Gold nanostructures aid the development of new photonic devices

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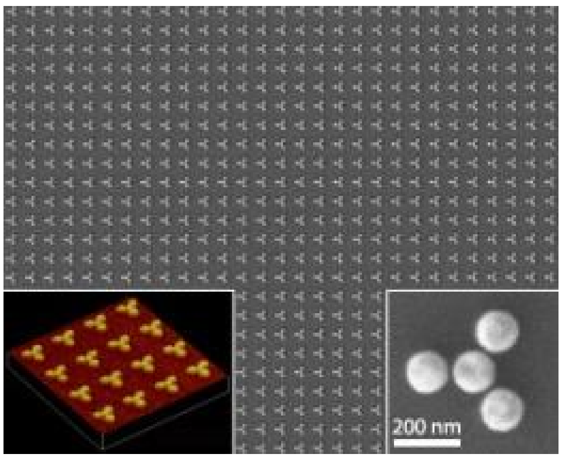

A plasmonic system modeling a trigonal planar molecule. The system consists of 142 nm-high gold nanodiscs with an 18 nm interparticle gap. Credit: A*STAR

Surface plasmon resonance—the collective vibration of electrons on the surface of metallic nanostructures in response to excitation with light or charge—has recently gained much attention from the scientific community because of its wide range of possible applications, particularly in photonics. Mohsen Rahmani and co-workers from the A*STAR Data Storage Institute have now expanded the potential uses of this phenomenon with their discovery that the surface plasmonics of assemblies of nanoparticles closely resembles the energetic interactions among atoms in two-dimensional molecules.

The resonance properties of surface plasmons are determined by the precise makeup up of the nanostructure, including the metal, the substrate and even the shape of the structure itself. Interactions among nanostructures when brought close together can also significantly alter the plasmon resonance of the system. This approach has been studied for application in the design of very sharp plasmon resonances that are highly sensitive to the external environment, with uses, for example, in gas sensing.

The researchers studied complex two-dimensional designs based on assemblies of four gold nanodiscs. With the gap between discs set at just 18 nanometers, strong interactions occurred among the plasmonic modes of the individual discs. Conceptually, this interaction among the optical states of the gold nanodiscs is similar to the electronic interaction between atoms in a molecule. “The trigonal planar molecules mimicked in our work are among the few naturally occurring planar molecules,” says Rahmani.

As in a molecule, the interactions among nanodiscs in a plasmonic system lead to multiple plasmon resonance peaks instead of the sole peak produced by a single isolated disc. “Based on such direct analogies, plasmonic nanostructures could therefore be a convenient tool to study the properties of more complex molecules,” explains Rahmani.

In the future, the researchers plan to design and fabricate three-dimensional structures, which would allow them to study a wider range of molecules. Such studies could lead to a better understanding of molecular orbital theory in planar trigonal molecules, and of the behavior of carbon atoms within graphene sheets. The analogy between molecules and plasmonic structures could also be used to advance the development of a number of photonic devices. “The analogy could benefit applications in nanolithography, optical switching and nonlinear spectroscopy,” says Rahmani. Given the vast number of molecules available as blueprints for the design of specific properties, the potential applications of such plasmonic systems are expected to be numerous and far-reaching.

More information: Rahmani, M., et al. Influence of plasmon destructive interferences on optical properties of gold planar quadrumers. *Nanotechnology* 22, 245204 (2011).

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