TE04

Nonreciprocal ferromagnetic resonance in metastructure "ferrite-grating of resonant elements"

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It is well known the nonreciprocal ferromagnetic resonance (FMR) with transversely magnetized ferrite in rectangular waveguide at distance $\lambda/8$ from side wall where polarization of microwave magnetic field is circular. For linearly polarized wave in waveguide centre, on the wall or in free space the effect is absent. Here we investigate unusual effects of metastructure adding planar gratings of different resonant elements. It has been observed appearance and increase of resonant nonreciprocal microwave response of metastructures with transversely magnetized ferrite (constant magnetic field H is parallel to ferrite plate and perpendicular to the propagation direction and microwave magnetic field) and artificial gratings of resonant conductive elements disposed parallel to propagation direction and microwave electric field. It has been observed nonreciprocal transmission at ferromagnetic resonance frequencies in waveguide centre and in free space also. It has been shown, that effects take place in the case of various conductive resonant elements: split rings, excited by both magnetic and electric microwave field; as well dipole elements excited by electric field. From mutual influence of ferromagnetic resonance and resonance in gratings elements increase of ferromagnetic resonance intensity and giant nonreciprocity (more 35 dB) of transmission are observed under certain magnitude of a constant magnetic field depending on distance between ferrite and grating. At that nonreciprocity sign depends on position of grating about ferrite. Frequencies of the grating resonance GR (I) are different for different gratings, therefore giant nonreciprocity of transmission is observed at different frequencies of ferromagnetic resonance FMR (II) by different values of constant magnetic field under mutual influence of the FMR and GR. Using two different gratings at certain distances from ferrite plate on the one and other hand one can observe two giant nonreciprocal effects different sign at two different frequencies simultaneously (Fig. 1).

Observed effects may be explained considering resonant gratings as waveguiding systems able to form surface waves. At that field polarization is transformed and becomes elliptically or circular polarized with opposed direction of rotation on the one and other hand of grating. Ferrite absorbs electromagnetic wave in the case when rotation directions of microwave magnetic field and precession of magnetic moment in ferrite are the same. Therefore ferrite does not absorb electromagnetic wave running in opposite direction or switching constant magnetic field direction or on the other hand of grating. The results offer the challenge to develop new systemsfor different application, including two-frequency filter-decoupling of coming from the opposite direction waves. The results are useful to design quasi-optical systems for GHz and THz region. .

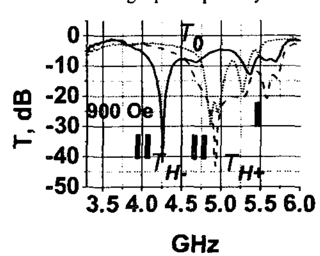

Fig. 1. Transmission coefficient T of metastructure with transversely magnetized ferrite plate in centre along axis of rectangular waveguide and with two gratings using different resonant elements: closed polygonal loops and line dipoles. T_{H}, and T_{H-} correspond to different direction of constant magnetic field or different propagation directions. T_0 corresponds to the field $H = 0$

TE05

Remote temperature sensor composed of an amorphous magnetic ribbon and a low Curie temperature ferrite tube

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INTRODUCTION

Recently, a remote temperature sensor madeof an amorphous magnetic ribbon was actively studied [1,2]. However, the sensitivity of the remote temperature sensor is not enough for the practical use. Then, the purpose of this study is to realize the high sensitivity remote temperature sensor by combining an amorphous magnetic ribbon and a low Curie temperature ferrite tube.

EXPERIMENTS

We used the amorphous magnetic ribbon (36 mm long and 2.5 mm width of Metglas2605SC) as a sensor element. The internal stress of the ribbon was relieved by annealing at 369 °C for 10 min. in an N_2 flow. During the annealing, a transverse magnetic field of 100 Oe was applied with a Helmholtz coil.

We measured the resonant frequency of the ribbon with a network analyzer. The drive/pick-up coil was connected to port 1 ofa network analyzer. The ribbon inserted in a low Curie temperature Mn-Zn ferrite tube (2.8 mm in inner diameter, 6 mm in outer diameter, 60 mm long and Tc = 40 °C) was placed at the center of the coil. Moreover, the DC bias magnetic field of 6.5 Oe was applied to the ribbon with a permanent magnet. We measured the resonant frequency at which the reflection coefficient, S_{11}, dipped, in the temperature range from 26 °C to 60 °C.

RESEARCH RESULTS AND DISCUSSION

Figure 1 shows temperature dependence of the resonant frequency. As the temperature increased from 35 °C to 40 °C, the resonant frequency of the ribbon has rapidly increased from 50.9 kHz to 67.0 kHz. This result suggests that the effective DC bias magnetic field applied to the ribbon has increased because the permeability of the Mn-Zn ferrite tube rapidly decreased in the vicinity of a Curie temperature. In addition, the change rate of the resonant frequency is 6.3 %/°C, in the temperature range from 35 °C to 40 °C. This value is 100 times as large as that of the previously reported remote temperature sensor [1]. Therefore, this confirms that the high sensitivity remote temperature sensor can be realized in an arbitrary temperature range by combining an amorphous magnetic ribbon and various Curie temperature ferrite tubes.

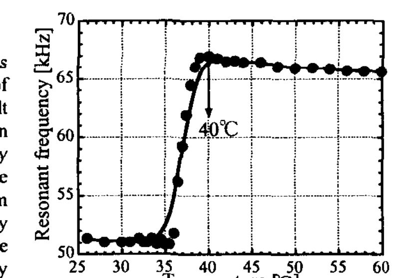

Fig. 1. Temperature dependence of the resonant frequency.

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