Enhanced optical activity in planar chiral nano-gratings

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Abstract :

The control of light with artificial structures is one of the key issues in modern photonics. Recent advances in nanotechnology have made such a control possible using periodic sub-wavelength structures. Optical activity occurs in chiral media that have no mirror symmetry and interact differently with left- and right-hand circularly-polarized light. When a linearly polarized light wave propagates in a chiral medium, the polarization plane azimuth rotates clockwise or counter-clockwise depending on the handedness of the material. We have demonstrated a giant optical rotatory power ($\sim 10^4$deg./mm) [2] of a two-dimensional array of metal nanoparticles that have no symmetry plane and are deposited on a dielectric substrate. The array is organized in a two-dimensional grating with a period smaller than the light wavelength, so that no diffraction takes place. The observed polarization effect in plane nanostructures originates from the three-dimensionality of the sample.

We examined the effect of coupling between surface plasmon polariton (SPP) modes on the optical activity of metal nanostructures. By measuring the in-plane wave vector dependence on transmission and polarization azimuth rotation, we show that coupling of the SPP modes with orthogonal polarization localized at different interfaces is responsible for the optical activity in metal nanostructures. A comparison of the dispersion curves of the transmission and polarization rotation allows us to conclude that optical activity in planar nano-gratings originates from the chirality-induced coupling of the orthogonally polarized SPP modes localized at the metal-air and metal-substrate interfaces. The electron oscillations in collective SPP modes at each interface in the chiral metal structure are separated by the thickness of the metal layer. The asymmetry of the air-metal-substrate structure results in non-parallel electric field vectors at the front and back surfaces. At SPP resonance, this leads the enhancement of the first order spatial dispersion, which is related to the non-local light- matter interaction responsible for optical activity. [3]

We will also present our recent experiments on optical activity of THz wave in chiral metal nano gratings [4].

The work has been done in collaboration with K. Konishi,N. Kanda, Yu. P. Svirko, T. Sugimoto, B. Bai and Jari Turunen. This work is supported in part by a Grant-in-Aid for Scientific Reserach (S) from Japan Society for Promotion of Science, Special Coordination Funds for Promoting Science and Technology from MEXT, Japan and CREST (JST).

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