Flexible design approach for nanosensors that overcomes practicality and reliability issues now available

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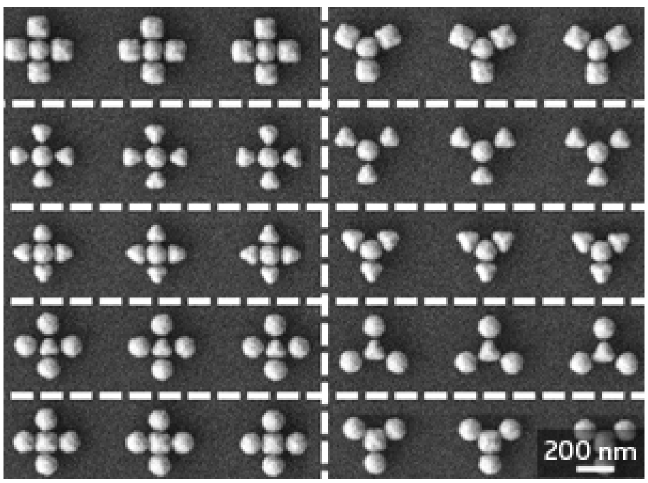

Electron microscope images of two different plasmonic structures that researchers can deconstruct into subunits to determine optical properties. Credit: 2012 American Chemical Society

(Phys.org)—Metal nanostructures can act as tiny antennae to control light since they can focus and guide light on the smallest of scales. The optical properties of these antennae depend strongly on their size and shape, making it difficult to predict which shape to choose for a desired optical effect without relying on complex theoretical calculations. Mohsen Rahmani and co-workers at the A*STAR Data Storage Institute, Singapore, and Imperial College London, UK, have now developed a method that allows for the practical and reliable design of these nano-antennae.

Their method is based on new understanding of the optical resonance properties of a few standardized building blocks of the antennae that arise from plasmons—the collective movements of electrons at their surface. "Our novel understanding captures aspects of device design that extend well beyond known optical interference mechanisms and significantly advances our understanding of the plasmonic resonance spectrum. This could bring about new applications," explains Rahmani.

Some of the most useful properties of plasmonic antennae arise when the metal nanostructures are brought within close proximity to each other. This leads to interference effects near their surface that cause sharp spectral features, known as Fano resonances. Any changes near the nanostructures, such as the introduction of a few molecules or fluctuations in temperature, can impact the sensitive Fano resonances. These changes can be detected and used for sensing applications.

Typically, researchers iteratively use computer models of nanostructures to optimize the design of plasmonic antennae. Rahmani and co-workers simplified the approach by using standardized subunits of nanoparticles called plasmonic oligomers (see image). For example, they deconstructed a cross-shaped structure, consisting of five dots, into two different subunits—one with three dots in a line and one with four outer dots. They then determined the plasmonic resonance of an entire array simply by combining those subunits.

By modeling the properties of the oligomers and comparing their results with measurements of optical spectra, Rahmani observed a systematic dependence of the optical resonances on individual subunits. The team's findings suggest that the optical properties of various plasmonic antennae can be designed easily from just a few basic building blocks.

"The possible combinations are almost endless and these structures could find many applications," says Rahmani. These range from nanoscale lasers and optical switches for telecommunications to biosensing. "We are now going to develop these oligomers as nanosensing platforms for detecting the adsorption of chemical molecules and protein monolayers."

More information: Rahmani, M., Lei, D. Y., Giannini, V., Lukiyanchuk, B., Ranjbar, M. et al. Subgroup decomposition of plasmonic resonances in hybrid oligomers: modeling the resonance lineshape. *Nano Letters* 12, 2101–2106 (2012). dx.doi.org/10.1021/nl3003683

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