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Nonreciprocal Optical Effects in Plasmonic Nanoparticle Aggregates

Authors : Ward Brullot, Thierry Verbiest

Abstract : Nonreciprocal optical effects, such as Faraday rotation or magnetic circular dichroism, are very useful both for fundamental studies as for applications such as magnetic field sensors or optical isolators. In this study, we developed layer-by-layer deposited 20nm thick plasmonic nanoparticle aggregates consisting of gold, silver and magnetite nanoparticles that show broadband nonreciprocal asymmetric transmission. As such, the optical transmittance, or absorbance, depends on the direction of light propagation in the material, which means that looking from one direction or the other, more or less light passes through the sample. Theoretical analysis showed that strong electric quadrupole fields, which are electric field gradients, occur in the aggregates and that these quadrupole fields are responsible for the observed asymmetric transmission and the nonreciprocity of the effect. Apart from nonreciprocal asymmetric transmission, also other effects such as, but not limited to, optical rotation, circular dichroism or nonlinear optical responses were measured in the plasmonic nanoparticle aggregates and the influences of the intense electric quadrupole fields determined. In conclusion, the presence of strong electric quadrupole fields make the developed plasmonic nanoparticle aggregates ideal candidates for the study and application of various nonreciprocal optical effects.

Keywords : asymmetric transmission, electric quadrupoles, nanoparticle aggregates, nonreciprocity
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