Polarization Enhancement in a Particle with a Core-Shell Structure

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Most metal and semiconductor particles acquire a layer of oxide on their surfaces when exposed to the atmosphere. At the same time, coating may be deliberately added onto a nanoparticle to adjust its functional properties. The presence of a non-conductive layer on the surface of a conductive particle results in a modification in its polarization properties. In this investigation, the polarization induced by a Terahertz electric field on a model semiconductor nanoparticle with a core-shell structure is studied by employing a transport formulation for the charge carriers in the semiconductor core. The total dipole moment induced on the particle enclaved by a dielectric shell is obtained by electromagnetic simulation tool and compared to that of the core particle without a shell. Computation results indicate that the presence of the dielectric shell leads to a shift in the surface plasmon resonance frequency, along with an overall increase in the total dipole moment of the structure. The latter can be attributed to the field enhancement effect of the dielectric shell, which results in a stronger polarization in the core while the polarization in the dielectric shell itself adds to the total dipole moment. An equivalent circuit for the core-shell nanoparticle has been developed to facilitate the estimation of the induced dipole moment. It is observed that the circuit topology for a bare nanoparticle can be adopted for the core-shell in the current study. The expressions for the values of some elements need to be modified to account for the field enhancement effects of the dielectric shell. Range in the validity of the circuit representation is discussed in terms of the frequency response of the resultant generalized admittance.