Silver nanostructures exhibit resonance feature that is useful for multitude of sensing applications

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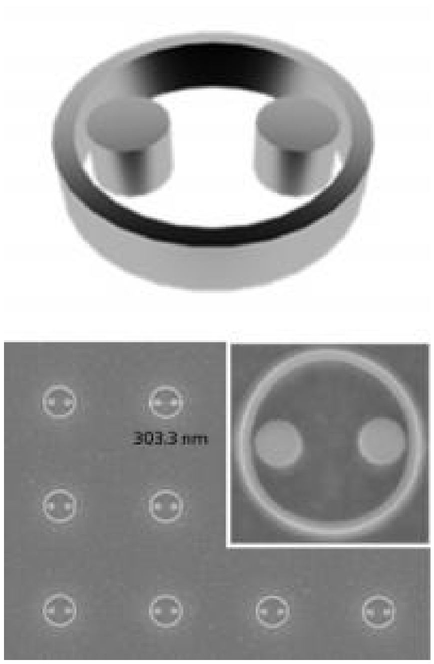

Scheme (top) of the dual-disk ring structure and scanning electron micrscosopy images of fabricated devices (bottom). Credit: Reproduced with permission, 2011 Optical Society of America

Certain metallic nanostructures are known to exhibit a distinctly asymmetric spectral feature. This characteristic feature, known as a Fano resonance, has attracted a considerable amount of attention due to its potential in sensing applications.

Fano resonance is caused by the interference of two eigenmodes (modes of electron excitations), so its shape and wavelength are sensitive to slight variations in the environment. A small change in the refractive index, for example, could lead to a big change in the Fano resonance.

So far, most of the metallic structures used to generate Fano resonances have been made of gold. The wavelength of such Fano resonances is typically in the infrared region, which is not ideal for practical sensing applications. Jing Bo Zhang and co-workers at the A*STAR Data Storage Institute have now proposed a silver dual-disk ring nanostructure for generating Fano resonance in the visible range.

The nanostructure comprises a dual-disk ring consisting of two silver disks, measuring tens of nanometers wide, placed inside a silver ring. The researchers calculated the optical modes of the structures using the finite-difference time-domain (FDTD) method. They found that the coupling between one of the dual-disk eigenmodes and one of the ring eigenmodes produces a Fano resonance just below 700 nanometers in wavelength, well within the visible spectrum.

The shape and wavelength of the Fano resonance can be finely tuned by varying the geometric parameters that define the dual-disk ring structure. The key capability of a biomolecule sensor is its reaction to a change in the surroundings. The calculations showed that by increasing the refractive index of the environment, the Fano resonance is strongly red-shifted. This is to simulate for a case in which a thin coat of a dielectric material, such as a layer of specific biomolecules, is assumed to cover the nanostructure.

The calculations were promising but had to be verified experimentally. The researchers used electron beam lithography and corresponding nanoprocessing techniques to fabricate silver dual-disk rings on quartz and indeed observed Fano resonance in the visible light range.

Observation of the Fano resonance and its sensitivity to environmental changes in the visible range is an important result for sensing applications. The researchers aim to improve the design of the nanostructure further. “We have already determined and fabricated the optimum geometry of dual-disk ring structures for biosensing,” says Zhang. “Next we are going to functionalize the surface of the structure chemically to examine and improve the sensing power experimentally.”

More information: Niu, L., et al. Fano resonance in dual-disk ring plasmonic nanostructures. Optics Express 19, 22974–22981 (2011).

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