Plasmonic responses of metallic/dielectric core–shell nanoparticles on a dielectric substrate

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Core–shell nanoparticles can be classified as dielectric–metal, metal–dielectric, and metal–metal according to their material compositions for the core and shell, respectively. These nanostructures have various advantages: the plasmonic response of the nanoparticles can be tuned and/or hybridized by changing the material composition, core/shell size ratio, and the surrounding medium. Such nanoparticles can offer unprecedented ways to exploit their optical properties with optimum field enhancement and tunable LSPR responses [1]. Their hybrid structures are promising for localized heating applications that necessitate a detailed study of absorption mechanisms with material and size combination.

Although there are numerous numerical studies based on NPs and their LSPR responses, most of them based on geometries involving free space without surface interactions or in an aggregate form. A recent numerical study of silica core-gold shell NP being placed on a BK7 substrate showed that enhanced absorption efficiency and a redshift of the plasmon response can be achieved for selective heating and nano-manufacturing purposes [2]. There are, however, limited number of studies on material comparisons that will guide the experimentalists to the optimum configurations for the enhanced effects. The objective of the present paper is to focus on the spectral absorption profiles of core–shell nanoparticles with various core–shell material and size configurations accompanied with surface interactions. Current study is the follow-up investigation of [2] with single core–shell nanoparticle placed on a semi-infinite BK7 glass substrate being illuminated by an EM light from bottom with total internal reflection. The spectral absorption behavior of core–shell nanoparticle is numerically studied with selected metal–dielectric, and dielectric–metal pairs for core and shell materials, respectively.

In this paper, the effects of material selection on the plasmonic response and local absorption are evaluated for core-shell nanoparticles placed over a BK7 glass substrate. Eight different core-shell pairs are studied using the vectorized version of discrete dipole approximation with surface interactions. Two classes of dielectric core–metallic shell and metallic core–dielectric shell particles are considered. It is shown that core–shell structures with dielectric materials can have absorption enhancement compared to the bare metallic nanoparticles. Moreover, it is observed that core–shell pairs yield multipeak localized surface plasmon resonance (LSPR) response due to their hybrid structure. Absorption enhancement and LSPR tuning ranges are shown with different dielectric materials that can be used in localized heating of designated core–shell NPs placed over a surface for nanomanufacturing purposes. In order to determine the optimum size configurations, a number of core-shell pairs are explored with specified volumetric filling ratio of core materials.

References

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