Rush!

a lot of effort into the fundamental aspects of graphene, but also into its unique properties, like electronic mobility. A hundred times faster and more efficient than gallium arsenide—the best semiconductor today—graphene could revolutionize fast and high-frequency electronics, and even spintronics.

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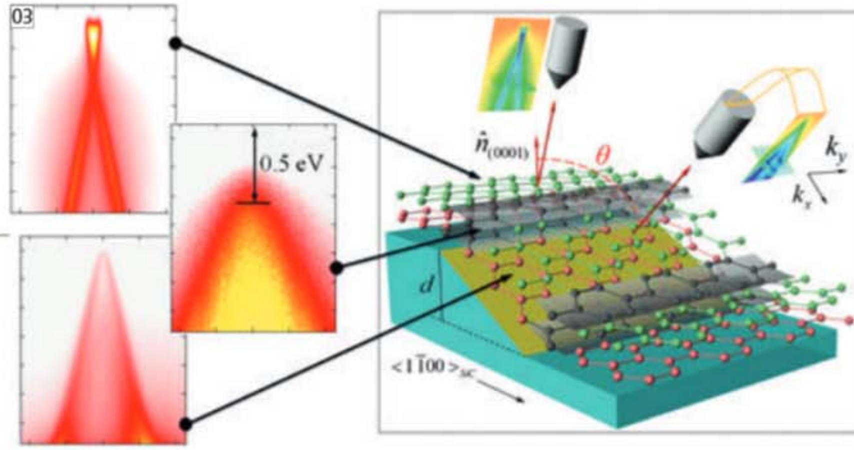
02 Researchers are working on new techniques to extract graphene from graphite.



03 Diagram showing nanometric graphene ribbons growing on the two graphene sheets. The semiconducting graphene (grey) is bent over the two trenches. Various orientations of the detector (grey "crayons") provide different photoemission data (boxes, left).

Next-Generation Semiconductors

BY BRETT KRAABEL

→ **Encouraged by graphene's excellent electrical properties,** researchers have spent over a decade trying to find ways for modifying it from its normal metallic state to a semiconducting one. Semiconducting graphene, it was reasoned, would lead to high-speed high-power electronics that would dwarf the current capabilities of silicon. This long effort has finally paid off. A French-American collaboration between CNRS's synchrotron Soleil and the Georgia Institute of Technology (GT) has found that bending graphene is an easy and scalable way to make semiconducting ribbons for next-generation integrated circuits (ICs).[1]

To obtain semiconducting graphene, scientists originally tried to cut it into thin ribbons that quantum effects would make semiconducting. Unfortunately, modern lithography techniques are still unable to produce ribbons sufficiently thin or with precise enough edges. "People were concerned that they would never get semiconducting graphene," recalls Edward Conrad, the principal investigator from GT. Until he and his CNRS colleagues approached the problem differently. "Although you can't make narrow-enough lines, it's easy to dig 2-nm-deep trenches," he explains. By etching trenches in silicon carbide and growing graphene over the trenches, the team hoped that the graphene coating the 2-nm-high trench walls would be semiconducting.

Results showed that, although not semiconducting on the trench wall, the graphene bending over the top of it acquired this property. Further research provided an explanation: bending graphene causes localized strain and distorts the carbon-carbon bond angles. These effects conspire to trap electrons in the very narrow ribbon-like region over which the graphene bends, making the material semiconducting. Following this discovery, industrially-produced graphene semiconductors could well be on their way.

01. J. Hicks et al., "A wide-bandgap metal-semiconductor-metal nanostructure made entirely from graphene," *Nat. Phys.*, 2013. 9: 49–54.

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