Damaging graphene to create a band gap

November 22 2010, By Miranda Marquit

(PhysOrg.com) -- "Graphene offers a lot of interesting potential applications for nanoelectronics," Florian Banhart tells *PhysOrg.com*, "but there is no band gap. This is a well-known problem. Without the band gap, switching as needed in electronic devices is difficult."

Banhart, a scientist at the University of Strasbourg in Strasbourg, France, believes that there is a solution to this problem. “Everyone tries to solve this problem, trying to create different properties in order to create a band gap. Our solution is doping with metal atoms attached to reconstructed defects in the graphene.”

Working with Ovidiu Cretu and Julio Rodríguez-Manzo at the University of Stasbourg, and with Arkady Krasheninnikov at the University of Helsinki, Risto Nieminen at Aalto University in Finland and Litao Sun at Southeast University in Nanjing, China, Banhart developed a method to modify the properties of graphene. The group’s work is published in Physical Review Letters: “Migration and Localization of Metal Atoms on Strained Graphene.”

“The idea is to be able to attach something to the surface of the graphene, changing some of the properties to get a band gap,” Banhart explains. By creating reconstructed defects, we can enhance the activity of the graphene and attach metal atoms firmly, possibly producing a band gap.”

Banhart and his colleagues created graphene layers that were then damaged. “We used an electron beam to damage the graphene,” Banhart says. “For this paper, we used tungsten atoms to bond to the graphene. The defects we created made it possible for the tungsten atoms to be trapped by the defects, creating stable bonds.”

Reconstructed defects increase the activity seen in graphene, making bonding to other atoms possible. “The graphene surface is normally rather inert,” Banhart explains, “but defects such as pentagonal or heptagonal rings enhance its activity. We saw enhanced chemical activity with the graphene.”

Even though Banhart and his colleagues hope that this work will lead to the eventual creation of nanoelectronic devices made with graphene, he points out that they were unable to show definitive evidence of band gap creation. “There is no evidence that we did create a band gap,” he admits. “But perhaps tungsten is not ideal. We used it because it is large, and easy to see with the electron microscope when trapped by the graphene.”

Banhart says that the tungsten has served its purpose, showing that it is possible to attach metal atoms to graphene with the help of defects on the graphene’s surface. He also points out that their recent work shows that it is possible to use this technique to modify graphene’s properties locally. “We have shown that our method might be used in the future to control graphene’s electronic properties better.”

The next step is to try to trap other atoms using defects in graphene. Banhart would also like to do more tests on the electronic properties of graphene doped in this manner. “It would be good to do more tests of graphene,” he says. “With more experiments, we should be able to begin to model the electronic structure of graphene more accurately. Once we better understand the properties of graphene, we should be able to better manipulate them so that we can get a band gap, and so that we can use them in nanoelectronic devices.”

More information: Ovidiu Cretu, et. al., "Migration and Localization of Metal Atoms on Strained Graphene," *Physical Review Letters* (2010). Available online: link.aps.org/doi/10.1103/PhysRevLett.105.196102