高周波駆動薄膜磁界センサの開発とバイオ応用

High-frequency drive thin film sensor and bio-application

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A very sensitive thin-film sensor was developed using a transmission line operating at room temperature. The sensor element consists of a coplanar line with amorphous-CoNbZr film. We already succeeded in the measurement of the MCG (magnetocardiogram) signals at 16 points without magnetic shielding, and these signals were found to roughly agree with MCG signals obtained with a SQUID (Superconducting Quantum Interference Device)[1]. However, the sensor system needs a magnetic coil (such as Helmholtz coil) to apply DC field, which results in increasing 1/f noise. In addition, this sensor is used with a high-frequency carrier of 1 GHz or higher, so we are considering the development and application of this sensor to ensure stable operation as a module mounted on a board without impairing the sensitivity of the sensor element. In the present study, we discuss direct bias to CoNbZr film and Cu film under a CoNbZr film and compare it with an application of bias magnetic field. We also have developed a straight coplanar line-type sensor with flip chip bonding. The high-frequency characteristics and sensitivity of the sensor element through comparison of cases with and without flip chip bonding was discussed. Good sensitivity with a phase change was obtained with flip chip bonding. Fig. 1 shows one example of a thin-film sensor. The sensor element consists of a meandering coplanar line, SrTiO film as an insulator, and an amorphous CoNbZr film and Cu film as an electrode. The coplanar structure was fabricated by the lift-off process. Amorphous CoNbZr film was deposited by RF sputtering on a glass substrate. In order to induce transverse magnetic anisotropy, a DC field of 0.3 T was applied during annealing after film deposition. Therefore, the easy axis, which was applied transverse to the coplanar line as shown in Fig. 1. SrTiO film was deposited by RF sputtering and annealed at 160°C during deposition. Cu and Cr film were deposited by RF sputtering. A high-frequency carrier flows in the center conductor of the coplanar line, not in the CoNbZr film, so the sensor is different from conventional GMI sensors in this respect. When this DC current flows directly in the CoNbZr film, permeability of the CoNbZr film changes, which results in the amplitude and the phase of the carrier is changed due to the skin effect and ferromagnetic resonance. Conventional wafer probes (GSG-40-150 and HFP-120-201) were put into contact with the sensor to apply carrier and DC current. The transmission coefficient (S_{21}) was measured by a network analyzer as the DC current was slowly changed. Fig. 2 shows the phase change (sensitivity) as a function of the DC field and carrier frequency. The sensor was connected with the flip chip bonding. The good phase change of about 290 degrees/Oe was obtained around 4 Oe and at 1.8 GHz. This proposed sensor can keep good sensitivity because the permeability was picked up in only the skin area of the magnetic thin film even if the dc field was not uniform inside the film.

Reference: 1) S. Yabukami *et al*, *Journal of the Magnetics Society of Japan*, 38, 25(2014).

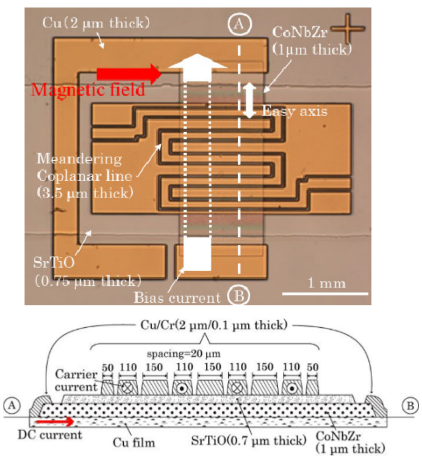

Fig. 1 Schematic view of the sensor.

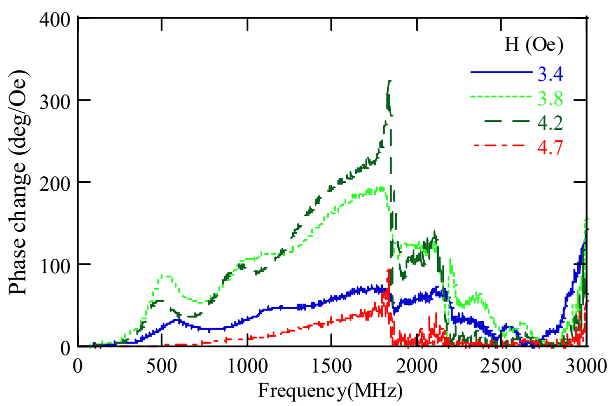

Fig. 2 Phase change of sensor output.