



# Northeastern

**Department of Civil and Environmental Engineering**

*Making Nano Big*

**Markus J. Buehler**

**Professor and Head**

**Department of Civil & Environmental Engineering,  
Massachusetts Institute of Technology, Cambridge, MA**

**Thursday, September 25th, 2014**

**12pm-1pm**

**458 Richards Hall**

## **Abstract**

What if we could design materials that integrate powerful concepts of living organisms – self-organization, the ability to self-heal, and an amazing flexibility to create astounding material properties from abundant and inexpensive raw materials? This talk will present a comprehensive review of bottom-up analysis and design of materials for various purposes – as structural materials such as bone in our body or for lightweight composites, for applications as coatings, and as multifunctional sensors to measure small changes in temperature or stress. These new materials are designed from the bottom up and through a close coupling of experiment and powerful computation as we assemble structures, atom by atom. Materiomics investigates the material properties of natural and synthetic materials by examining fundamental links between processes, structures and properties at multiple scales, from nano to macro, by using systematic experimental, theoretical or computational methods. We review case studies of joint experimental-computational work of biomimetic materials design, manufacturing and testing for the development of strong, tough and mutable materials for applications as protective coatings, cables and structural materials. We outline challenges and opportunities for technological innovation for biomaterials and beyond, exploiting novel concepts of mathematics based on category theory, which leads to a new way to organize hierarchical structure-property information. Altogether, the use of a new paradigm to design materials from the bottom up plays a critical role in advanced manufacturing, providing flexibility, tailorability and efficiency.

## **Bio**

*Professor Markus J. Buehler* is the Head of the MIT Department of Civil and Environmental Engineering, 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 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.

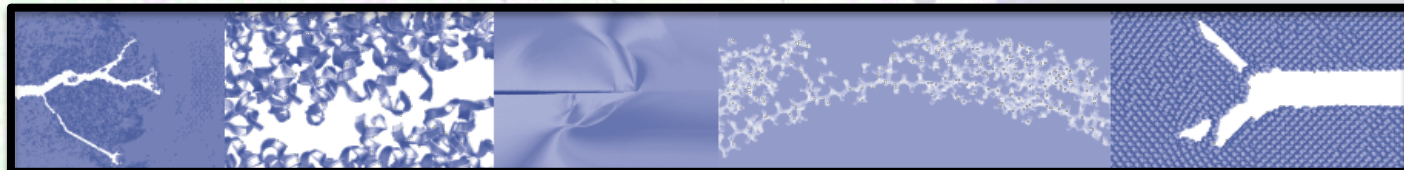
Buehler received the TMS Hardy Award, the MRS Outstanding Young Investigator Award, the ASME Thomas J. R. Hughes Young Investigator Award, the ASME Sia Nemat-Nasser Medal, the ASCE Rossiter W. Raymond Memorial Award, the ACS Stephen Brunauer Award, the ASCE Alfred Noble Prize, and the Leonardo da Vinci 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, 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.



# Markus J. Buehler, PhD

Department of Civil and Environmental Engineering

MASSACHUSETTS INSTITUTE OF TECHNOLOGY



## Education

- PhD, Civil Engineering, *MAX PLANCK INSTITUTE FOR METALS RESEARCH, UNIVERSITY OF STUTTGART*
- MS, Engineering Mechanics, *MICHIGAN TECH*
- BS/pre-diploma, Process and Chemical Engineering, *UNIVERSITY OF STUTTGART*

## Research Interests

- **Materials science and mechanics of natural and biological protein materials = MATERIOMICS**
- **Large-scale atomistic modeling**
- **Interactions of chemistry & mechanics, bridging chemical scales**

## Selected Service and Awards

- **Head, Laboratory for Atomistic and Molecular Mechanics**
- **PECASE, NSF CAREER, Young Investigator awards from ASME, MRS, Darpa, & US Navy**
- **Alfred Nobel Prize 2012**
- **Editor position for 9 journals**