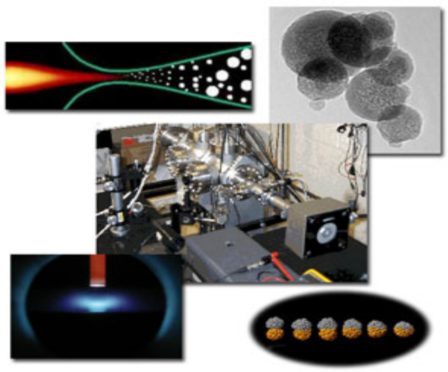
Nano-Manufacturing



While nanotechnology promises to revolutionize everything from energy production to cancer treatment, scientists must first tackle the fundamental problems of making, examining, and controlling precisely-shaped nanoparticles. Tumor-busting vesicles, handheld bio-scanners, and other futuristic systems will remain science fiction without practical and scalable nano-manufacturing capabilities. Researchers at the University of Maryland's NanoCenter have the manufacturing capabilities needed for turning nanotechnology's potential into reality.

Michael Zachariah, Sang Bok Lee, and John Fourkas manufacture intricate nano-structures needed to advance all fields of nanotechnology. Their novel technologies and specialized facilities have positioned them at the cutting edge of manufacturing for applications in environmental and toxicity testing, and medical diagnostics and drug delivery systems.

Sheryl Ehrman, Teng Li, and Gary Rubloff create nano-structures for energy technologies that are cost effective, environmentally friendly, and exponentially more powerful than current options. Their techniques enable extraordinary control over manufacturing at the nano-scale, a capability that extends to applications such as flexible electronics and sensor technologies.

Gottlieb Oehrlein uses plasma etching to "print" components at nano-scale resolution. His research on the interactions between plasma and organic molecules seeks to unlock the full potential of controlled patterning at nanoscale dimensions.
http://www.nanocenter.umd.edu/faculty/faculty_list.php

Standardizing Nanoparticles for Broad-Based Applications

Many nanotechnology applications remain only theoretical until the correctly sized and shaped substances can be made consistently and studied uniformly. At the Center for Nano-Manufacturing and Metrology – a collaborative effort between the university and the National Institute of Standards and Technology (NIST) – Michael Zachariah has assembled a research team with unmatched expertise for manufacturing and characterizing nanoparticles. Their work is critical for fundamental nanotechnology research, such as establishing the research protocols necessary for toxicity tests.

Zachariah's team also characterizes carbon nanotubes for targeted drug delivery, supplies precisely sized nanoparticles needed for animal testing of drugs, and works with the Department of Defense in propulsion research.

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Manufacturing Novel Nanotubes for Medical Applications

The nanotubes Sang Bok Lee manufactures overcome limitations impeding other drug targeting-and-release technologies. Lee uses dimension- and shape-controlled template synthesis, in which minutely defined cylindrical pores are filled with different materials to examine their promise for numerous applications. The process provides the high degree of control critical for all nano-manufacturing.

By precisely defining their inner and outer surfaces, Lee can give his nanotubes the properties of ideal drug carriers. He further discovered that adding iron oxide inside nanotubes allows them to be tracked with MRI systems. The oxide he developed is the only inorganic nanoparticle approved by the FDA as an MRI enhancement contrast agent.

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Complex, Multipurpose 3-D Nano-Infrastructure

John Fourkas makes complex 3-D nanostructures – containing intricate tunnels, bridges, and chambers – that can be used to create microscopic machines with moving parts. Fourkas invented Multiphoton Absorption Polymerization (MAP), which uses the focal point of a laser to harden viscous resins into precise shapes. By applying a novel "scaffolding" process, known as membrane assisted micro-transfer molding (MA-µTM), Fourkas transforms the shapes into the even more complex forms needed for 3-D micro-machines.

Fourkas has already attached objects to biological tissue without damage. This opens possibilities for embedding complex monitoring devices right into individual cells and for developing less invasive and more sensitive MRI technologies. Fourkas also explores this process for fabricating optical sensors and novel electrical components.

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Cost-Effective, Eco-Friendly Energy Production and Sensor Technologies

Sheryl Ehrman's research enables inexpensive, environmentally friendly nano-manufacturing. She employs gas phase synthesis, which uses a furnace to control expansion of molecules to the desired size. The technique does not use solvents, so it is a cost effective, "green" manufacturing process.

Ehrman collaborates with the U.S. Army to develop hydrocarbon-based fuel, with NSF to manufacture porous film-based gas sensors, and with NIST to create increasingly precise measurements for nanoparticles.

Gas phase synthesis has many potential applications for biotechnology, electrical and optical devices, and inexpensive production of solar energy.

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Polymer Based Print Manufacturing

Teng Li makes organic/inorganic hybrid polymer structures for applications in flexible electronics, solar energy, and lighting. Li uses roll-to-roll printing – a process much like that used for newspaper production – to create nanoscale circuitry with the deformation characteristics of springs (or other bendable objects). These circuits will become platforms for breakthrough products, such as televisions that can be rolled up like newspapers.

Recent research suggests that Li's polymer-based print manufacturing can increase exponentially the efficiency of solar cell panels. Li has also produced small Organic Light Emitting Diodes (OLEDs) that enable highly efficient, malleable light sources.

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Manufacturing at the Atomic Level

Gary Rubloff develops methods for a broad array of nanotechnology manufacturing applications. Using Atomic Layer Deposition (ALD), Rubloff deposits films over complex nano-topography one atomic layer at a time. This remarkable degree of control will allow existing semiconductor, storage, display, and sensor technologies to be produced on smaller scales and with more demanding device structures. It also enables manufacturing of new devices confined to nanoscale dimensions, and could revolutionize applications from energy generation and storage to targeted drug delivery.

Rubloff currently develops the equipment needed to scale up these techniques for industrial manufacturing.

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Plasma Etching for Organic Imaging

Gottlieb Oehrlein's work on plasma etching brings nanoscale resolution to image transfer in semiconductor fabrication. The process uses unique properties of ionized gases to carve ultra-fine grooves and traces into thin films of semiconducting materials. Plasma etching has been used since the seventies, but only recently has it been possible to etch structures on the nano-scale. With a Nanoscale Interdisciplinary Research Team (NIRT) grant from NSF, Oehrlein improves the design and manufacture of the base imaging material. These materials allow him to etch nano-scale structures, thus enabling production of smaller, more powerful chips that consume less energy.

Despite these advances, researchers do not fully comprehend the laws that govern interactions between plasma and organic molecules. Oehrlein therefore plans to research the scientific foundations for controlled patterning at nanoscale dimensions.

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