

융합진공과학, 양자 광기능 물성연구에의 도전

- 스핀 광자결정을 중심으로

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A representative item, in the field of photonics aiming at ultrafast devices, is photonic crystals (PC) which are a new-concept material or structure to control the propagation of light in various ways. Furthermore, even spin PC (SPC) and metamaterials such as left-handed materials (LHM) appear recently, where magnetic components are also included in the basic periodic arrangement of nonmagnetic ones to be controlled magnetically as well. The interest in photon-spin interaction is grown, but the basis is not solid yet. It is a crucial time to promote this kind of research, and this chance hopefully provides an opportunity for it. SPCs are very promising for applications in modern photonics, since they possess an additional degree of freedom. The SPCs can be prepared as periodic one-, two- and three-dimensional structures composed of, at least, two different magnetic and nonmagnetic, or magnetic and magnetic materials with different refractive indices. The linear SP properties of one-dimensional SPCs with three-defect asymmetric structures were studied. The requirements of a Kerr rotation of about 45° and a reflectance higher than 95% are met simultaneously with the 44-layer structure. The frequency response of reflectance is greatly broadened as the length of the rear structure is increased, without any evident effect on the Kerr rotation. These conditions are also satisfied at both normal and slightly oblique incidence. In addition, we investigated the nonlinear optical response, including the optical bistability, of one-dimensional SPC with two-defect layers, upon intensive optical radiation in the polar SP configuration for the normal incidence of light. The relationship of defect modes inside photonic band gap with the distance between defect layers was obtained. The cubic nonlinear polarization leads to the effects of optical bistability on the frequencies of defect modes. Two-dimensional SPC were also fabricated utilizing precise semiconductor manufacturing and nano-fabrication techniques, and their magneto-optical properties and magnetic-domain structures are extensively elucidated. The LHM compose of two parts: magnetic component providing a negative magnetic permeability $\mu < 0$, and electric component yielding a negative electric permittivity. The control of the magnetic frequency band for $\mu < 0$ plays an important role for the practical application of LHM when it is combined with the electric component. The cut-wire pair was used instead of split-ring resonator to provide $\mu < 0$ for the composed metamaterials (CMM). The cut-wire pair and the CMM structures were designed, built, and measured, first of all, in the microwave frequency range.