Compact THz Isolator Using Nonreciprocal Magnetoplasmonic Mirror

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A key element for protecting of coherent sources and achieving of 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, combining gyrotropy nearby plasmon resonances. A first crucial requirement to realize this is a sufficiently strong THz gyrotropic material. In the last decade new fabricating and material processing methods have enabled creating a new type of ferrite material with hexagonal magnetoplumbite structure (e.g. $SrFe_{12}O_{19}$). Gyrotropy in this material is created by gyromagnetic effects when saturation magnetization precesses nonreciprocally (NR) at Larmor frequency $\omega_0 = \mu_0\gamma H_{int}$ around internal magnetic field H_{int}. Permeability of hexaferrites acquires in THz range a tensorial form and its unequal off-diagonal elements are responsible for NR behavior.

First important step for development of the device is complete material characterization of 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 TDS and the VNA setup (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 (Fig. 1Center). 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. 1Right).

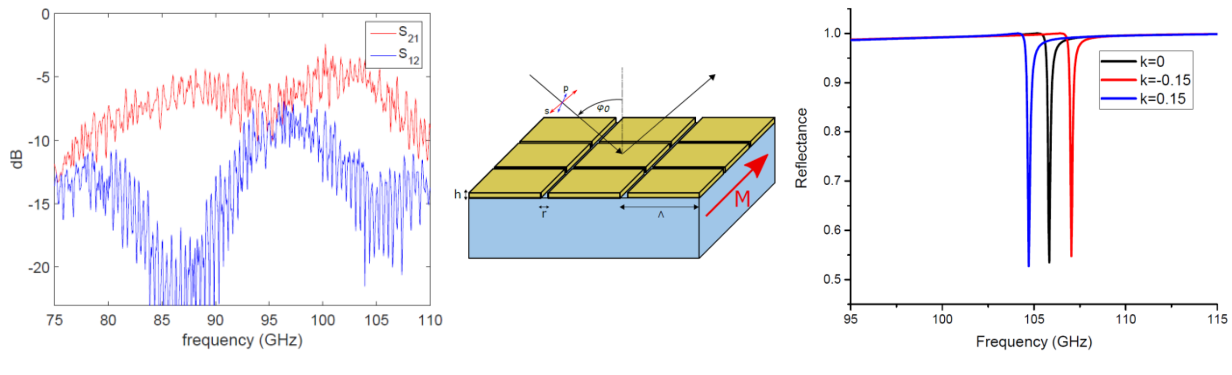

Figure 1: Left: Forward (S21) and backward (S12) transmittance of magnetized Sr-hexaferrite (FB6N) measured in free-space (75-110 GHz) with angles of polarizers P1 = -45°, P2 = 30° from vertical axis. Center: design of the isolator. Right: simulation results showing a shift of reflection dip according the direction of substrate magnetization (or incidence).