Fabrication of high sensitive magnetic field sensor with amorphous wire and fine pitch coils

T. Kato[1], S. Iwata[2], Y. Honkura[3]

[1]Dept. of Electrical Eng. and Computer Science, Nagoya Univ., Furo-cho, Chikusa-ku, Nagoya 464-8603 Japan

[2]Institute of Materials and Systems for Sustainability, Nagoya Univ., Furo-cho, Chikusa-ku, Nagoya 464-8603 Japan

[3]Magnedesign Corporation, 33-10 Ogawa Higashi Sendai, Higashiura-cho, Chita 470-2102, Japan

Phone: +81-52-789-3304, Fax: +81-52-789-3153, E-mail: takeshik@nuee.nagoya-u.ac.jp

1. INTRODUCTION

Magneto-impedance sensor is known to be a candidate for high sensitive magnetic field sensor at room temperature to detect quite small magnetic field from biological activity, e.g., human brain and heart fields [1]. The magneto-impedance sensors are composed of an amorphous ferromagnetic wire and winding coils, and to realize highly sensitive magnetic field sensors, micro-fabrication of the magneto-impedance devices are necessary. In this paper we report the fabrication of the magneto-impedance sensors with micro-fabricated fine pitch coils and roughly 50 times increase of the sensitivity compared to the commercially available magneto-impedance sensor.

2. EXPERIMENTS

Figure 1 shows schematic illustration of magneto-impedance sensor. As shown in the figure the magnetization of the amorphous wire in the wire surface layer points in the circumferential direction while that in the wire center points along the wire axis. When the wire is placed in the magnetic field, the surface magnetization canted slightly along the field direction. The pulse current flowing along the wire tends to rotate back the surface magnetization in the circumferential direction, which induce the induction voltage to the coil winding the wire with a turn number of N. The minimum detectable field is dominated by the thermal stability of the domain structure. For the detection of the bio-magnetic field of around 1 pT, the thermal stability factor K_uV should be larger than $M_s \times 1$ pT, where K_u, V, and M_s are the uniaxial anisotropy, volume, and magnetization of the wire, respectively. If we assume the $K_u = 1$ kerg/cc and $M_s = 1000$ emu/cc, the necessary dimension of the wire is estimated to be 4 μmφ × 500 μm, which is smaller than the present amorphous wire: 15 μmφ x 920 μm (see Fig. 2). The sensitivity of the wire is roughly proportional to NL^2 / D^2, where L and D are the wire length and diameter, respectively, and for the detection of 1 pT, the wire dimension of 5 μmφ × 900 μm and winding coil with a coil pitch of 2 μm, corresponding to turn number of ~3000, are estimated to be required.

Figure 2 shows optical micrograph of the micro-fabricated amorphous wire sensor with a wire of 15 μmφ × 920 μm, winding coil with a pitch of 5.5 μm, and coil turn number of 560. The output signal of this sensor is shown in Fig. 3, and the sensitivity of 400 mV/G was confirmed, which is roughly 50 times larger than that of commercially available magneto-impedance sensor.

REFERENCES

[1] L. V. Panina *et al*., Appl. Phys. Lett., **65**, 1189 (1994).

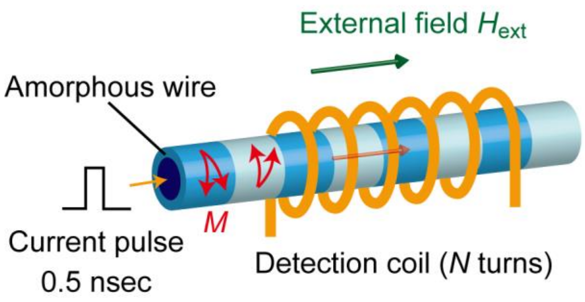

Fig. 1 Schematic illustration of magneto-impedance sensor.

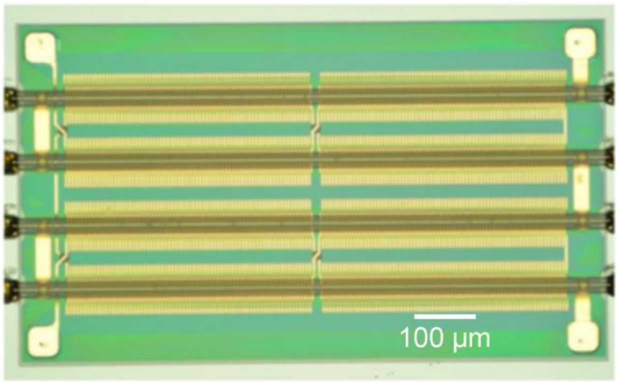

Fig. 2 Optical micrograph of the micro-fabricated amorphous wire sensor with a wire of 15 μmφ × 920 μm, winding coil with a pitch of 5.5 μm, and coil turn number of 560.

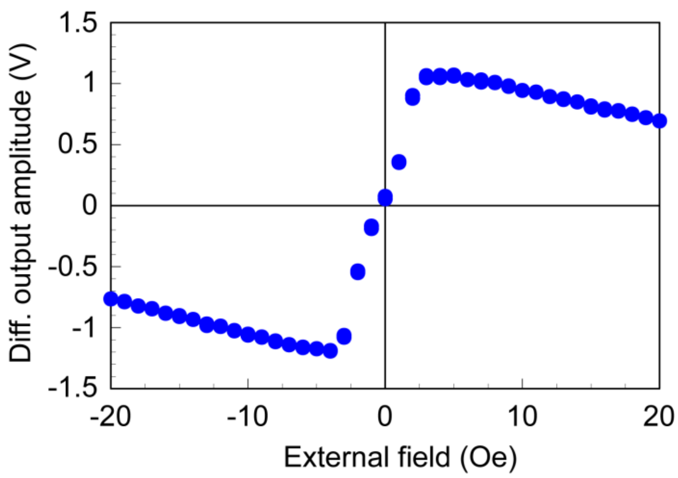

Fig. 3 External field dependence of the differential output voltage from the fine pitch coil after applying a current pulse of 0.5 nsec into the amorphous wires on the sensor shown in Fig. 2.