooms has been reserved at special rates for short course attendees at the **Hilton Garden Inn**. Attendees should contact the hotel directly to make reservations by calling 847-475-6400 or 1-800-HILTONS, to qualify for special rates guests **must** mention "NSF Summer Institute on Nano Mechanics and Materials". The rooms at the **special rate of \$119 will only be held until May 31, 2007**.

Daily Schedule

The lectures start at 9:00 a.m. and end at 4:00 p.m. with a one-hour lunch break and breaks between each discussed topic.

For additional information, contact:

<http://tam.northwestern.edu/summerinstitute/Home.htm>

email: summerinstitute@mail.mech.northwestern.edu



NSF Summer Institute on Nano Mechanics and Materials *

Co-sponsored by: ASME, the NASA URETI BMat Center, NU Nanoscale Science and Engineering Center, Northwestern University, and the CSET, NSF IGERT on Virtual Tribology and AVS Science & Technology Society

Professor Wing Kam Liu (Director)
Professor Ted Belytschko (Co-Director)
Professor Yip Wah Chung (Co-Director)
Professor Q. Jane Wang (Co-Director)

Northwestern University, Robert R. McCormick School of Engineering and Applied Science, 2145 Sheridan Rd. Evanston, IL 60208

*Funded by the Civil and Mechanical Systems Division, monitored and guided by Dr. Ken P. Chong.

A Short Course on Inspiring the Coalescence of Fundamental and Application Specific Functional Nanomaterial Development

Instructors:

Scott A. Barnett (Northwestern University)
Jae-Hyun Chung (University of Washington)
Donald E. Ellis (Northwestern University)
Mark C. Hersam (Northwestern University)
Wing Kam Liu (Northwestern University)
Arun Majumdar (UC Berkeley)

July 9-12, 2007