Optical and magneto-optical properties of magnetophotonic crystals

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In much the same way that semiconductor crystals affect the propagation of electrons, photonic crystals (periodic composites of macroscopic dielectric media of different refractive index) affect the propagation of light, providing a new mechanism to control and manipulate the flow of light. The key to this lies in the concept of a photonic band gap originating in the periodic structure itself and localization of light at a defect introduced into the periodic structure.

When the constitutive material of PCs is magnetic, or even only the defect is magnetic, the resultant PCs (let us simply refer to as magnetophotonic crystals (MPCs)) exhibit very unique optical and magneto-optical properties: The strong photon confinement associated with the magnetic defect can be exploited to enhance and optimize magneto-optical (MO) effects and optical non-linearity. In fact, extremely large enhancement in MO Faraday and Kerr effects have been demonstrated with one-dimensional (1D) MPCs composed of a magnetic garnet thin film sandwiched between dielectric Bragg mirrors. This is particularly attractive for constructing film-type optical isolator/circulator elements and functional MO micro devices. Strong enhancement in resonant second-harmonic generation (SHG) intensity was also obtained for the 1D-MPCs within the spectral range of pass band. Both significant non-linear MO Kerr effect (NOMOKE) rotation of second-harmonic wave polarization and magnetization- induced variations of the SHG intensity were detected at the vicinity of a localized photonic state. Spectrum of the NOMOKE rotation of the SH wave polarization shows gradual monotonic increase of rotation angle up to 7 deg in spectral range from 790 nm to 830 nm.

A ordered pore array structure is discussed from the viewpoint of the application to two-dimensional photonic crystals (2D-MPC). We prepared porous alumina templates with pore diameter of 60 nm and thickness of 2 mm. By using this templates as mask, the Bi:YIG film deposited by rf-magnetron sputtering were etched by Ar ion gun. we were able to fabricate 2D-MPC of Bi:YIG with hole structure. We also devoted to a new approach for creation of three-dimensional magnetophotonic crystals (3D-MPC) which is made of dielectric spheres covered with magnetic materials. In our experiments LATEX or SiO_2 spheres with diameter of about 200 nm were coated with magnetite fine particle (magnetic garnet or ferrite).

At the conference, preparation methods of 1D, 2D and 3D-MPCs are described together with their fundamental optical and magneto-optical linear and non-linear properties.