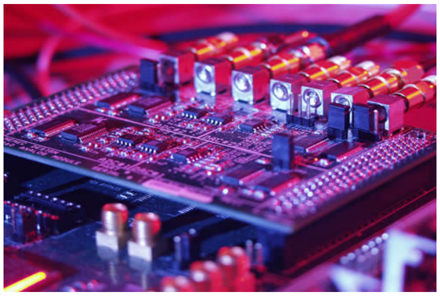
Nanoelectronics



Innovations in nanotechnology promise to revolutionize the forms and functionalities of electronic devices. Offering much more than current technologies on a smaller scale, nanoelectronics researchers apply the unique properties of single particles to change the ways components are powered, manufactured, and used. These advances will enable the next generation of electronics: organic LEDs, personalized body sensors, bendable displays, and high-power, environmentally friendly energy supplies. Though the field is still in its early stages, scientists at the University of Maryland are developing both practical applications and fundamental nanoelectronic theory.

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 nanowires permit the ultra-fast electrochemistry needed to develop super-capacitors. Williams and Fuhrer develop materials and manufacturing capabilities for elastic, chip-less electronics.

John Melngailis advances numerous critical supporting technologies for semi-conductors. His research with focused ion beams improves the speed and security of Radio Frequency Identification tags, an alternative for bar codes with widespread applications in inventory checking, retail store checkout, airport baggage handling, and passport scanning.

Lawrence Sita is uncovering the basic theory for predicting the reactions of single molecules to electrical stimulus. His published research appears to provide a comprehensive, viable framework for manufacturing nanoscale transistors.
http://www.nanocenter.umd.edu/

Nanotubes for Supercapacitors and Electronic Paper

Sang Bok Lee fabricates nanotubes and nanowires needed to create supercapacitors and light, flexible displays. Using dimension- and shape-controlled template synthesis, Lee devises ultra-fast electrochemical techniques that can easily be transferred to the industrial production. His team currently works with Samsung on developing "electronic paper"— a display device with high storage capacity that can be carried and manipulated like a piece of paper.

The applications of Lee's manufacturing techniques are only beginning to be explored. He plans to develop a system that integrates energy harvesting and energy storage to create devices that power themselves. For example, a cell phone could recharge itself with solar energy harnessed by embedded nano-structures in the casing.

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Electron Steering and Flexible Electronics

Ellen Williams' work with graphene and nano-transfer printing promises breakthroughs in displays, sensors, and even electronic fabrics. Graphene is a carbon sheet only a single layer thick (as opposed to 3-D graphite).

Working with Michael Fuhrer (see below), Williams constructed a perfectly pure graphene device that demonstrates unique adhesion
characteristics: Electrons can be "steered" along the graphene to create an array of electronic properties. The nano-transfer printing technology Williams and Fuhrer helped create allows novel and inexpensive ways of integrating nanoelectronics into usable forms. Their prototypes can be stretched, bent, or twisted, and they are often transparent. Companies are investing in this technology to develop such applications as unobtrusive, portable pollution sensors and electronic devices woven into fabrics.

Williams currently works on shrinking organic semi-conductor devices to the nano scale, tailoring the properties of graphene for high-speed applications, and controlling adhesion among different nanoelectronic materials.

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"Chip-less" Electronic Devices

Fuhrer uses "pre-assembled" carbon nanotubes and nanopatches to build electronic structures that do not need silicone chips, and therefore have the potential to work on any surface – glass, plastic, or fabric. Pre-assembled means using simple, standard techniques to reduce source materials into functional nanoscale components. Fuhrer's team invents technologies to construct novel nanostructures and explore their electrical properties.

His research indicates that semi-conducting nanotubes not only conduct well, but can also be easily manipulated to change functions. This finding suggests new capabilities for field-effect transistors, the basis of most computer chips.
In the future, Fuhrer hopes to work out the problems of scaling up nanotube production.

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Beam Deposition Technologies

John Melngailis uses nanoscale ion and electron beam fabrication to provide critical supporting technologies for the semi-conductor industry. His work has vastly increased the security and speed of Radio Frequency Identification (RFID) tags, an alternative for bar codes. The technology is also used in failure analysis, mask repair, and prototype chip design

A pioneer in beam deposition research, Melngailis has collaborated to apply nano-scale local deposition techniques to characterize nanofibers, semi-conductor nanowires, and carbon nanotubes. He also recently developed a method for depositing metals of a purity far higher than that attainable through previously available methods. All of these innovations can be used to enhance the performance of chips.

Melngailis now hopes to build prototype RFID tags, and also an ultrahigh vacuum chamber that would permit deposition of materials of even higher purity.

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A Unified Theory of Nanoelectronics

Current innovations in nanoelectronics, however remarkable, still represent only a crude state of the art. No current theory can consistently predict the results of electrically stimulating single molecules. To fulfill the tremendous potential of nanoelectronics, scientists need a uniform theory of conductance through molecular frameworks. Lawrence Sita believes that such a theory would shift the focus from scalability (sizing down current architectures) to developing radically different materials and products.

Sita and his research team, along with scientists at Duke University, develop technologies for applying electrical bias to single molecules and groups of molecules. Their methods could provide the key to discovering a comprehensive nanoelectronic theory. Sita's team can manufacture virtually any molecular framework, and his published research offers the most viable current framework for the manufacturing of nanoscale transistors. Currently, Sita is developing methods for injecting electrons into organic material.

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