Staying ahead of the curve with 3-D curved graphene

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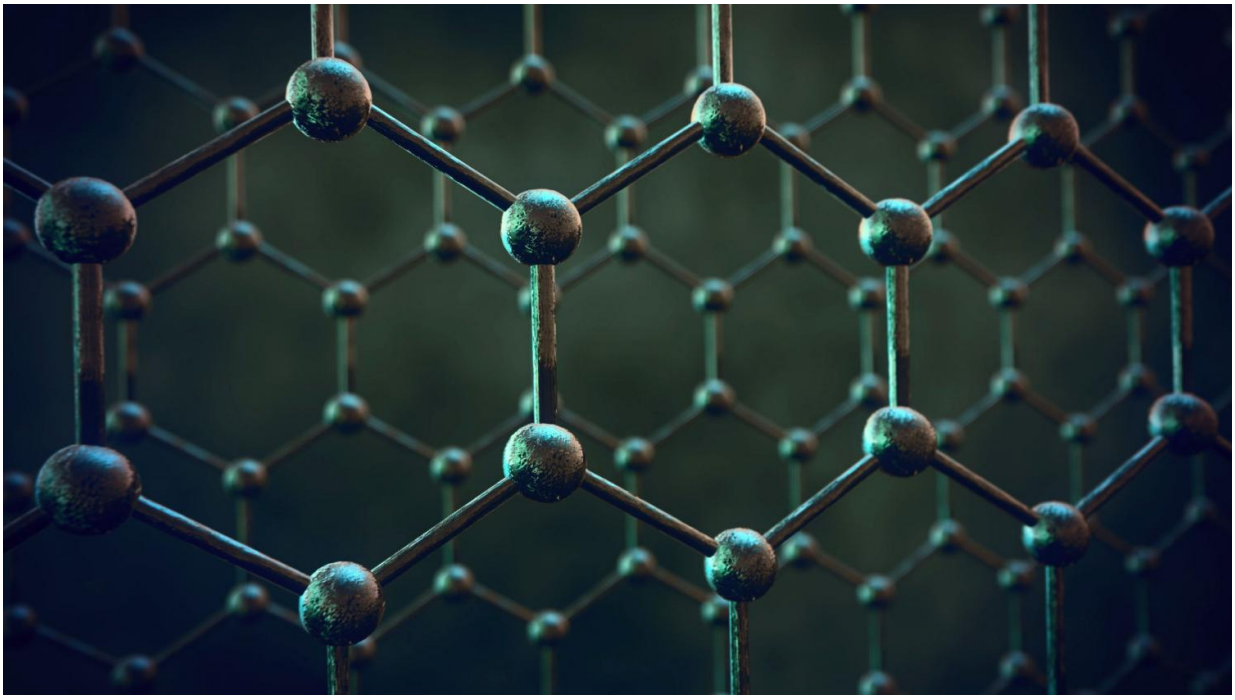

This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

A team of researchers has amplified 3-D graphene's electrical properties by controlling its curvature.

"Our research showed the conservation and the degradation of the ultra-low dissipative transport of Dirac electrons on the 3-D curved surface

for the first time," said Yoichi Tanabe, leading author of the study.

Graphene is a 2-D atomic-layer material, shaped like honeycombs, which possesses excellent electrical, chemical, thermal, and mechanical properties for a wide range of applications such as semiconductors, electrical batteries, and composites.

Graphene sheets stacked together form graphite which makes up the lead in our pencils. However, packing together graphene tightly means it loses its 2-D electronic properties.

One way to overcome this is to separate the graphene sheets with air-filled pores—like a sponge—at the nanometer scale and make it into a three-dimensional structure. This amplifies graphene's properties for practical purposes.

But doing so is not without its challenges; converting 2-D graphene into 3-D graphene introduces crystal defects and a host of other problems that cause it to lose its desirable characteristics. Little is known about how the curved surface degrades the graphene's electric transport properties and whether this is the reason for graphene losing its Dirac fermions.

The research team sought to investigate this by taking a single, 2-D graphene sheet and folding it into a 3-D structure with a bicontinuous and open porous structure.

The structure, with a curvature radius down to 25-50 nanometers, retained the basic electronic properties of 2-D graphene well. Meanwhile, the motion of electrons on the 3-D curvature enhanced electron scattering that had originated from the intrinsic curvature effects. In fact, nanoscale curvature provides a new degree of freedom to manipulate graphene's electronic behaviors for the emergent and unique

electrical properties of 3-D graphene.

More information: Yoichi Tanabe et al. Dirac Fermion Kinetics in 3D Curved Graphene, *Advanced Materials* (2020). DOI: 10.1002/adma.202005838

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