Terahertz magnetic response of rare earth orthoferrites

Xiaojian Fu*1, and Tie Jun Cui1
1State Key Lab of Millimeter Waves, School of Information Science and Engineering, Southeast University, People’s Republic of China
*corresponding author: fuxj@seu.edu.cn

Abstract - For most condensed matters, the magnetism rapidly declines above microwave frequencies, and the magnetic permeability is usually taken as unit in the optical regime. The so-called metamaterials can achieve high frequency magnetic response by employing the artificially designed magnetic resonance. However, the working frequencies of metamaterials depend on the periodic structure and may not be easy to tune. In this study, we investigate the intrinsic magnetic properties of rare earth orthoferrites, which may have potential application in tunable terahertz metamaterials.

ReFeO3 type oxides (Re=Y3+ or rare-earth ions) have attracted lots of attentions, due to their multiferroic, antiferromagnetic resonance (AFMR) and photocatalytic features1,2. The rare earth orthoferrites have a perovskite structure with a G-type antiferromagnetic ordering3. Figure 1 presents the schematic diagram of atomic arrangements in ferrites, where O atoms are not shown. It is demonstrated that the eight Fe3+ ions locating in two neighboring layers forms a simple cubic. Moreover, the nearest Fe3+ ions possess opposite spin magnetic moments, and hence G-type ordering is obtained.

Fig. 1. The atomic arrangements in ReFeO3-type ferrites.

Orthoferrites possess two terahertz magnetic resonant modes, the so-called quasi-ferromagnetic mode and quasi-antiferromagnetic mode, both of which are temperature dependent. Recent researches with terahertz time-domain spectroscopy have shown that coherent spin procession can be induced by the terahertz magnetic field in ReFeO3 crystals, accompanied by the remarkable magnetic dipole absorption and radiation at the resonant frequencies2,4. In this study, the terahertz magnetic responses of ReFeO3 ceramics have been experimentally investigated with terahertz spectroscopy5. Figure 2 shows the time-domain spectra of GdFeO3 ceramics at various temperatures. It is observed that there are some regular oscillations after the main transmitted pulses, which proved to be THz radiation signals. After Fourier transformation, the corresponding frequency-domain spectra can be obtained. As can be seen in Figure 3, obvious absorption and emission are induced by the
antiferromagnetic resonance. Besides, the resonant mode hardens as the sample cools because of the increase of effective field in the ceramic grains at low temperature.

This kind of temperature dependent magnetic response may have the potentials for application in tunable metamaterials since electromagnetic coupling effect may be induced between the magnetic ceramics and metamaterials.

**Fig. 2.** The time-domain spectra of GdFeO$_3$ ceramics at various temperatures.$^5$

**Fig. 3.** The frequency-domain spectra of GdFeO$_3$ ceramics at various temperatures.$^5$

**Acknowledgements** This work was supported by China Postdoctoral Science Foundation under Grant No. 2014M560372 and Jiangsu Planned Projects for Postdoctoral Research Funds under Grant No. 1402036B.

**REFERENCES**