Nonlinear magneto-optical effects in all-garnet magneto-photonic crystals

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Nonlinear-optical effects in magnetic materials, such as magnetization-induced second-harmonic generation (MSHG), supplements and extends greatly the magneto-optical Kerr and Faraday effects. MSHG is governed by the next (quadratic) order of optical susceptibilities and it has been proven to be versatile and sensitive tool for studying magnetized surfaces and interfaces, planar magnetic nanostructures and nanoparticles. Apart from the variety of spectacular effects observed in photonic crystals, such as suppression of group velocity and inhibition of spontaneous emission, materials with photonic band gap (PBG) are of great importance for nonlinear optics also. For example, recently MSHG is observed for the first time in the magnetic photonic-crystal microcavities with the spacer formed from bismuth-doped iron garnet [1]. The possibility of effective fulfillment of the phase-matching conditions at the PBG edge allows the enhancement of second-harmonic generation. In this work the first realization of phase-matched MSHG is reported. The large magnetic effects in intensity and polarization of the MSHG wave observed in garnet magneto-photonic crystals [2] (MPC) open up new applications of MPC as magnetic nonlinear-optical switchers.

MSHG spectroscopy is performed using the linear polarized output of ns-parametric generator/amplifier tunable from 730 to 1200 nm. MPC are grown by the RF sputtering of four quarter-wavelength-thick layers of Bi-substituted yttrium-iron-garnet separated by silicon oxide layers of the same optical thickness. The PBG is centered near 900 nm and has the spectral width of approximately 200 nm. Magnetic properties of MPC are probed independently by spectroscopy of Faraday rotation, which shows the enhancement of the polarization rotation angle till 1.2 degrees for wavelength of 1100 nm corresponding to the PBG edge. The intensity of the MSHG wave reflected from MPC is enhanced by at least two orders of magnitude when the fundamental radiation is tuned across the PBG edge. The rotation of the MSHG wave polarization up to 80 degrees is observed at the PBG edge in longitudinal geometry. The MSHG intensity contrast close to the unit for the opposite magnetic-field directions is observed in the transversal geometry.

References

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