New research could revolutionize flexible electronics, solar cells

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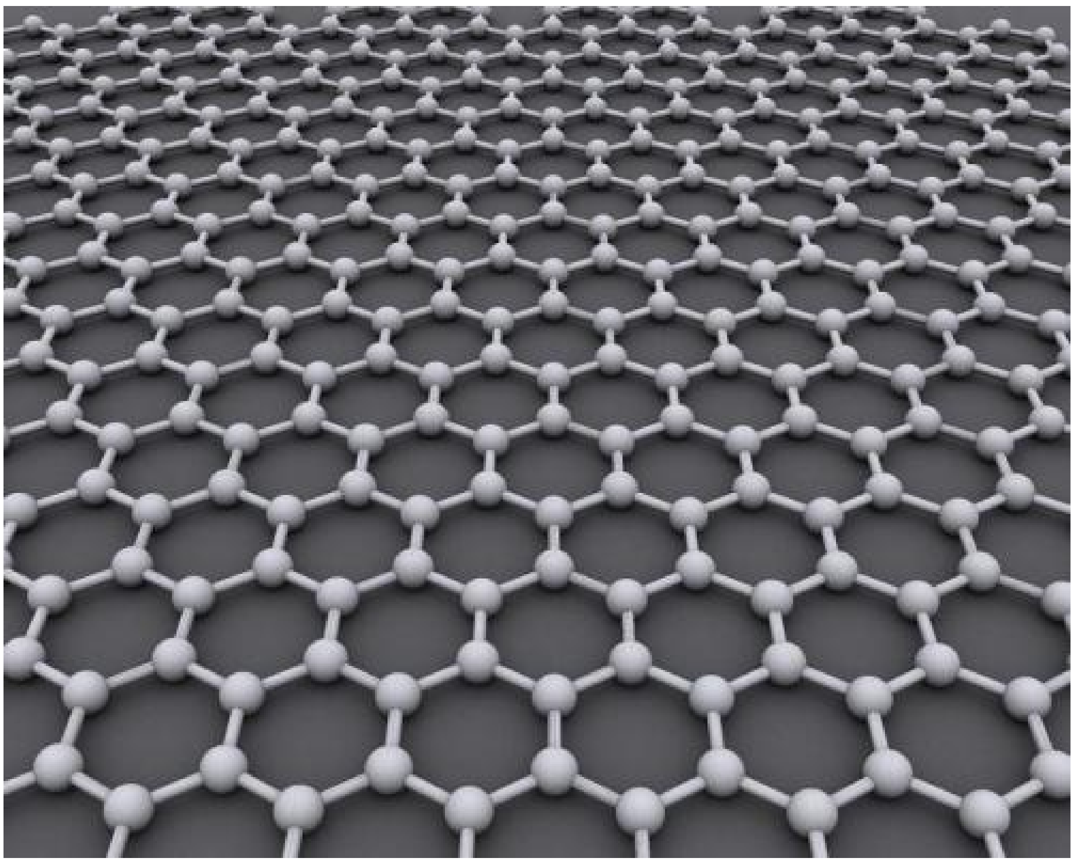

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Binghamton University researchers have demonstrated an eco-friendly process that enables unprecedented spatial control over the electrical properties of graphene oxide. This two-dimensional nanomaterial has the potential to revolutionize flexible electronics, solar cells and biomedical instruments.

By using the probe of an atomic force microscope to trigger a local chemical reaction, Jeffrey Mativetsky, assistant professor of physics at Binghamton University, and PhD student Austin Faucett showed that electrically conductive features as small as four nanometers can be patterned into individual graphene oxide sheets. One nanometer is about one hundred thousand times smaller than the width of a human hair.

"Our approach makes it possible to draw nanoscale electrically-conductive features in atomically-thin insulating sheets with the highest spatial control reported so far," said Mativetsky. "Unlike standard methods for manipulating the properties of graphene oxide, our process can be implemented under ambient conditions and is environmentally-benign, making it a promising step towards the practical integration of graphene oxide into future technologies."

The 2010 Nobel Prize in Physics was awarded for the discovery of graphene, an atomically-thin, two-dimensional carbon lattice with extraordinary electrical, thermal and mechanical properties. Graphene oxide is a closely-related two-dimensional material with certain advantages over graphene, including simple production and processing, and highly tunable properties. For example, by removing some of the oxygen from graphene oxide, the electrically insulating material can be rendered conductive, opening up prospects for use in flexible electronics, sensors, solar cells and biomedical devices.

The study provides new insight into the spatial resolution limits and mechanisms for a relatively new process for patterning conductive regions in insulating graphene oxide. The minimum conductive feature size of four nanometers is the smallest achieved so far by any method for this material. Mativetsky said this approach is promising for lab-scale prototyping of nanoscale conductive patterns in graphene oxide. "There is significant interest in defining regions with different functionalities, and writing circuitry into two-dimensional materials. Our approach provides a way to directly pattern electrically-conductive and insulating regions into graphene oxide with high spatial resolution," said Mativetsky.

This research not only enables fundamental study of the nanoscale physical properties of graphene oxide but also opens up new avenues for incorporating graphene oxide into future technologies. Because the process developed by Mativetsky avoids the use of harmful chemicals, high temperatures or inert gas atmospheres, his work represents a promising step towards environmentally-friendly manufacturing with graphene oxide. "At first, this will mainly be useful for studying fundamental properties and lab-scale devices," said Mativetsky. "Eventually, this work may help lead to the practical integration of graphene oxide into low-cost and flexible electronics, solar cells, and sensors."

The study, "Nanoscale Reduction of Graphene Oxide under Ambient Conditions," first appeared in the online version of the international journal *Carbon* on Sept. 8, and will be published in print in the December issue. Mativetsky was recently awarded a three-year grant from the National Science Foundation to further study his approach to tailoring the structure and properties of graphene oxide.

More information: Austin C. Faucett et al. Nanoscale reduction of graphene oxide under ambient conditions, *Carbon* (2015). DOI: 10.1016/j.carbon.2015.09.025

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