Defense Technical Information Center Compilation Part Notice

ADP011602

TITLE: Quasistatic Magnetoelectric Particles: Experimental Investigation at Microwave Frequencies

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: International Conference on Electromagnetics of Complex Media [8th], Held in Lisbon, Portugal on 27-29 September 2000. Bianisotropics 2000

To order the complete compilation report, use: ADA398724

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP011588 thru ADP011680

Quasistatic Magnetoelectric Particles: Experimental Investigation at Microwave Frequencies

A. K. Saha[1], E. O. Kamenetskii[2], and I. Awai[1]

[1] Department of Electrical & Electronic Engineering, Yamaguchi University, Tokiwadai 2-16-1, Ube Shi 755-8611, Japan, email: saha@emlab.eee.yamaguchi-u.ac.jp

[2] Department of Electrical Engineering-Physical Electronics, Tel-Aviv University Tel-Aviv-269978, Israel; email: kmntsk@eng.tau.ac.il

Abstract

The theoretical aspects of electrodynamics of bianisotropic media raised in recent publications may be considered as interesting as such but not very relevant as long as experimental validation, or at least some proof of principle is missing. New particulate bianisotropic composites – the magnetostatically controlled bianisotropic materials (MCBMs) - have been recently conceptualised. Recently, an experimental evidence for the magnetoelectric (ME) coupling in small straight-edge ferrite resonators with different -form surface metallizations has been observed experimentally. As the further extension of these investigations, experimental results of ME coupling in disk-type ferrite resonators are reported in this paper.

1. Introduction

New particulate bianisotropic composites based on ferrite ME particles – the MCBMs - have been recently conceptualised [1-2]. Different types of ferrite ME particles can be realized with the use of different forms of ferromagnetic resonant bodies and surface metallic electrodes. One of the main features of the YIG-film resonators is a very rich spectrum of magnetostatic (MS) oscillations. The straight-edge ferrite resonators have evident technological advantage in cutting as compared to the disk-form samples. At the same time, disk-form resonators have regular (with respect to magnitude and mutual spacing) spectrums of MS oscillations [3-4], when the spectrums of straight-edge samples are irregular [5]. In our previous experiments [6-8] with ME particles, based on straight-edge YIG-film resonators with different types of surface electrodes, we observed strong ME coupling. But characterization of the observed spectrums and an analysis of correlation between the MS and ME spectrums were hampered because of irregularity of pictures of MS oscillations in a straight-edge ferrite body. In this paper we show new experimental results of ME spectrums in disk-form ME particles with different types of surface metallic electrodes. Certain characterizations of the observed spectrums and important conclusions are made.

2. Experiment

A general view of a ferrite quasistatic ME particle is shown in Fig.1. We used a disk form (diameter = 5mm, thickness = 0.1mm) YIG film ($4\pi M_S$ = 1780 Gauss) resonator with two different types of surface metallic electrode. These two types of surface metallizations (one- dimensional, or wire-form and two-dimensional, elliptical form) are shown in Fig.2. ME particles were placed in different positions of a rectangular cavity (Fig.3), resonant in TE_{101} mode at 4.02 GHz. We observed rich spectrums of absorptions peaks. The experimental results with a wire type surface metallization are

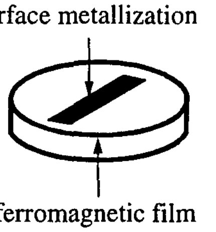

Fig.1 Suggested quasistatic ME particle

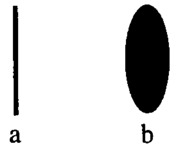

Fig.2 Two forms of surface metallizations (a) wire and (b) elliptical

shown in Fig. 4 and those with elliptical one are shown in Fig. 5. Position of the sample, type of metallization and orientation with respect to the y-axis (or, in other words, with respect to the E-field) are described in each figure.

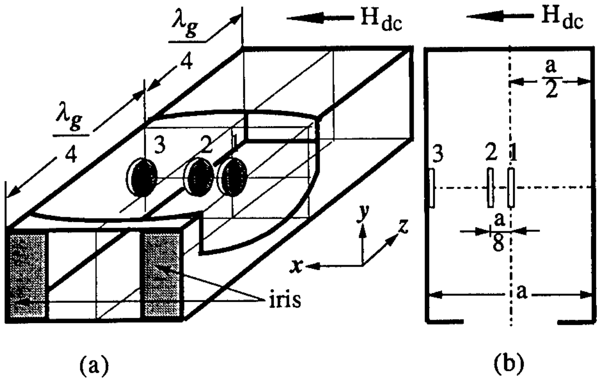

Fig.3 Experimental arrangement showing the positions of the ME particle in the cavity. (a) rough sketch, (b) top view

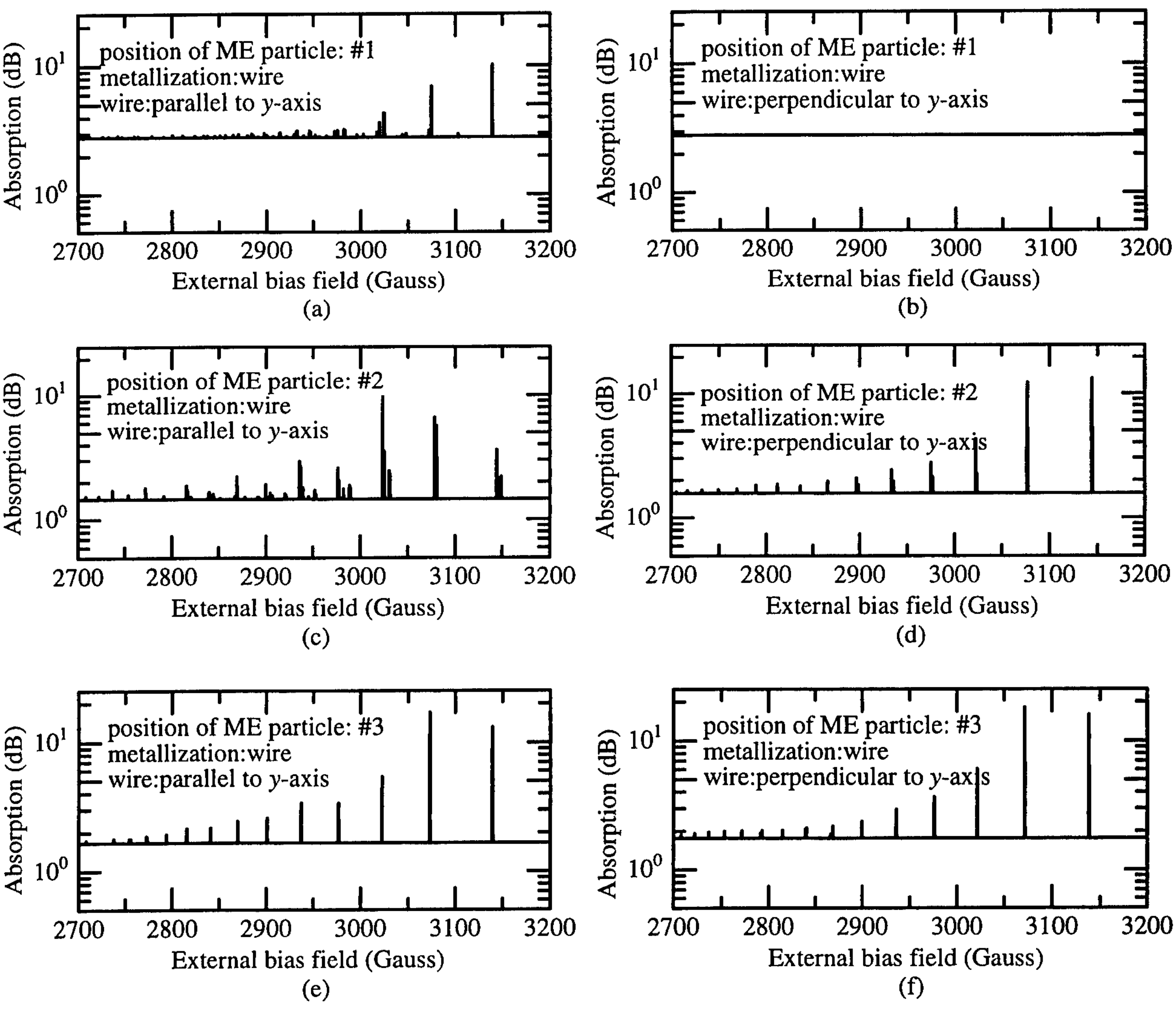

Fig. 4 Absorption spectrum of disk type YIG resonator with wire (length = 4mm and diameter= 0.1mm) type surface metallization.

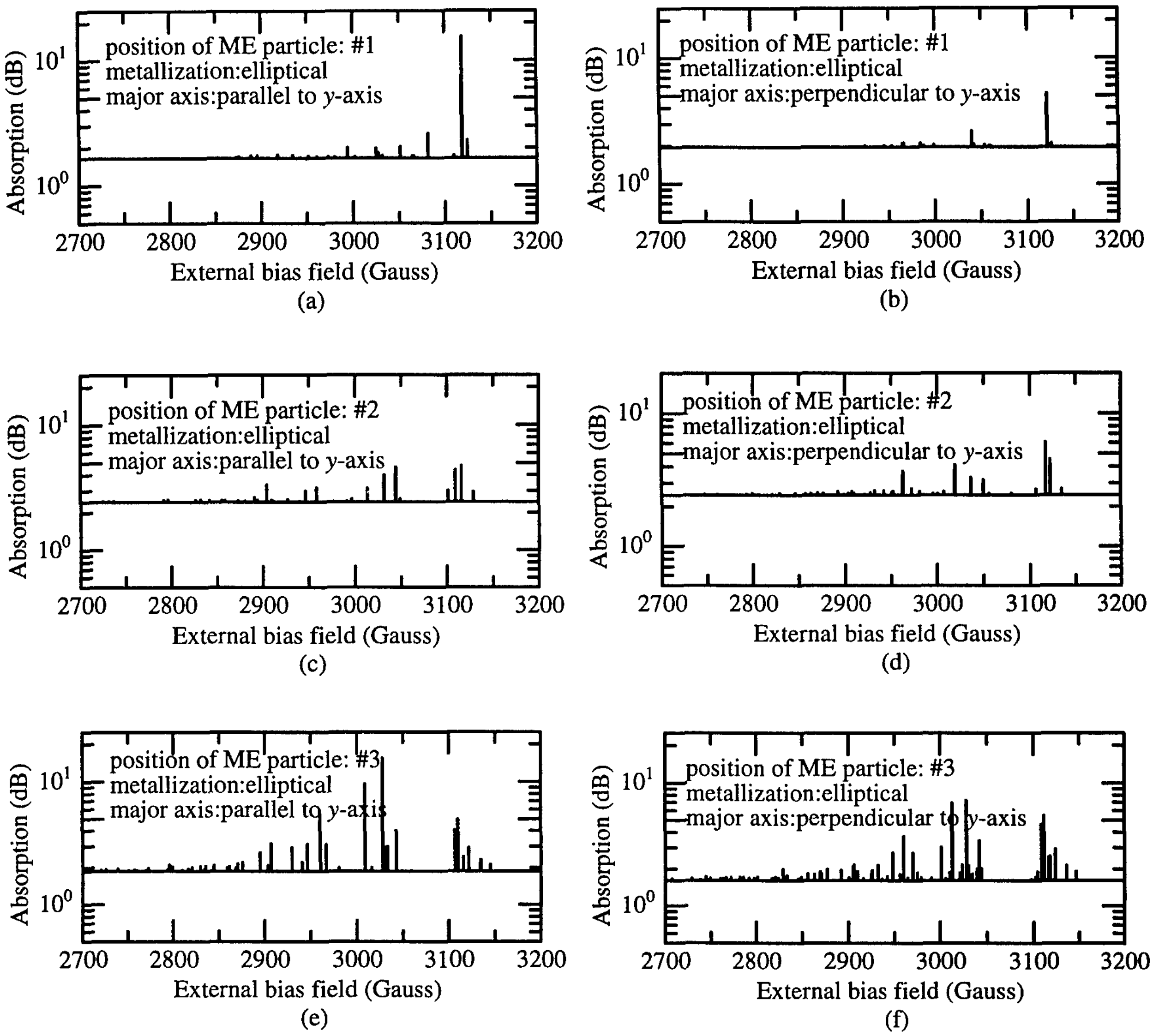

Fig. 5 Absorption spectrum of disk type YIG resonator with elliptic (major axis = 4mm and minor axis = 2mm) type surface metallization.

It is seen that zero levels of the absorption spectrums are different in each picture of Figs. 4 and 5. This is attributed to the fact of variation of the type and orientation of surface electrodes with respect to the E-field as well as positions of the ME particles in the cavity.

3. Discussion and Conclusion

A detailed analysis of absorption spectrums obtained for different types of ME particles and different types of the exciting fields leads us to a very important conclusion that only for ME particles based on disk-form ferrite resonators with wire-form surface electrodes, one has a spectrum of the unified ME oscillating modes. Since different types of the exciting fields produce the same oscillation spectrum, a system is characterized by a set of parameters with certain spectral properties. This fact gives us a possibility to represent a disk + wire ME particle as a particle characterized by two (electric and magnetic) moments and so find it as a particle most applicable for bianisotropic composites. Compared to a case of a wire-form metallization, where only linear surface electric currents are possible, in two-dimensional metallizations different distributions of linear and circular (closed-loop) surface electric currents are possible. This fact gives different pictures of spectrums excited by the different-type external fields, as we can see in our experiment.

References

[1] E. O. Kamenetskii, "On the technology of making chiral and bianisotropic waveguides for microwave propagation," *Microw. Opt. Technol. Lett.*, Vol. 11 (2), pp. 103-107 (1996).

[2] E. O. Kamenetskii, "Theory of bianisotropic crystal lattices," *Phys. Rev. E*, Vol. 57, pp. 3563-3573 (1998).

[3] J .F. Dillon, Jr., "Magnetostatic modes in disks and rods," *J. Appl. Phys.*, Vol. 31, pp.1605-1614 (1960).

[4] T. Yukawa and K. Abe, "FMR spectrum of magnetostatic waves in a normally magnetized YIG disk," *J. Appl. Phys.*, Vol. 45, pp. 3146-3153 (1974).

[5] W. S. Ishak and K. W. Chang, "Tuneable microwave resonators using magnetostatic wave in YIG films," *IEEE Trans. Microw. Theory Techn.*, Vol. MTT-34, pp. 1383-1393 (1986).

[6] E. O. Kamenetskii, I. Awai, and A. K. Saha, "Experimental evidence for magnetoelectric coupling in a ferromagnetic resonator with a surface metallization," *Microw. Opt. Technol. Lett.*, 24 (1), pp. 56-60 (2000).

[7] E. O. Kamenetskii, I. Awai, and A. K. Saha, "Bianisotropic particles based on magnetostatic resonators: A way to realize microwave bianisotropic materials and devices," in *Proceedings of the 29th European Microwave Conference*, publ. Microwave Engineering Europe, Munich, Germany, 1999, Vol.1, pp.40-43.

[8] E. O. Kamenetskii, A. K. Saha, and I. Awai, "Microwave magnetoelectric effect in magnetostatic ferrite resonators: Role of surface electrode configuration," *IEEE Trans. Magn.* (accepted for publication).