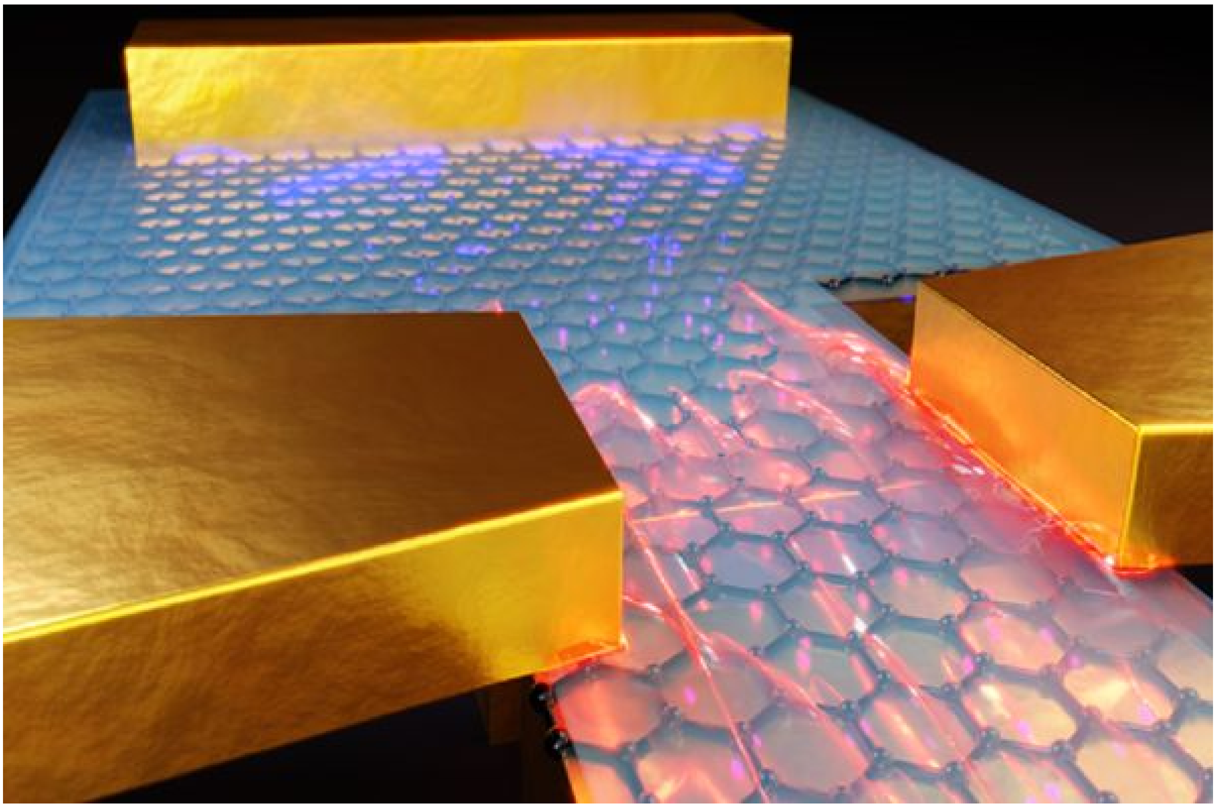


New type of graphene photodetector enables low-cost cameras for self-driving cars and robots

An international team of researchers reports the results of the study in Nature Communications.

October 23, 2020

In general, most of the objects we use in our everyday life emit light in a range of the spectrum that is invisible to the naked eye. Typically, for those room-temperature objects, this emission happens in the infrared optical range. What is even more interesting is that the spectrum of light emitted by these objects contains detailed information about the type of molecules the object is made of. Hence photodetection in the infrared leads to a myriad of applications such as night vision, thermal imaging, molecular spectroscopy, gas detection, optical communications and many others. Nevertheless, currently commercially available mid-IR detectors present limitations and thus, are not capable of fully exploiting the potential of these applications.

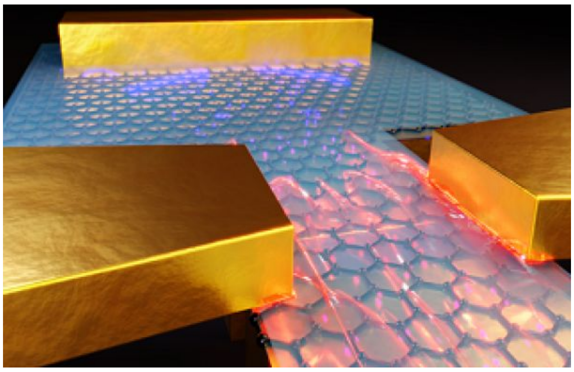
Alternatively, two dimensional (2D) materials have shown astonishing properties to capture and control at the nanoscale, in particular infrared light. These properties combined with the photodetection capabilities of graphene can enable novel ways for detecting infrared light.

In a recent study published in Nature Communications, an international team of researchers report on having been able to combine all these unique features into one single device. The work was carried out by ICFO researchers Sebastia?n Castilla, Varun-Varma Pusapati, Khannan Rajendran and Dr. Seyoon Kim, led by ICREA Prof. at ICFO Frank Koppens and former ICFO scientist Dr. Klaas-Jan Tielrooij (from ICN2), in collaboration with researchers Ioannis Vangelidis and Prof. Elefterios Lidorikis from University of Ioannina and with scientists from CIC NanoGUNE BRTA, Massachusetts Institute of Technology (MIT), CSIC-Universidad de Zaragoza and the National Institute for Material Sciences.

The team integrated three concepts to achieve the device at hand: metallic plasmonic antennas, ultra sub-wavelength waveguiding of light and graphene photodetection. Specifically, the 2D-material hexagonal boron nitride was used as the waveguide for hyperbolic phonon polaritons, which can highly confine and guide mid-infrared light at the nanoscale. By carefully matching the nano-antenna with the phonon polariton waveguide, they efficiently funnel incoming light into a nanoscale graphene junction. By using this approach, they were able to overcome intrinsic limitations of graphene, such as its low absorption and its small photoactive region near the junction.

By exploiting this technique, the authors demonstrated the technological relevance of such detector. They were able to report a record performance of the device working at operating at room temperature by obtaining a very high sensitivity (noise-equivalent-power) of 82 pW/Hz1/2, an extremely high speed, by showing a setup-limited rise time of 17 nanoseconds, and a high dynamic range. Also, they showed that it operates without bias, which leads to negligible power consumption and dark-current, outperforming current mid-infrared graphene and commercial detectors in various aspects. All of these performance features combined make this novel photodetector a remarkable platform for low-cost infrared cameras, as the materials used in its fabrication are CMOS compatible at the waferscale level. The system has proven to fulfill the ongoing trend of decreasing the size, weight and power consumption (SWaP) of infrared imaging systems.

The results of the investigation have been published under the study ï¿½Plasmonic anten a coupling to hyperbolic phonon-polaritons for sensitive and fast mid-infrared photodetecti n with graphene.ï¿½ The work was carried out within the framework of the Graphene Flag hip Core 2 and Core 3 that enforces graphene based technology from the lab to the market.



Schematic illustration of the active area of the graphene based infrared photodetector. Image courtesy from Matteo Ceccanti and Simone Cassandra.