Highly tunable hybrid plasmonic devices for trapping nano-objects

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The first evidence of particle confinement using plasmonics was demonstrated by Garcés-Chávez in 2006. They used the Kretschmann configuration with the top surface of a prism coated by a thin gold layer in order to observe large scale ordering of colloidal particles.[1] Later Righini *et al*. modified the experimental apparatus by fabricating golden micro-disks, instead of using a thin gold layer, leading to the successful trapping of polystyrene spheres on top of these microstructures.[2] In 2011, Gordon and Pang achieved 12 nm particle confinement. Their devices consisted of double nano-holes which were connected by a slit punched on a thin gold film.[3]

We study the optical properties of a hybrid gold nano-disk and nano-hole array design which demonstrate high plasmon resonances in the near-infrared regime (NIR)[4] and is suitable for nano-object manipulation. Figure 1 shows the design of a single cell of such an array. The tunability of the device is associated with the variation of different parameters such as the periodicity, and dimensions of the different components of the array. The resonance modes of this hybrid design exhibit splittings to low and high energy modes caused by the electromagnetic interference between the disk and hole plasmons. The devices are excited at a glass-water interface by evanescent fields. The enhancement in the NIR is in the biologically compatible part of the spectrum where low photo damage is desirable. Characterization curves of the devices are obtained by collecting spectrometric measurements from the reflected light at the prism-water interface. Furthermore, the nano-rings are connected by grooves that act as trapping sites. In this region, further enhancement and confinement of the local fields are observed. The dependency of the plasmon resonance frequency on both the incident light angle and polarization are studied. These dependencies are also investigated during trapping experiments. Two means of fabrication of the devices are also discussed: Electron Beam Lithography (EBL) followed by Electron Beam Deposition (EBD), and Focused Ion Beam (FIB) etching.

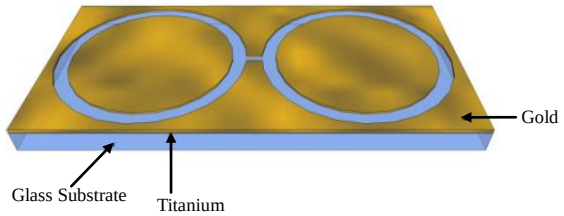

Fig. 1: Schematic of hybrid plasmonic device consisting of gold nano-disk and nano-hole array cell.

References

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