Compact THz nonreciprocal components using hexagonal ferrite ceramics

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A key element to protect coherent sources and achieve desired power stability and spectral purity for certain applications is an isolator, which in THz range has still no effective solution. Our concept of a novel THz isolating device builds on the recently demonstrated proof-of-principle design based on a one-way reflecting surface for NIR and visible wavelengths. This combines gyrotropy with a surface plasmon resonance [2]. A first crucial requirement to realize this, is a sufficiently strong THz gyrotropic material. In the last decade new fabrication and material processing methods have enabled a new type of ferrite material with hexagonal magnetoplumbite structure (e.g. $SrFe_{12}O_{19}$). Gyrotropy in this material is the result of gyromagnetic effects occurring when the saturation magnetization precesses nonreciprocally (NR) at Larmor frequency $\omega_0 = \mu_0\gamma H_{int}$ around internal magnetic field H_{int}. As a result the permeability acquires a tensorial form and its unequal off-diagonal elements are responsible for NR behavior. The internal field in hexaferrites is particularly strong (up to 20kOe), resulting in a Larmor frequency in the mm-wave range.

A first important step for the development of the device is complete material characterization of the used hexaferrites. In a first instance the diagonal permittivity and permeability elements have been characterized using both standard Time-Domain Spectrometry (TDS) and time-windowed Vector Network Analyzer (VNA) characterization. In a second step, the off-diagonal tensorial contributions are characterized in a Faraday configuration by measuring the magnetized samples with magnetization co-aligned with the beam path. This was done both on the VNA setup and TDS (Fig. 1Left). The obtained strong THz gyrotropy of hexaferrites proves their unique potential for THz isolator applications, as will be shown by first designs of a NR magnetoplasmonic mirror using the fitted material parameters. Our design combines strong gyromagnetic properties of hexaferrites in THz range with surface plasmon resonances formed due to the presence of a metallic grating at the hexaferrite surface. Close to these SPP resonances there can appear frequency ranges where the device acts as a one-way mirror (Fig. 1Center). Figure 1Right shows first fabricated samples with 6 different filling factors of grating for test measurement.

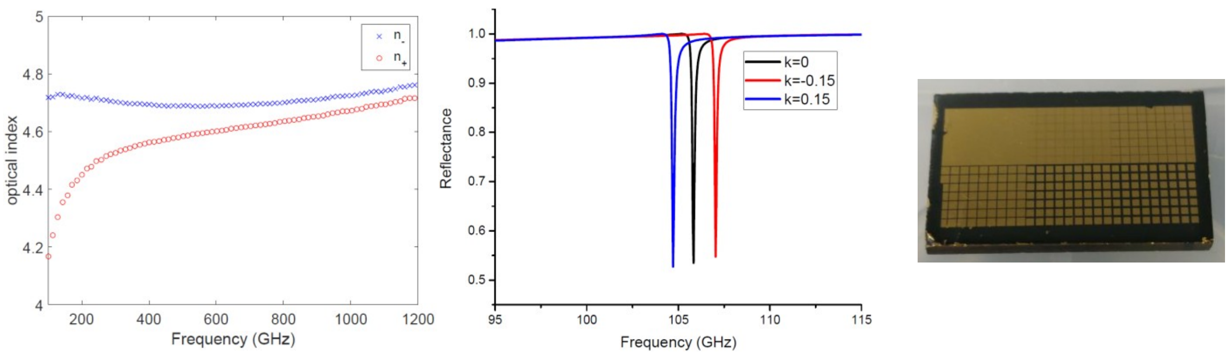

Fig.1. Left: Difference in optical indices of hexaferrite for left and right circularly polarized light measured by TDS proving strong material gyrotropy. Center: simulation results showing a shift of reflection dip according the direction of substrate magnetization (or incidence). Right: Picture of the first fabricated samples for test measurement.

[1] L. Halagačka et al., Opt. Ex., vol. 21, pp. 21741-21755, 2013.