Physics team develops simple way of controlling surface plasmon polaritons in graphene

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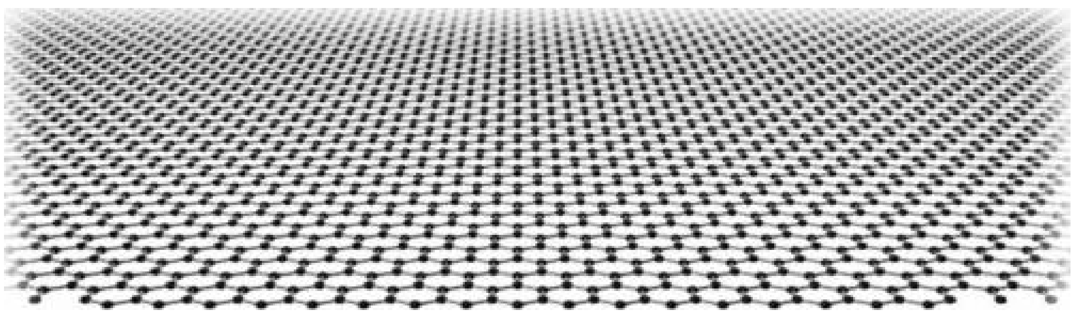

Credit: University of Manchester

(Phys.org) —A team of researchers working in Spain has developed an improved way to control surface plasmon polaritons (SPPs) in graphene. In their paper published in the journal *Science*, the team describes their new technique and the ways it might someday be used.

A plasmon is defined as a quantum of plasma oscillation and is generally considered to be a quasiparticle. Polaritons are quasiparticles that arise when plasmons couple with photons—and as their name implies SPPs are polaritons that exist on the surface of a material and propagate into it. Researchers at several facilities are currently studying the properties of SPPs in an effort to create extremely tiny devices that operate both optically and electronically. In order to make that happen, a means must be developed of controlling the size and shape of SPPs—that's what the team in Spain has achieved.

SPPs can be made to occur in metals, but prior research has shown that graphene is a better material because SPPs can propagate deeper into it. Two years ago, the same research team in Spain (working with others) developed a way to create and image SPPs in graphene using a near-field scanning optical microscope. With this latest effort, they've taken that work further with the development of a method that allows for actually controlling the SPPs. To make it happen, they covered a sheet of graphene with extremely tiny (3 µm) antennas made of gold—the antennas absorb photons at a given frequency. Doing so created an optical dipole which caused the creation of evanescent light. Because the antenna was directly connected to the graphene, SPPs were created from the near field—changing the antenna size allowed for altering the SPPs that were created. The team found that a straight antenna caused the creation of planar SPP waves. When the antenna had a concave tip, the SPP waves were focused to a single point. The team also found that the SPP waves could be refracted using a two-dimensional bilayer graphene prism.

More research must be done with SPPs before they can be used to create opto/electronic devices, however, because the distance they propogate into the graphene (just 1–2 µm) is still too small to be of practical use. The team hopes to increase that distance by using better quality graphene and by developing a better doping process.

More information: Controlling graphene plasmons with resonant metal antennas and spatial conductivity patterns, *Science* DOI: 10.1126/science.1253202

ABSTRACT

Graphene plasmons promise unique possibilities for controlling light in

nanoscale devices and for merging optics with electronics. Here,we introduce a versatile platform technology based on resonant optical antennas and conductivity patterns for launching and controlling of propagating graphene plasmons, constituting an essential step for the development of graphene plasmonic circuits. We demonstrate the launching and focusing of infrared graphene plasmons with geometrically tailored antennas, and how they refract when passing through a 2-dimensional conductivity pattern, here a prism-shaped bilayer. To that end, we directly map the graphene plasmon wavefronts using an imaging method that will also benefit the testing of future design concepts for nanoscale graphene plasmonic circuits and devices.

Press release

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