Shaping of Plasmonic Nano-Vortex Fields

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The Laguerre-Gaussian (LG) beam, called as optical vortex, that possesses helical wave-front and doughnut beam profile has recently attracted significant attention because of the unique characteristics of carrying the orbital angular momentum in addition to the spin angular momentum corresponding to circular polarization. Recently, we demonstrated that multipolar plasmons of metal nano-disks can be selectively excited by circularly-polarized optical vortex beams [1]. The orbital and spin angular momenta are transferred from LG-mode photons to localized plasmons. This plasmonic field localized by the nano-disk just corresponds to the whispering gallery mode (WGM), where the angular mode number is determined by the total angular momentum of the LG beam. Unfortunately, the mode volume of this plasmonic resonator is sub-micrometer dimension that is restricted by the diffraction limit of the surface plasmon wave.

In order to realize the WGM nanocavity, we design the tailored plasmonic structure consisting of metal multimer surrounding a single-nanometer-sized gap (Fig. 1). This metal structure makes it possible to localize the optical vortex field into the nanogap space with conserving the high-order orbital and spin angular momenta. We discuss on the relation between the degrees of freedom in the multimer structure and the transferable angular momenta, i.e., the angular mode number of the WGM nanocavity. We also demonstrate efficient and selective excitation of the optical forbidden state in an artificial molecule placed in the nano-vortex field. By controlling nano-shape of photons, photochemical reactions and photophysical processes become free from the selection rule of electronic transitions [2,3]. The orbital angular momentum transfer from nano-vortex photons to molecules also induces rotational radiation pressure, i.e., optical torque [4], which may lead to nano-vortex flow of molecules and to chiral structuring of molecular assemblies.

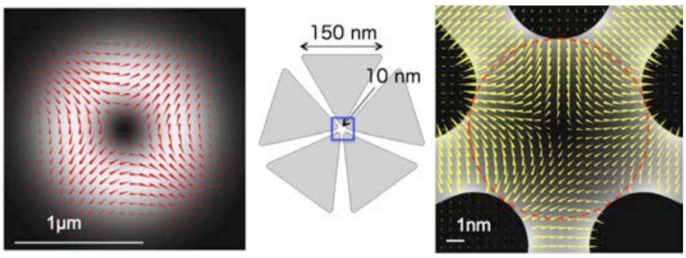

Fig. 1 The electric field of the incident LG beam (left), the plasmonic multimer structure (middle), and the nano-sized optical vortex field (right).

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