Technological challenges of 1-Dimensional magnetic photonic crystals

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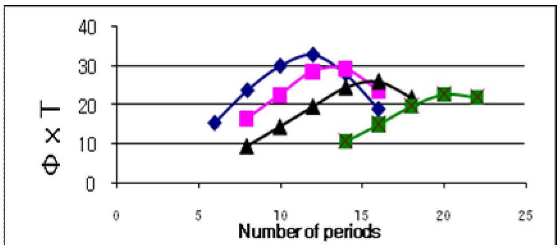
Abstract- Visible-region magnetic photonic crystals (MPC) designed for higher-order bandgap operation have been proposed to overcome the technological restrictions originating from the strong thickness dependency of the individual magnetic layer properties observed in MPC structures.

Various theoretical approaches to the design of different magnetic photonic crystals with excellent optical and magneto-optical (MO) characteristics for discrete and integrated magneto-optics have been reported recently. Fabricated 1D-MPC samples often exhibit significantly lower transmittance and Faraday rotation at the design wavelength (especially in the visible spectral range), due to physical and technological obstacles such as the high absorption of RF-sputtered Bi-iron garnet films, destructive magneto-optical interference in MPCs with high resonator quality, or due to the technological problems related to the manufacturing repeatability of the optical and magnetic properties in multiple ultra-thin garnet layers[1-3].

Our research group has achieved a significant progress in improving the magneto-optical quality of RF-sputtered iron-garnet films of composition $(BiDy)_3(FeGa)_5O_{12}$ [2]. However, the transmission electron microscopy study of ultra-thin layer cross-sections of such films has demonstrated that significant thickness-dependent effects (and therefore variations in the observed properties) can be expected in very thin (< 200 nm) nanocrystalline RF-sputtered garnet layers [2,3].

Based on the computer modeling of $(NM)_x(MN)_x$ MPC structures (N/M are nonmagnetic/magnetic layers) designed for 633 nm operation at higher-order bandgaps, so that the thicknesses of N and M are $h=\lambda/(4n)$ (-X- curve), $h=3\lambda/(4n)$ (-Δ-), $h=5\lambda/(4n)$ (-□-), and $h=7\lambda/(4n)$ (-◊- ,) we show that using thicker individual layers ($h=7\lambda/(4n)$) results simultaneously in reducing the non-uniformity in layer thicknesses and their magnetic properties, and also leads to improving the MO performance of MPCs, as shown in Fig. 1. In addition to improving the uniformity of the thickness and the thickness-dependent properties of the magnetic layers (due to the much larger thicknesses of the individual layers in comparison with the typical size of a single nanocrystallite), reducing the total number of layers used provides additional technological benefits. The parameter $T\times\Phi$, where T is the transmittance of the MPC at the design wavelength and Φ is the Faraday rotation angle at the same wavelength is found to be quite useful for comparing the efficiencies of different MPC designs.



The work was supported by RFBR grant 09-02-90437-Ukr_f_a and 09-02-92671-IND_a.

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