

The new shape of technology

Engineering research uses graphene to form tomorrow's electronics



Graphene research at Kansas State University is taking many shapes: dots, cloaks, ribbons, snowflakes and more.

Vikas Berry, the William H. Honstead professor of chemical engineering, is fabricating these shapes from graphene, a form of carbon that is only one atom thick. He is using it to improve electronics, optoelectronics and computers.

Berry's recent project — supported by a five-year \$400,000 National Science Foundation CAREER award — focuses on graphene quantum dots, which are ultra-small sheets of carbon atoms. Berry's eight-member research team is controlling the size of these graphene particles and shaping them into squares, triangles, rectangles or ribbons. By doing so, they can control graphene's properties over a wide range to develop transistors for future computers, to manipulate graphene-based devices and to engineer novel graphenic nano-systems. The work will be published in an upcoming issue of Nature Communications.

"Several of the graphene quantum dots of shapes — like squares and rectangles — and of defined sizes are unprecedented," Berry said.

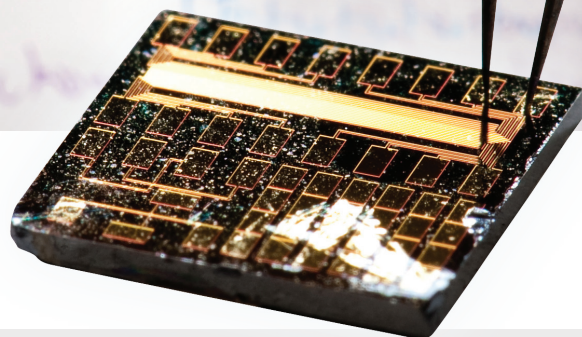
"Our group is the first to synthesize these quantum dots with a wide variety of controlled structure in large quantities. Since their quantum mechanical properties evolve from their shape and size, these quantum dots could be incorporated into several optoelectronic applications, including solar cells."

Because of the high electronic mobility in graphene, it may lead to ultrafast computers, making it a hot topic in the semiconductor industry. Berry has received support from MEMC Electronic Materials, a Missouri-based global supplier of electronic materials to the semiconductor and solar industries, to develop ideas to integrate graphene with silicon. Berry and Mike Seacrist, senior fellow at MEMC, have jointly filed for a patent on this project.

Recently, Berry's team created a microscopic graphene cloak that protects bacteria and other cells under an electron microscope so they can be imaged at their natural size with higher resolution. Their work with graphene cloaks appeared in the journal Nano Letters in 2011. Now the team is using bacterial biochemical processes to create fine wrinkles on the graphene.

"This can be an important breakthrough, since the wrinkles and the associated strain open a band gap in graphene, making it advantageous to fabricate graphene transistors with high rectification," Berry said. "The next step is to compare graphene-devices with and without wrinkles to evaluate the effectiveness of the process for future incorporation into devices."

— Jennifer Tidball



Berry has several other recent projects and accolades related to graphene.

- He has received \$300,000 from the Office of Naval Research to study tapered ribbons of graphene, which have important electrical properties.
- He is currently collaborating with Zhiping Xu from Tsinghua University in China to conduct simulations on the process to produce quantum dots. Berry is also working with Vivek Shenoy from Brown University to study molecular motion on graphene's surface.
- He has a \$301,700 National Science Foundation-funded project on a route to functionalize graphene.
- Berry's team has imbedded gold "snowflakes" on graphene to make it more useful in electronic applications.

