New graphene-based sensor design could improve food safety

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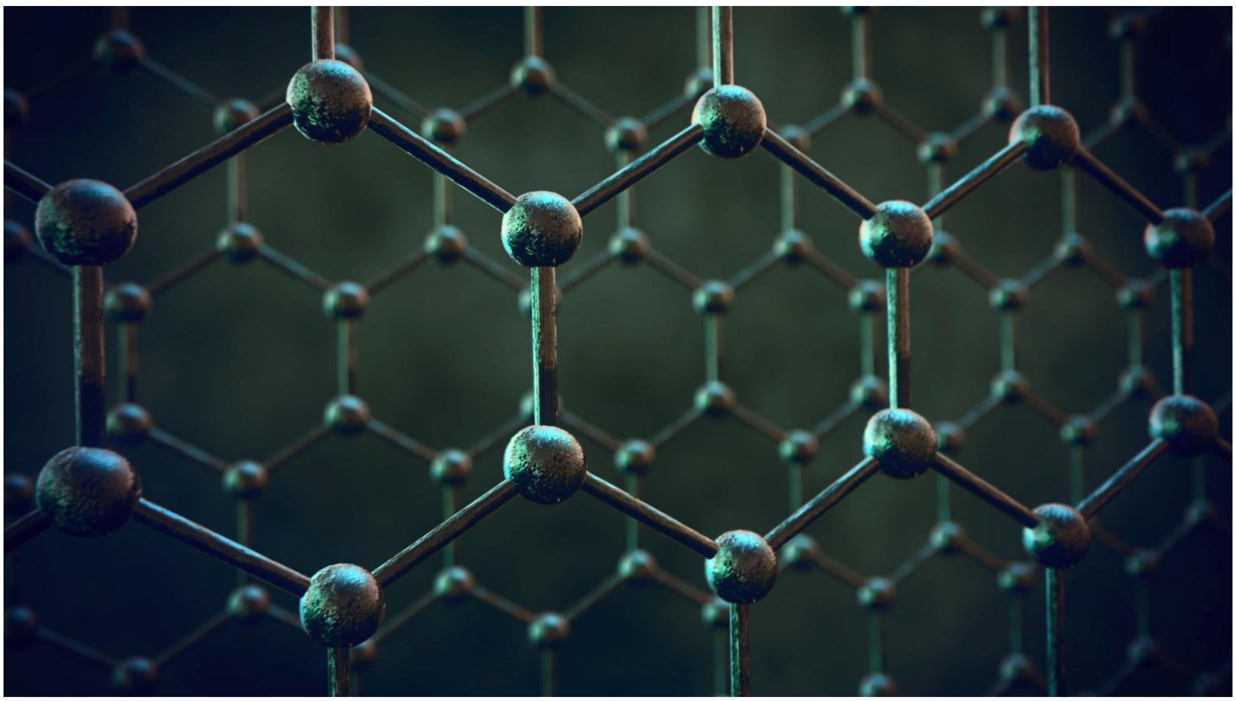

This visualisation shows layers of graphene used for membranes. Credit: University of Manchester

In the U.S., more than 100 food recalls were issued in 2017 because of contamination from harmful bacteria such as *Listeria*, *Salmonella* or *E. coli*. A new sensor design could one day make it easier to detect pathogens in food before products hit the supermarket shelves, thus preventing sometimes-deadly illnesses from contaminated food.

In the journal *Optical Materials Express*, researchers report a new design for a sensor that can simultaneously detect multiple substances including dangerous bacteria and other pathogens. In addition to food safety, the new design could improve detection of gases and chemicals for a wide range of other applications.

"Our design is based on graphene sheets, which are two-dimensional crystals of carbon just one atom thick," said research team member Bing-Gang Xiao, from China Jiliang University. "The sensor is not only highly sensitive but can also be easily adjusted to detect different substances."

Sensing with graphene

The excellent optical and electronic properties of graphene make it attractive for sensors that use electromagnetic waves known as plasmons that propagate along the surface of a conducting material in response to light exposure. A substance can be detected by measuring how the refractive index of the sensor changes when a substance of interest is close to the graphene's surface.

Researchers have taken advantage of graphene's unique properties to create sensors and materials for a range of applications in recent years. Compared to metals like gold and silver, graphene exhibits stronger plasmon waves with longer propagation distances. In addition, the wavelength at which graphene is responsive can be changed by applying a polarization voltage instead of recreating the whole device. However, few previous research efforts have demonstrated sensitive graphene sensors that work with the infrared wavelengths necessary to detect bacteria and biomolecules.

For the new sensor, the researchers used theoretical calculations and simulations to design an array of nanoscale graphene disks that each contain an off-center hole. The sensor includes ion-gel and silicon layers that can be used to apply a voltage to tune the graphene's properties for detection of various substances.

The interaction between the disks and their holes creates what is known as the plasmon hybridization effect, which increases the sensitivity of the device. The hole and the disk also create different wavelength peaks that can each be used to detect the presence of different substances simultaneously.

Simulations performed by the researchers using mid-infrared wavelengths showed that their new sensor platform would be more sensitive to substances present in gases, liquids or solids than using discs without holes.

The researchers are now working to improve the process that would be used to make the array of nanoscale discs. The accuracy at which these structures are fabricated will greatly impact the performance of the sensor.

"We also want to explore whether the graphene plasmon hybridization effect could be used to aid the design of dual-band mid-infrared optical communication devices," said Xiao.

More information: Shaokang Gong et al, Hybridization-induced dual-band tunable graphene metamaterials for sensing, *Optical Materials Express* (2018). DOI: 10.1364/OME.9.000035

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