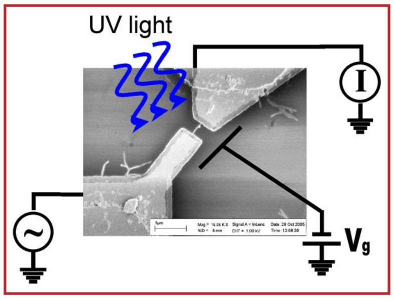
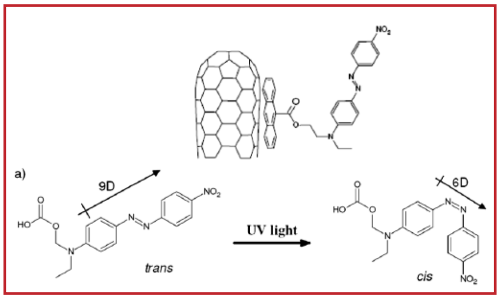
Materials Science and Technology
Nanoscience





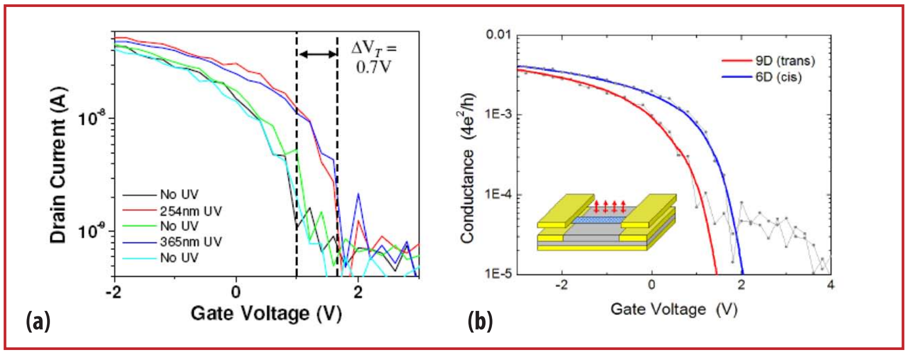


Figure 1: (Top left) Scanning electron micrograph of a chromophore-functionalized nanotube between electrodes. The current through the nanotube can be switched with a back gate (V_g) or by shining UV light.
Figure 2: (Top right) Sketch of carbon nanotube functionalized with azo-benzene. Under UV light, the azo-benzene undergoes a trans to cis transformation accompanied by a large change in dipole moment.
Figure 3: (a) Current-voltage characteristics of functionalized carbon nanotube field-effect transistors. Upon exposure to UV light, the threshold voltage is shifted to more positive values of the gate voltage. (b) Calculated conductance of the nanotube transistor in the presence of surface dipoles (solid lines) showing excellent agreement with the experiments (grey circles).

Red dye makes nanotubes switch in the blue

Photoswitching at the nanoscale can now be performed at low light levels

We are all familiar with the light switch, where an electrical circuit turns the lights ON and OFF. But, what if this concept could be reversed and an electrical circuit could be switched using light? Such a concept is at the heart of modern approaches to enable solar cells, photodetectors, and optical communications. However, conventional materials such as silicon have some fundamental optoelectronic limitations that prevent such applications from being more pervasive. Many of these limitations are overcome with the use of carbon nanotubes. These nanowires of pure carbon have unique optical properties that can be tailored for optoelectronics, and they have the additional ability to rapidly transmit an electrical signal.

Previous approaches to study the optoelectronic properties of carbon nanotubes have focused on bare carbon nanotubes, but large light intensities produced by lasers are required to generate an electrical signal. Sandia scientists, in collaboration with researchers at the University of Wisconsin-Madison, have demonstrated that coating the nanotubes with a common dye makes them sensitive to much lower light intensities—those of simple lamps. Interestingly, while the dye is typically used to impart red color, it makes the nanotubes sensitive to blue light.

The functionalized nanotubes were integrated as channels in field-effect transistors, and these transistors were switched ON and OFF with light. The switching is entirely reversible and repeatable, and the devices are stable in ambient.

A scientific paper with further details, titled "Optically Modulated Conductance in Chromophore-Functionalized Carbon Nanotubes," appeared in the February 23, 2007, issue of *Physical Review Letters*.

Technical Contact:
François Léonard, Ph.D.
925-294-3511
fleonar@sandia.gov

Science Matters Contact:
Alan Burns, Ph.D.
505-844-9642
aburns@sandia.gov

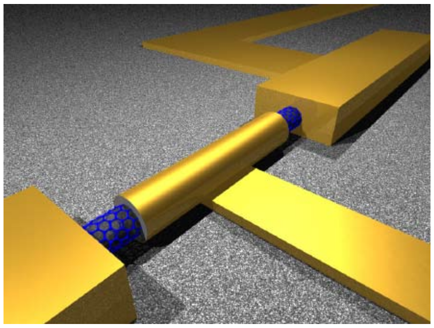
Sandia National Laboratories

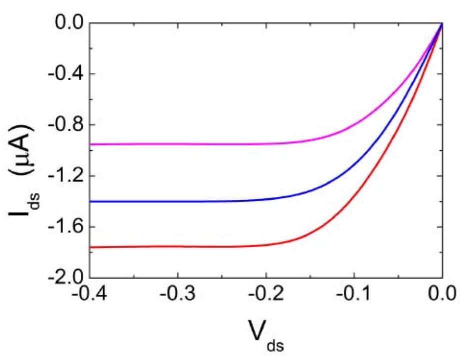
LDRD Laboratory Directed Research & Development

Theory and Modeling of Electronic Transport in Nanostructures

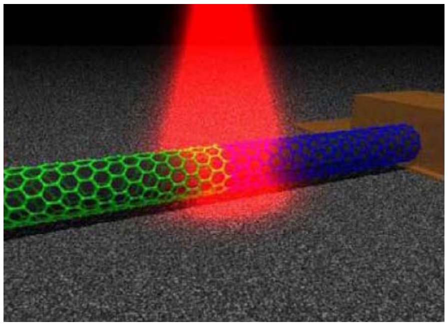
At Sandia, we develop theories and numerical approaches to calculate the electronic transport properties of nanostructures such as carbon nanotubes, nanowires, and single molecules. The goal of our work is to develop a fundamental understanding of the properties of nanostructures and to identify novel behaviors and exploit them in novel nanodevices.

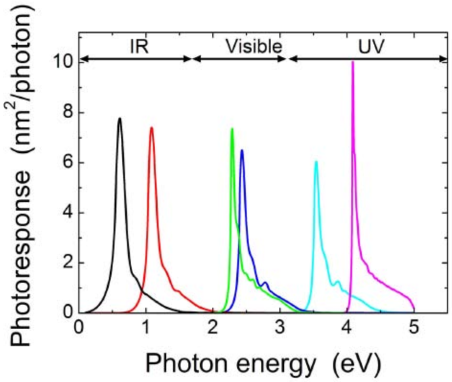
Carbon Nanotube Transistors



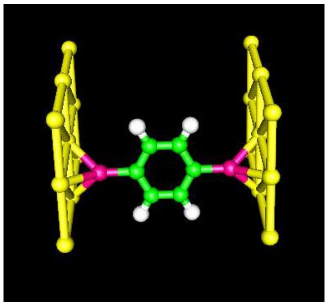


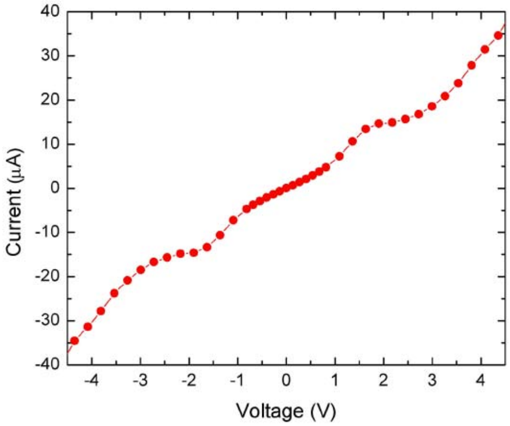
Carbon Nanotube Optoelectronics

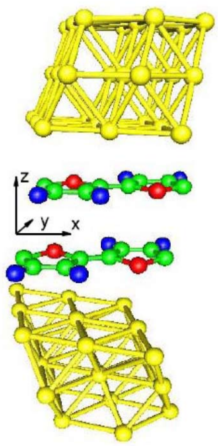




Molecular Electronics







Sandia National Laboratories

6/2007

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2007-3337P

NNSA National Nuclear Security Administration