Evaluation of high frequency magneto-optic effect of magnetic garnet film

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We constructed high frequency near-magnetic field measurement system composed of time-resolved magneto-optical effect measurements with femtosecond lasers and magnetic garnet thin films. Since its performance depends on the high-frequency response of the magneto-optic effect of the magnetic garnet thin film used as a magnetic field sensor, we have evaluated the Faraday rotation angle of the magnetic garnet film in high frequency.

Keywords: magnetic garnet film; femto-second laser; magneto-optical effect; high frequency near magnetic field

1. Introduction

We have been investigating a time-resolved magneto-optic effect measurement (also called stroboscopic measurement) method using a femtosecond laser and magnetic garnet for measuring the magnetic field component of near-high frequency electromagnetic fields generated near electronic circuit boards [1]. When assuming that future mobile communication systems will use higher frequency bands, it will be necessary to measure electromagnetic field at these frequencies. Therefore, the frequency characteristics of the magneto-optical effect of the magnetic garnet film and its magnetic field measurement sensitivity were evaluated.

2. Experiments

A femtosecond laser (wavelength: 1030 nm, 171 fs, repetition rate: ≃ 40 MHz) was used as the light source. We used light whose wavelength was converted to 515 nm using a SHG crystal for measurements. The magnetic garnet film used for magnetic field detection is a single-crystal in-plane isotropic magnetization film, which was made by LPE. The reflective layer composed of a dielectric multilayer film is formed on the surface of the garnet film, and it is placed on an MSL (Microstrip line in figure 1, length: 10 mm, width: 95 µm) with the reflective film side as the bottom surface. The linearly polarized laser light is vertically entered through a 50× objective lens so that its focus is directly above near edge of width direction of the MSL (Fig. 1). When a high-frequency signal is input to the MSL it generates high frequency magnetic field around the MSL. Polarization state of the reflected light is changed due to the magneto-optic effect of the garnet corresponding to the rising of in-plane magnetization. The reflection light is separated to p and s polarizations and balance detected. Here, by synchronizing the repetition frequency of the laser emission and the high-frequency signal applied to the MSL, the laser emits light only at a specific phase at a frequency that is an integral multiple of the repetition frequency.

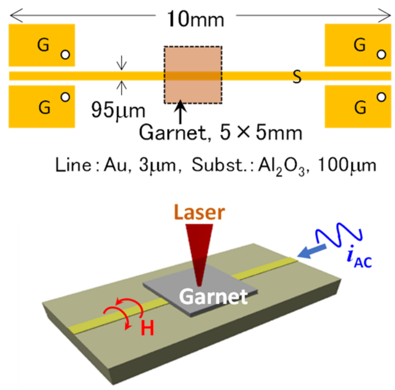

Figure 1: MSL for measurements of near-magnetic field (above). Schematic illustration of incident laser light to garnet film on MSL (below).

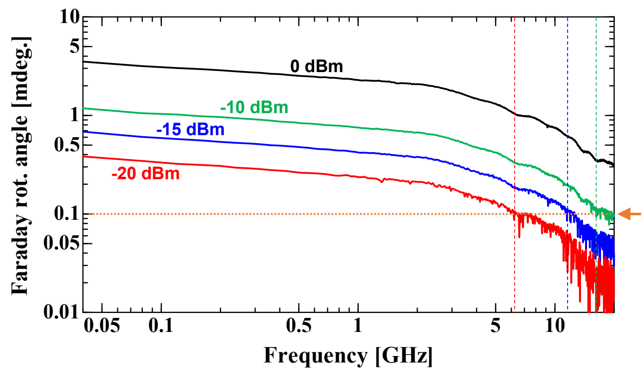

Figure 2: Frequency dependence of the Faraday rotation angle of magnetic garnet film.

3. Results and discussion

Figure 2 shows frequency dependence of the Faraday rotation angle up to 20 GHz. The power of the high-frequency signal was decreased from 0 to 20 dBm in every 5 dBm. It can be seen that the Faraday rotation angle decreases as the frequency increases. From the result, the minimum rotation angle that can be detected by our system is about 0.1 mdeg. From this value and the dependence of the Faraday rotation angle of the magnetic garnet thin film on the applied magnetic field, the magnetic field sensitivity is estimated to be about 1.7 A/m (0.021 Oe).

References

[1] S. Hashi, et al., Proc. of EMC Japan/APEMC Okinawa, ThuPM1C.4, (2024).

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