MIT | PROFESSIONAL EDUCATION

Course title: **Multiscale Materials Design**

Dates: June 22-26, 2015 (**This course has limited enrollment. Apply early to guarantee your spot*.)

Register: http://web.mit.edu/professional/short-programs/courses/multiscale_materials_design.html

Learn how to design and manufacture better materials from less

As the demand for high-performance materials with superior properties, flexibility, and resilience grows, a new design paradigm from the molecular scale upwards has revolutionized our ability to create novel materials. This course covers the science, technology, and state-of-the-art in atomistic, molecular, and multiscale modeling, synthesis and characterization. Through lectures and hands-on labs, participants will learn how superior material properties in nature and biology can be mimicked in bioinspired materials for applications in new technology through a multi-hierarchy material structuring technology. Bridging multiple levels of length- and time-scales, this course trains participants in applications to polymers, metals and ceramics as well as composites. The course also covers sustainable infrastructure materials such as concrete and asphalt, and energy technology. The use of novel manufacturing techniques involving multi-material 3-D printing will play an important role in lectures and labs.

The course will focus on practical problem-solving computational tools paired with a detailed discussion of experimental techniques to probe the ultimate structure of materials, emphasizing tools to predict key mechanical properties. In hands-on labs, participants will use state-of-the-art additive manufacturing to synthesize optimized material samples via a direct route from computer to 3-D printer. Specific case studies of molecular mechanics, bio-inspired composites, and dynamic fracture of composites and polymers will be presented and carried out by participants in computational labs. Simulation codes, algorithms, and details of the implementations of different simulation technologies, including validation, will be presented, including practical issues such as supercomputing (hardware and software), parallelization, Graphics Processing Computing (GPU), and others. A specific focus is on structural polymers and composites, including innovative material platforms such as carbon nanotubes, graphene, and protein materials for bio-inspired materials.

What you will learn

- Practical problem-solving computational tools paired with a detailed discussion of experimental techniques to probe, understand and design the ultimate structure of materials – from atoms upwards
- Learn tools to predict mechanical properties such as strength, toughness, deformability, and elasticity, as well as optical, thermal and electronic properties
- Learn how to use multiscale tools in energy recovery and sustainable materials & structures
- Demonstrate the synthesis of computationally designed hierarchical composites using 3-D printing and other advanced manufacturing techniques, followed by subsequent mechanical testing. Includes validation of computational predictions, focused on fracture toughness and strength
- Learn how to critically evaluate & apply the use of computational tools in materials design, e.g.: molecular mechanics, nanotechnology, multiscale/hierarchical materials, and emerging technologies
- Learn fundamentals and codes to perform state-of-the-art techniques, such as molecular dynamics, molecular mechanics, and coarse-graining, used to cover a range of length- and time-scales
- Apply a new paradigm by introducing innovative material solutions for use in infrastructure and environment by hierarchical structuring

Who should enroll

Scientists, engineers, or employers from any industry in materials or that builds on a material interaction platforms (civil, medical, mechanical and material engineers, energy, pharmaceuticals, regenerative medicine, as well as construction materials such as concrete) who are interested in understanding how to optimize a material's structure, durability, and performance. There are no prerequisites for this course.

About the instructor

Markus J. Buehler, Head of the MIT Department of Civil and Environmental Engineering, is an internationally renowned materials scientist and Professor at the Massachusetts Institute of Technology. He directs the Laboratory for Atomistic and Molecular Mechanics (LAMM), leads the MIT-Germany program, and is Principal Investigator on numerous national and international research programs. Buehler's primary research interest is to identify and apply innovative approaches to design better materials from less, using a combination of high-performance computing, new manufacturing techniques, and advanced experimental testing. He combines bio-inspired materials design with high-throughput approaches to create materials with architectural features from the nano- to the macro-scale, and applies them to various domains that range from composites for vehicles, coatings for energy technologies, to innovative and sustainable construction materials.

Buehler is a sought-after lecturer and has given hundreds of invited, keynote, and plenary talks throughout the world. His scholarly work is highly-cited and includes more than 250 articles on computational materials science, biomaterials and nanotechnology, many in high-impact journals such as Nature and PNAS. He authored two monographs in the areas of computational materials science and bio-inspired materials design, and is a founder of the emerging research area of materiomics. He has appeared on numerous TV and radio shows to explain the impact of his research to broad audiences.

Buehler received the TMS Hardy Award, the MRS Outstanding Young Investigator Award, the Alfred Noble Prize, the ASME Thomas J. R. Hughes Young Investigator Award, the ASME Sia Nemat-Nasser Medal, the ASCE Rossiter W. Raymond Memorial Award, the ACS Stephen Brunauer Award, and the Leonardo da Vinci Award given by the Engineering Mechanics Institute of ASCE. He is also recipient of the National Science Foundation CAREER award, the United States Air Force Young Investigator Award, the Navy Young Investigator Award, and the Defense Advanced Research Projects Agency (DARPA) Young Faculty Award, as well as the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest honor bestowed by the United States government on outstanding scientists and engineers in the early stages of their careers. He was an invitee at several National Academy of Engineering Frontiers of Engineering Symposia and has delivered several plenary lectures at this forum. He recently received the Harold E. Edgerton Faculty Achievement Award for exceptional distinction in teaching and in research or scholarship, the highest honor bestowed on young MIT faculty. He serves as a member of the editorial board of numerous international publications, including the Journal of the Royal Society Interface, Nanotechnology, Computational Materials Science, and is Editor-In-Chief of BioNanoScience, a journal he co-founded. He is the founding Chair of the Biomechanics Committee at the Engineering Mechanics Institute of the American Society of Civil Engineers (ASCE), a member of the U. S. National Committee on Biomechanics, and Co-Chair of the Nanoengineering in Biology in Medicine Steering Committee of the American Society of Mechanical Engineers (ASME). He has chaired several international conferences in the area of materials science and engineering, nanotechnology, nanomedicine and biomechanics.