Symposium on Undergraduate Nano-Education:
"Addressing the Challenges of Nanoscale Science & Engineering Education"

Presentation: "Interactive Simulations for Illustrating "Nano" Concepts: Nanoparticles, Nanowires, and Nanoporous Materials"

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Presenter Biography:

Richard D. Braatz is Millennium Chair and Professor of Chemical and Biomolecular Engineering and Lead of the Nanomaterials Work Circle for the National Center for Learning & Teaching in Nanoscale Science & Engineering (NCLT). He maintains an active research program in the simulation, design, and control of systems that have length scales ranging from the atomistic to the nanoscopic to the macroscopic, with applications including carbon nanotube-based devices, integrated circuits, microfluidic devices, biodegradable polymeric drug delivery systems, and protein and pharmaceutical crystallization. His efforts in teaching and research has been recognized by honors and awards including the UIUC School of Chemical Sciences Teaching Excellence Award, the Curtis W. McGraw Research Award from the Engineering Research Council, the Collaboration Success Award from The Council for Chemical Research, and the Excellence in Process Development Research Award from the American Institute of Chemical Engineers. Richard is a Fellow of the American Association for the Advancement of Science and the Institute of Electrical and Electronics Engineers. Through his involvement with the NCLT, he co-developed interactive software for students in chemistry, materials science, and engineering to explore phenomena important at the nanoscale. The software is available through the NanoEd Resource Portal, a web-based educational resource (http://www.nanoed.org).

Abstract:

This presentation discusses self-contained interactive software developed for teaching key ideas in nanoscale science and technology through applications to nanoparticles, nanowires, and nanoporous materials made of semiconductors, metals, and polymers. Interactive software is described for exploring

- How the successive addition of a chemical to a solution of gold nanoparticles can result in changes in the color of the solution, by changing the size of aggregates of gold nanoparticles.
- The relationship between the absorption rate with respect to the diameter of super-absorbent polymer particles.
- The illumination of titanium dioxide nanoparticles with ultraviolet light to excite its electrons to higher energy levels, which results in a series of chemical reactions that degrade organic chemicals in contaminated water. Students determine the characteristics of the nanoparticles and manipulate the ultraviolet light to maximize the degradation rate of the organic chemical.
- The manufacture of copper nanowires (called interconnects) in electronic devices via etching followed by electrochemical deposition. Students determine the diffusion and chemical reaction conditions that minimize defects in the nanowire.

The interactive software considers nanoconcepts associated with the importance of surface area-to-volume ratio as objects decrease in size, the dependence of chemical reactivity and electronic structure on size for nanosized particles, and the need for precise tradeoffs between competing physical phenomena to construct nanoscopic objects by self-assembly. Underlying most of the interactive software are mathematical models based on differential equations or Monte Carlo methods that have been configured in such a way that there are minimal delays in the user interactions with the software. The NanoEd Resource Portal (http//www.nanoed.org) that hosts the interactive software lists examples of appropriate courses to use the materials, which have been field-tested in community college science and university engineering courses. The interactive software was co-developed by teachers, scientists, and engineers.