UC San Diego Physicists Reveal Secrets of Newest Form of Carbon

June 10, 2008

Kim McDonald

Using one of the world's most powerful sources of man-made radiation, physicists from UC San Diego, Columbia University and Lawrence Berkeley National Laboratory have uncovered new secrets about the properties of graphene-a form of pure carbon that may one day replace the silicon in computers, televisions, mobile phones and other common electronic devices.

Graphene-a single layer of carbon atoms arranged in a honeycombed lattice-has a number of advantages over silicon. Because it is an optically transparent conductor of electricity, graphene could be used to replace current liquid crystal displays that employ thin metal-oxide films based on indium, a rare metal that is becoming increasingly expensive and likely to be in short supply within a decade. The problem for scientists is that not much is known about its optical and electronic properties because graphene, which was discovered only four years ago, has resisted traditional forms of spectroscopy.

In this week's advance online publication of the journal *Nature-Physics,* the physicists report that they used the Advanced Light Source at the Berkeley lab-one of the most powerful and versatile sources of electromagnetic radiation, from the infrared to x-ray region, in the world-to reveal some of those secrets. The researchers said that their study shows that the electrons in graphene strongly interact not only with the honeycomb lattice, but also with each other.

"Infrared and optical experiments are capable of providing some of the most valuable insights into the electronic properties of materials, including interactions between electrons in a material," said Dimitri Basov, a professor of physics at UC San Diego who headed the project. "But it was extremely difficult to measure the absorption of light in a single monolayer of graphene, because not much light is absorbed. To do this, we had to start with a very bright light. It was spectroscopy to the extreme."

The radiation from the Advanced Light Source, or ALS, is about 100 million times brighter than that from the most powerful X-ray tube, the source used in a dentist's machine. High brightness means that the radiation is highly concentrated and many photons per second can be directed onto a tiny area of a material.

Just as dentists use x rays to see inside your gums, scientists use the ALS's radiation-generated by accelerating electrons around a circular racetrack at close to the speed of light-to look inside materials.

"It took some difficult experimental work to make this measurement," said Basov. "It was by far the most complicated measurement we have ever done."

Zhiqiang Li, a UCSD physics graduate student in Basov's group, was the first author of the paper. Other principal investigators involved in the discovery were Michael Martin, staff scientist at the Berkeley laboratory's ALS; Philip Kim, an associate professor of physics at Columbia University; and Horst Stormer, a professor of physics at Columbia and winner of the 1998 Nobel Prize in Physics.

Funding for the project was provided by the U.S. Department of Energy.

Media Contact: Kim McDonald, 858-534-7572 Comment: Dimitri Basov, 858-822-1211