GE Global Research Develops "Ideal" Carbon Nanotube Diode

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GE Global Research, the centralized research organization of the General Electric Company, announced the development of an ideal carbon nanotube diode that operates at the "theoretical limit," or best possible performance. This is a significant improvement upon the original nanotube diode device that GE developed and announced last year. This latest breakthrough will enable even smaller and faster electronic devices with increased functionality.

In the course of its research, the GE team led by Dr. Ji Ung Lee made a related discovery when it observed a photovoltaic effect in the nanotube diode device. This is a very significant development that could lead to new approaches and breakthroughs in photovoltaic research. Photovoltaics research is a key component of GE's Ecomagination initiative, which was launched in May. Ecomagination represents the company's commitment to aggressively drive and bring to market new technologies that help its customers address their most pressing energy and environmental challenges.

GE reported its discovery in the cover story of the August 15, 2005 edition of Applied Physics Letters.

"GE's success in developing the 'perfect' carbon nanotube device has not only ushered in a new era in electronics, it has potentially opened new doors in solar energy research," said Margaret Blohm, GE's advanced technology leader for nanotechnology. "The discovery of a photovoltaic effect in our nanotube device could lead to exciting breakthroughs in

solar cells that make them more efficient and a more viable alternative in the mainstream energy market.

Blohm added, "Photovoltaics research is already a major component of GE's Ecomagination initiative, and this latest discovery will only further the company's quest to find alternative sources of clean, sustainable energy to benefit our customers and society at large."

Under Ecomagination, GE has pledged to more than double its level of investment in the development of new, environmental-friendly technologies from $700 million to $1.5 billion over the next five years. As part of this commitment, GE Global Research has an active program in photovoltaics that is investigating how to generate power from sunlight more cost effectively and more efficiently. The recent discovery of a photovoltaic effect in the carbon nanotube diode device will only help further the ongoing research efforts.

Diodes are fundamental semiconductor devices that form the basic building blocks of electronic devices, such as transistors, computer chips, sensors, and light emitting diodes (LEDs). Unlike traditional diodes, GE's carbon nanotube device has the ability to perform multiple functions - as a diode and two different types of transistors - which should enable it to both emit and detect light.

In addition to opening new doors in photovoltaics research, GE's carbon nanotube diode device could have many applications in computing, communications, power electronics and sensors.

The carbon nanotube diode was developed by a team led by Dr. Ji Ung Lee, a Micro- and Nano-Structures Technologies scientist who works in the Nanotechnology Advanced Technology Program at the GE Global Research Center in Niskayuna, N.Y.

Technical Details

The p-n junction diode forms the basis for nearly all electronics and therefore, its quality is often a good predictor of the performance of a semiconductor device. Not surprisingly, the demonstration of an ideal diode behavior, the theoretical limit of performance for any diode, is a much sought after goal. The fact that carbon nanotubes can readily form an ideal diode is a strong tribute to their potential usefulness in electronics.

Diodes are formed by joining a p-type and an n-type semiconducting material. In the GE device, the two regions were formed using an electrostatic doping technique using two separate gates that couple to two halves of a single carbon nanotube. By biasing one gate with a negative voltage and the other with a positive voltage, a p-n junction can be formed. GE scientists discovered that an ideal diode could be realized by suspending the middle portion of the carbon nanotube where the carrier recombination occurs. These results show that carbon nanotubes can be very sensitive to the substrate that they are in contact and provide important clues to the fundamental workings of any carbon nanotube based devices.

The scientists further elaborated on the ideal diode behavior by examining their photovoltaic properties, the process in which light energy is converted to electricity. Despite being some 1000 times smaller than the wavelength of light, the carbon nanotube diodes showed significant power conversion efficiencies owing to the enhanced properties of an ideal diode.

The full technical paper about this research is available in the August 15, 2005 issue of Applied Physics Letters or online at apl.aip.org/ .