

'Rivet graphene' proves its mettle: Toughened material is easier to handle, useful for electronics

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a polymer layer to keep it from wrinkling or ripping. But the polymer tended to leave contaminants behind and degrade graphene's abilities to carry a current.

"Rivet graphene proved tough enough to eliminate the intermediate polymer step," Tour said. "Also, the rivets make interfacing with electrodes far better compared with normal graphene's interface, since the junctions are more electrically efficient.

"Finally, the nanotubes give the graphene an overall higher conductivity. So if you want to use graphene in electronic devices, this is an all-around superior material," he said.

Rivet graphene (outlined in yellow) is nearly as transparent as pure graphene and retains its strength and conductivity even when flexed. The material was created at Rice University. Credit: Tour Group/Rice University

Nanoscale "rivets" give graphene qualities that may speed the wonder material's adoption in products like flexible, transparent electronics, according to researchers at Rice University.

The Rice lab of chemist James Tour reported the creation of "rivet graphene," two-dimensional carbon that incorporates carbon nanotubes for strength and [carbon spheres](#) that encase iron nanoparticles, which enhance both the material's portability and its electronic properties.

The material is the subject of a paper in the American Chemical Society journal *ACS Nano*.

Until now, researchers have had to transfer graphene grown via [chemical vapor deposition](#) with Tests proved rivet graphene retained the strength



A sheet of rivet graphene (outlined in yellow) floats in water. The enhanced graphene created at Rice University can be transferred from its growth substrate without the need for contaminating polymers. Credit: Tour Group/Rice University

of the Tour lab's rebar graphene (which incorporates nanotube reinforcement) as well as rebar's ability to float on water. But the rivets also enhanced the material's ability to transfer current between electrodes and the graphene, even when bent, the researchers reported.

The rivets are layers of [carbon](#) wrapped around a 30-nanometer iron core, dubbed "nano-onions" by the lab. The structures are grown in place in the CVD furnace after the dispersal of nanotubes and deposition of graphene. A final step welds all the elements together, Tour said.

Rivet [graphene](#) is transparent enough for flexible and [transparent electronics](#), he said, and the simplified process should be scalable.

More information: Xinlu Li et al. Rivet Graphene, *ACS Nano* (2016). [DOI: 10.1021/acsnano.6b03080](https://doi.org/10.1021/acsnano.6b03080)

Provided by Rice University

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