Umklapp scattering in superlattices found to degrade high-temperature mobility of graphene's charge carriers

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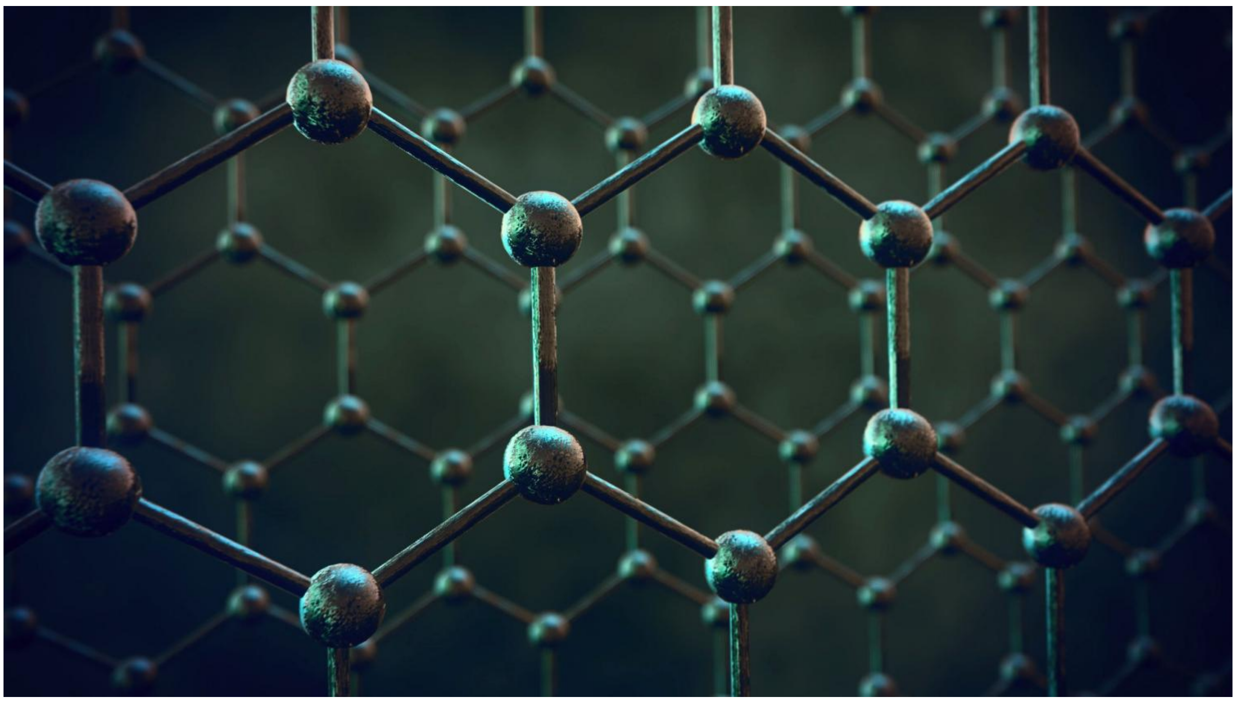

This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

A team of researchers from the U.K., Japan and the U.S. has found that Umklapp scattering in moiré superlattices can degrade the intrinsic high-temperature mobility of its graphene's charge carriers. In their paper published in the journal *Nature Physics*, the group describes their study of superlattices made with graphene and using hexagonal boron nitride as a substrate, and what they found.

A superlattice is a structure made by layering two or more very thin materials together—it is typically on the order of a few nanometers, and usually made at least partially with graphene. As scientists look for ways to continue shrinking down the materials and structures used to make devices such as smartphones and laptops, they have looked to structures like nanoscale atom cluster arrays based on quantum dot superlattices. Notably, it has been observed that an optimal design for a superlattice follows a moiré pattern (based on the textile). But such ideas may have to be modified due to the findings by the researchers on this new effort. In their work, they have found that Umklapp electron-electron (Uee) scattering degrades the mobility of the charge carriers in graphene.

Uee is a scattering process that gives metals electrical resistance, and is used with superlattices. It allows electrons to transfer momentum to the lattice, giving metals resistance. The researchers note that it has traditionally been quite difficult to measure the process due to interference from other phenomena.

In their experiments, the researchers created test lattices from graphene and hexagonal boron nitride. In testing done with the superlattices, they found that Uee scattering dominated movement properties in lattice heterostructures. That dominance led to an excess of resistivity, which grew along with the lattice. The net result was a reduction in room-temperature mobility by more than an order of magnitude.

The researchers note that their findings do not rule out the use of Uee and superlattices in future electronic devices—they found that the increased resistivity could be prevented by misaligning or twisting the crystals that form the structure. An extra step perhaps, but not a deal breaker.

More information: J. R. Wallbank et al. Excess resistivity in graphene superlattices caused by umklapp electron–electron scattering, *Nature Physics* (2018). DOI: 10.1038/s41567-018-0278-6

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