Discovery points way to graphene circuits

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Rice University materials scientists have made a fundamental discovery that could make it easier for engineers to build electronic circuits out of the much-touted nanomaterial graphene.

Graphene's stock shot sky-high last year when the nanomaterial attracted the Nobel Prize in physics. Graphene is a layer of carbon atoms that is just one atom thick. When stacked atop one another, graphene sheets form graphite, the material found in pencils the world over. Thanks to the tools of nanotechnology, scientists today can make, manipulate and study graphene with ease. Its unique properties make it ideal for creating faster, more energy-efficient computers and other nanoelectronic devices.

But there are hurdles. To make tiny circuits out of graphene, engineers need to find ways to create intricate patterns of graphene that are separated by a similarly thin nonconductive material. One possible solution is "white graphene," one-atom-thick sheets of boron and nitrogen that are physically similar to graphene but are electrically nonconductive.

In a new paper in the journal Nano Letters, Rice materials scientist Boris Yakobson and colleagues describe a discovery that could make it possible for nanoelectronic designers to use well-understood chemical procedures to precisely control the electronic properties of "alloys" that contain both white and black graphene.

"We found there was a direct relationship between the useful properties of the final product and the chemical conditions that exist while it is being made," Yakobson said. "If more boron is available during chemical synthesis, that leads to alloys with a certain type of geometric arrangement of atoms. The beauty of the finding is that we can precisely predict the electronic properties of the final product based solely upon the conditions -- technically speaking, the so-called 'chemical potential' -- during synthesis."

Yakobson said it took about one year for him and his students to understand exactly the distribution of energy transferred between each atom of carbon, boron and nitrogen during the formation of the "alloys." This precise level of understanding of the "bonding energies" between atoms, and how it is assigned to particular edges and interfaces, was vital to developing a direct link from synthesis to morphology and to useful product.

With interest in graphene running high, Yakobson said, the new study has garnered attention far and wide. Graduate student Yuanyue Liu, the study's lead co-author, is part of a five-student delegation that just returned from a weeklong visit to Tsinghua University in Beijing. Yakobson said the visit was part of an ongoing collaboration between Tsinghua researchers and colleagues in Rice's George R. Brown School of Engineering.

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