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Low-temperature magneto-optical properties of microcavity magnetic photonic crystals with the temperature of magnetic compensation

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The high transparency in optical range and large magneto-optical response of the magnetic photonic crystals (MPCs) based on Bi-substituted yttrium–iron-garnet films allow their applications and attract a great deal of attention of numerous research groups. Three types of (Bi, Gd, Al)-substituted yttrium-iron-garnet films and three types of magnetic photonic crystals that had one-layer and double-layer magneto-optical micro-resonators were prepared and investigated. The nominal compositions of these films were: $Bi_{1.0}Y_{0.5}Gd_{1.5}Fe_{4.2}Al_{0.8}O_{12}$ (M1), $Bi_{2.8}Y_{0.2}Fe_5O_{12}$ (M2) and $Bi_{2.5}Gd_{0.5}Fe_{3.8}Al_{1.2}O_{12}$ (M3). The resonant cavities in photonic crystals were: 2M1 (MPC type III), M1/M3 (MPC type II), and M1/M2 (MPC type I). The films M1 and M3 had temperatures of magnetic compensation near to 140 K and 22 K.

The overturn of magnetic moments of both layers in the double-layer micro-resonators of MPCs at cooling occurred simultaneously. Any features that would indicate on the independent magnetic overturns in the underlayer (M1) and in main layer (M3) were not found. Such the temperature behavior of Faraday rotation indicates the existence of sufficiently rigid exchange coupling between layers of composite resonator. The values of magnetic reversing temperatures in these MPCs were below 20K (MPC type I), close to 25 K (MPC type II) and 135K (MPC type III). The last value is close to the magnetic compensation temperature 135K of the relevant magnetic film (M1) in this MPC with the one-layer resonator.

It was found that positions of the resonant peak in spectra of the optical transmittance and the Faraday rotation of all MPCs with decreasing temperature from 300K up to 20K different insignificantly – not more than 5% from half-width of the resonant band.