Using CNTs as infrared sensors

January 4 2010, By Miranda Marquit

(PhysOrg.com) -- Semiconductors provide the bases for many different avenues of device research. Indeed, many of the technological devices that are commonplace in our society are reliant on semiconductors. However, as we increasingly explore the opportunities afforded on the nanoscale, new semiconductor materials are needed. One of the more promising semiconducting materials at this level is the carbon nanotube (CNT).

“There is great promise in using a carbon nanotubes for sensors.” Ning Xi tells *PhysOrg.com*. Xi is John D. Ryder Professor of Electrical and Computer Engineering at Michigan State University, and leads a group that is working on engineering CNT band gaps for use as infrared sensors. Xi worked with Kin Wai Chiu Lai, Carmen Kar Man Fung and Hongzhi Chen at Michigan State, and Tzyh-Jong Tarn at Wasington University in St. Louis to develop a process that is described in Applied Physics Letters: “Engineering the band gap of carbon nanotube for infrared sensors.” This project is supported by the Office of Naval Research.

“For semiconductor material, the band gap is one of the most important parameters,” Xi explains. “The band gap represents how much energy is needed to move an electron. In order for the electron to move, it has to be able to jump over this gap. You have to change the composition of the material in order to change the band gap, and this is very difficult. People have been trying all kinds of ways to do this for years.”

As far as sensors are concerned, using CNTs with different band gaps

can help pinpoint different types of light. "Infrared light has a certain wavelength," Xi says. "You need a certain band gap to detect this. If you have nanotubes with different band gaps, you can design a sensor to detect different spectrum of infrared. And since these nanotubes are so small, arraying different CNTs with different band gaps is possible."

In order to engineer the band gaps so that they can provide the semiconducting sensors, Xi and his colleagues created a process of stripping away layers of multi-wall CNTs. "The interesting thing with carbon nanotubes is that the band gap depends on the radius. If you have a multi-wall nanotube, you can peel away the outer layer to change the radius. And that changes the band gap as well. Instead of changing the semiconductor material, it is possible to tune the band gap to the proper value, one step at a time."

Xi and his colleagues and collaborator developed a process that allows them to use feedback control to remove layers of multi-wall CNTs. "We were able to do this experimentally, with relative ease compared to earlier processes for band gap tuning," Xi points out. "We were able to generate different types of carbon nanotubes with different band gaps, and able to detect multiple wavelengths of light across a spectrum."

Being able to tune a band gap without having to make a new material is a big step forward in semiconductors, and Xi hopes that this process can be used for other purposes. "We are primarily interested in infrared nanosensors, but there could be other applications for this technology."

More information: Lai, et al., "Engineering the band gap of carbon nanotube for infrared sensors," Physical Review Letters (2009). Available online: link.aip.org/link/?APPLAB/95/221107/1