Photon manipulation in plasmonic crystal

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Abstract

Plasmonic devices, consisting of subwavelength nanostructures at optical frequency, have been widely applied to many research fields such as bio-sensing, super-resolution imaging, energy harvesting, nanolaser and so on. The strong confined electromagnetic fields in the affinity of nanostructures provides an efficient channel to guide, enhance, and modulate light energy beyond the diffraction limit. In this thesis, we first studied the plasmonic devices in linear optical regime, especially from the view of phase information in the light matter interaction; then more efforts were paid to the nonlinear plasmonics, in which the organic-plasmonic hybrid nanostructures provided a useful platform for demonstrating some interesting physical phenomena.

Firstly, we studied the fundamental optical properties of typically propagating surface plasmonic polariton (SPPs), which were generated by plasmonic gratings. Optical elliptical response of excited SPPs was studied experimentally and theoretically in both amplitude and phase domains. Then we studied the strong coupling effect from plasmonic Fabry-Perot nanocavity, in which giant Rabi splitting phenomenon with a splitting energy $\sim$ 148 meV was obtained experimentally. From these studies, the interaction of SPP wave with other resonant structures were well understood from the view point of phase evolution.

Secondly, we moved from linear optics the nonlinear plasmonic optics and tried to understand how the plasmon enhancement acts on the nonlinear optical processes. In the first example, plasmon enhanced third harmonic generation (THG) on one dimensional gratings was experimentally demonstrated by integrating the nonlinear active medium into the plasmonic devices. Later, the generation of THG vortex beam was also realized by introducing hologram based plasmonic design. Lastly, we re-examined a conventional symmetry problem in nonlinear molecular optics. It was found the that the metacrystal, consisting of plasmonic molecule with feature size much larger than conventional molecules, also follows the conventional selection rules

of third harmonic generation.

We believe the knowledge we accumulated in this work also provides a strong background for our future studies on ultra-fast plasmonic switching, in which the all-optical low loss, optical switch can be realized by using the engineered optical properties of plasmonic devices.

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