ナノ円錐台からなる磁気メタ表面におけるファラデー回転

Faraday rotation in a magnetic metasurface based on circular truncated nanocones

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Monocrystalline yttrium iron garnet (YIG) is one of the most promising materials in the study of magneto-optical (MO) devices for its moderate MO effect and low loss in the telecommunication band. Recently, all-dielectric MO metasurfaces have been numerically demonstrated to exhibit giant enhancement of Faraday rotation as well as high light transmission when employing electromagnetically induced transparency (EIT) effect [1]. The device structures considered there assume to possess perfectly vertical sidewalls in the nanopatterned MO materials. Unfortunately, the fabrication of such steep sidewalls is rather challenging for YIG-based materials [2]. For actual implementations, it is therefore necessary to assess Faraday rotation in MO metasurfaces with tilted sidewalls.

Here, we investigate an all-dielectric MO metasurface consisting of an array of circular truncated nanocones (height 260 nm, base diameter ~600 nm) made of Bi:YIG (BIG) (Fig. 1a). The nanocones are embedded in a low index (1.45) matrix. The structure is consistent with that in [1] except that the nanocones have tilted sidewalls. Figure 1(b) shows a computed light transmission spectrum for a device with the perfect side wall. The sharp peak in the broad dip stems from EIT. Tilting the sidewall induces a decrease of the EIT peak (Fig. 1c-d). For these computations, we recover the EIT condition for each tilt angle by adjusting the diameter of the cones. Then, we evaluated Faraday rotation angle at each EIT condition with varying tilt angle (Fig. 2). We found a gradual decrease of the rotation angle. Nevertheless, even with a title angle of 80°, a large Faraday rotation of ~ 6° is observed, which is ~8 times larger than the Faraday rotation angle in an unstructured BIG thin film (0.72°) with the same thickness. We consider that the tilt angle of 80° could be attainable by sophisticating dry etching process for YIG.

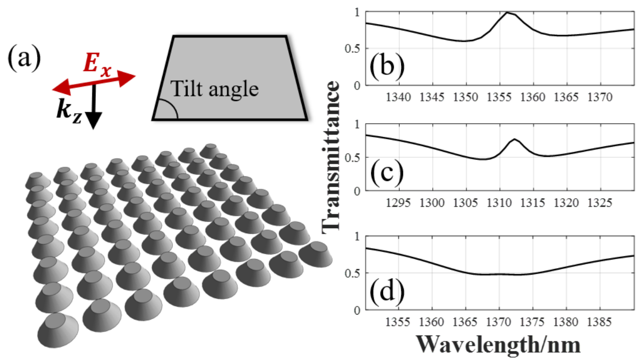

Figure 1. (a) Illustration of the circular truncated-nanocone metasurface. Transmittance spectra under normal incidence for the base angles of 90° (b) 85° (c) and 80° (d), respectively.

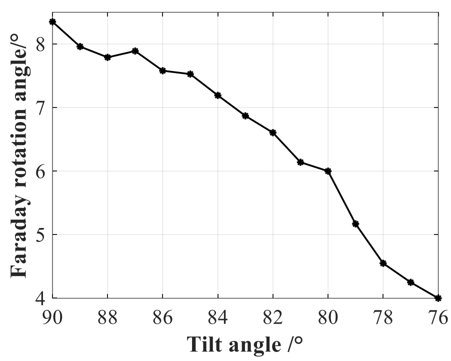

Figure 2. Faraday rotation angle at each EIT condition plotted as a function of title angle.

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References: [1] Christofi, A., *et al.*, *Optics Letters* **43**(8), 1838-1841 (2018). [2] Daria O. I., *et al.*, *Nature Communications* **11**(1) 5487 (2020).

