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(G) Study of Bragg Scattering in the Presence of Dipole-Dipole Interaction in Plasmonic Nanohybrids

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In this work, the Bragg Scattering for metallic nanohybrid made of an ensemble of metallic nanorods doped in a substrate. Such substrate can be any suitable gas, liquid and solid. Moreover, a theory was developed to describe the relation between an external incident laser intensity and Bragg scattered light intensity. When the external laser was applied to the metallic nanohybrids, the photons from the laser will interact with the surface polaritons in the nanorods and produced surface plasmon polaritons (SPPs). On the other hand, the incident photon induced dipoles in the ensembled nanorods, so the nanorods can interact with each other via dipole-dipole interactions (DDI). The developed theory involved the coupled-mode formulism based on Maxwell's equation with the presence of SPP and DDI fields and analytical expressions for the SPP/DDI coupling constants were obtained in a similar manner as [1]. It is found that, the intensity of Bragg scattering would depend on the susceptibility induced by SPP and DDI field. The susceptibility was calculated by the quantum mechanical density matrix method [2]. Combining these methods, an analytical expression for the Bragg scattering intensity as a function of incident laser intensity. Next, the theory was used to compare with the experimental data for a nanohybrids made of doping Au-nanorods into water. A decent agreement between the theoretical model and experimental data was observed. Later, several numerical simulations were performed to investigate the effects of SPP/DDI coupling, laser detuning and phase factor. The theoretical model was used to predict the Bragg intensity due to different parameters. The Bragg scattering intensity was found to be enhanced by higher SPP/DDI coupling constant. Such an enhancement can be interpreted by the extra coupling mechanism from the SPP and DDI polaritons with acoustic phonons. On the other hand, the peaks for the Bragg scattering intensity can be split into many peaks due to SPP/DDI coupling and the phase constant. Such a splitting of the peaks can be explained by the Bragg factor in the theory. In conclusion, the enhancement effect can be used to fabricate new nano-sensors, and the splitting effect can be used to design new nano-switches where the peaks can be interpreted as the ON position.

Reference:
[1] Singh, M.R. and Black, K., J. Phys. Chem. C. 122, 26584-26591 (2018).
[2] . Singh, M. R., Electronic, Photonic, Polaritonic and Plasmonic Materials, Wiley Custom. Toronto, 2014.

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Plasmonic

Keyword-2

Surface plasmon polaritons

Keyword-3

metallic nanohybrids

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