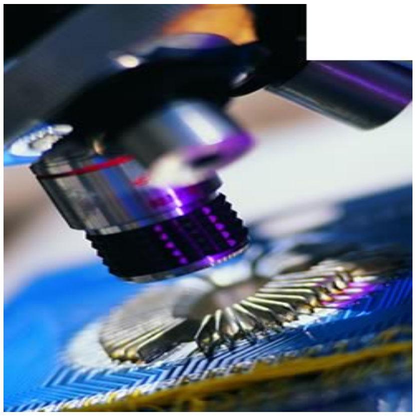
Nanotechnology at Maryland



Nanotechnologies – technologies using the special properties that materials exhibit at the billionth-of-a-meter scale – will revolutionize how we detect and treat health problems, create and use electronics, generate and store energy, and sense and control biochemical hazards. Due to our unique capabilities, the University of Maryland's NanoCenter has been a leader in extending the possibilities of nanotechnology.

The center, led by founding Director Gary Rubloff, is an interdisciplinary collaboration of chemists, biologists, physicists, and engineers. Rubloff coordinates the use of shared state-of-the-art facilities, guides nanotechnology education initiatives, and promotes technology transfer from the university to the marketplace.

The NanoCenter leads the industry in developing instrumentation and techniques central to the three critical tasks of all nanotechnology research – observing, creating, and controlling substances at the near atomic level. This basic research is applied in five specific areas: improving medical applications, understanding the health effects of nanoparticles, creating bio-electro-mechanical systems, developing electronic innovations, and expanding nano-manufacturing capabilities.

Nanotechnology for Medical Applications

Nanotechnology promises to transform medicine. The unique properties of nanoparticles offer better, safer ways to detect disease, neutralize pathogens, and repair traumatized tissue. And scientists at Maryland are developing novel techniques for targeted drug delivery, ultra-rapid diagnostics, and the next generation of tissue- and limb-reconstruction technologies.

Drug delivery and diagnostic technologies developed through the NanoCenter will erase many of the invasive and destructive elements of disease detection and treatment. Researchers create coated nanocapsules that release drugs only after these "smart" coatings indicate the presence of the intended target. The technique minimizes side effects typically caused by powerful compounds (like chemotherapy treatments). Maryland researchers have already successfully delivered drugs directly to tumors, with minimal absorption by non-target organs. They have also developed the only inorganic nanoparticle approved by the FDA as an MRI enhancement contrast agent.

Bill Bentley, an internationally renowned expert in bio-engineering, has pioneered test-bed "nanofactories" – tiny machines that sense when and where a drug is needed and then synthesize it at the proper dosage while traveling to the delivery site. Among many other applications, nanofactory technology can change the way we treat infection. By sensing and changing the chemical signals bacteria use to communicate with each other, nanofactories can shut down pathogens before they form antibiotic resistance.

Researchers at Maryland are also enabling the next generation of organic tissue replacement. They develop artificial muscles made of electro-active polymers, and cell-based sensors that signal these muscles to contract or extend. Also, cranio-facial surgeons at the University's dental school have used nanoparticle systems to deliver adult stem cells that can regenerate lost bone or cartilage. This process achieves functional and attractive therapeutic results without side effects.

Health Effects of Nanotechnology

While nanoparticles can be used for revolutionary medical advances, they can also pose health threats. Researchers at Maryland create breakthrough technologies for sensing these hazards and modifying particle designs to prevent damage.

Gary Rubloff and Elisabeth Smela have invented cell-based sensors for monitoring responses to hazardous substances. These sensors, or biochips, read biochemical messages from individual cells placed in nano-scale chambers. The research leads to novel, extremely precise pathogen identification methods and improves the efficacy and cost efficiency of clinical trials.

The measurement technologies Michael Zachariah develops are also critical for gauging the health impact of nanoparticles. His research supports work in characterizing pathogens, improving the nanotubes used for targeted drug delivery, and developing the research protocols needed to standardize toxicological testing.

bioMEMS – Labs on a Computer Chip

bioMEMS are Micro-Electrical Mechanical Systems applied to biotechnology. Sometimes referred to as "labs on a chip," these biocompatible, miniature machines can gather and transmit information from cells, and can often respond dynamically to that information. The NanoCenter's cutting edge research with bioMEMS promises major advances in mechanized drug discovery processes, non-invasive therapies, point of care medical diagnostics, and especially biochemical detection devices.

Elisabeth Smela, Pamela Abshire, and Benjamin Shapiro recently won the University of Maryland's Invention of the Year Award for their bioMEMS "cell clinic" pathogen detection system. The key nanotechnology – integrated sensor actuation control – "captures" and characterizes individual cells rather than group averages. These bio-machines are much more sensitive than existing chemical sensors, capable, for example, of differentiating between individual strains of the same toxin. They can also significantly improve in vivo diagnostics and drug/toxicity screening.

Other researchers at the NanoCenter foster innovations in rapid, precise bimolecular detection systems. Reza Ghodssi, for example, is developing an integrated hand-held system that can detect the presence of even a single bacterium.

New Forms and Functionalities for Electronics

Researchers at Maryland also apply the unique properties of nanoparticles to enable the next generation of electronics: organic LEDs, personalized body sensors, slim bendable displays, and high-power, environmentally friendly energy supplies.

Sang Bok Lee, Ellen Williams, and Michael Fuhrer work with carbon nanotubes and nano-transfer printing to develop high-energy storage devices, extremely precise sensors, and flexible electronics. Lee's team currently works with Samsung on "electronic paper"— a display device with high storage capacity that can be carried and manipulated like a piece of paper. He also is devising a system that integrates energy harvesting and energy storage to create devices that power themselves.

Williams and Fuhrer constructed a perfectly pure graphene – a carbon sheet only a single layer thick – that allows electrons to be "steered" across the surface. The bendable, stretchable electronic prototypes built from this technology are being developed for such applications as unobtrusive, portable pollution sensors and electronic devices woven into fabrics. In the future, your jacket could be your iPod.

Nano-Manufacturing

The revolutionary promises of nanotechnology – from inexpensive, clean energy production to radically new cancer treatments – depend on the ability to make, examine, and control precisely-shaped nanoparticles. Researchers at the NanoCenter develop the manufacturing capabilities needed for turning nanotechnology's potential into reality.

The Co-Laboratory for Nanoparticle Based Manufacturing and Metrology (NM^2), a collaboration between the University and the National Institute of Standards and Technology (NIST), leads the industry in making and characterizing specific nanoparticles. Michael Zachariah, NM^2's director, establishes the research protocols crucial for investigating toxicity, characterizes carbon nanotubes for targeted drug delivery, and supplies precisely sized nanoparticles needed for animal testing of drugs.

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 numerous applications, such as flexible electronics and sensor technologies.
For more information, see http://www.nanocenter.umd.edu/