EC05

Operation of Orthogonal Fluxgate of Fundamental Mode in Null Detection Method

Ichiro Sasada and Masanori Murakami*
Kyushu University, Dept. Applied Science for Electronics and Materials, Kasuga-koen, Kasuga, Fukuoka 816-8580, Japan

An orthogonal fluxgate magnetometer (OFG) of fundamental mode [1, 2] has the resolution as high as 10 pT/√Hz [3, 4]. In this paper, an OFG consisting of a U-shaped amorphous wire core is operated in in the null detection method, where magnetic field exposed to the wire core is cancelled by a feedback current and the amplitude of the magnetic field is detected from the value of the feedback current. An advantage of this method is that the sensitivity of the magnetometer is solely defined by parameters of the feedback circuit, such as coil constant and current detecting resistor value. Schematic diagram is shown in Fig. 1, where the pickup coil is also used as a feedback coil. An interesting feature of this system is that a lock point of the feedback loop occurs at 90 degree out of phase between the clock signal and the pre-amplified voltage. *Ci*, *Ri* and *Cf*, *Rf* separate a high frequency and a low frequency signal path. An example of the noise level of the magnetometer system is shown in Fig. 2 reaching 10 pT/√Hz level at higher than 10 Hz. The excitation condition was 10 mA(rms) for 100 kHz ac with 14 mA dc bias current. The noise level can be further reduced by refining a sensor head and by optimizing circuit parameters. Further advancement and the operating mechanism will be discussed.

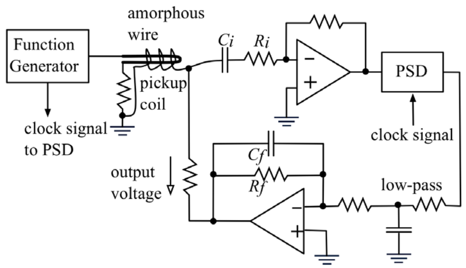

Fig. 1. Schematic diagram of the OFG magnetometer with feedback.

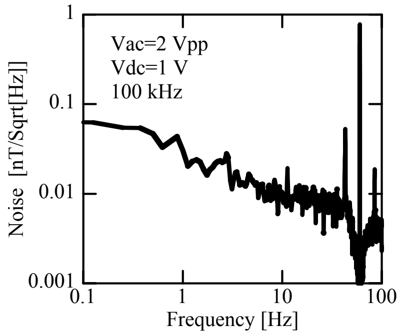

Fig. 2. Noise spectrum of the sensor, where the sensor head is kept in a five shell magnetic cylinder.

REFERENCES

[1] I. Sasada, Journal of Applied Physics, Vol. 91, No. 10, pp. 7789-7791 (2002).
[2] I. Sasada, IEEE. Trans. Magn., Vol. 38, No. 5, pp. 3377-3379 (2002).
[3] E. Paperno, Sensors and Actuators A: Physical, vol. 116, pp.405-409, 2004.
[4] I. Sasada, H. Kashima, Intermag, Madrid, AM-12, 2008 (umpublished).

EC06

Magneto-Impedance of Electroplated Ni-Fe Permalloy Thin Strips and Narrow Wires

Hojun Lee[1], Wonbae Bang[1], Kimin Hong[1]*, Dohun Kim[2], Jiwon Na[2], and Won Young Jeung[2]

[1] Department of Physics, Chungnam National University, Daejeon, 305-764, Korea
[2] Metal Processing Research Center, Korea Institute of Science and Technology, Seoul 136-791, Korea
*Corresponding author: kmhong@cnu.ac.kr, Phone: +82-42-821-5456, Fax: +82-42-822-8011

Soft magnets have been used for various devices including GMI (Giant Magneto-Impedance) sensors and magnetic read heads.[1] They were usually fabricated with vacuum deposition methods such as DC/RF sputtering and electron beam deposition. Electroplating technique is also a useful method for fabrication of soft magnets because it allows relatively fast deposition of high purity products. Proper soft magnets have low coercivity and high permeability. It is known that high surface planarity is required to obtain low coercivity of the soft magnets.[2] We adjusted the magnetic properties of electroplated Permalloy thin films by using appropriate organic additives and obtained low coercivity resulting from improved surface planarity. The magneto-impedance effect of the electroplated thin strips and narrow wires was investigated.

The substrate was P-type Si(100). A 10-20 nm thick seed layer was deposited with electron-beam evaporation and DC magnetron sputtering methods for use as a working electrode. The plating electrolyte was composed of $NiSO_4$, $FeSO_4$, and H_3BO_3. Organic additives such as sulfopropyl pyridinium betaine (SPPB) Saccharin N-propane sulfonate (SNPS) were added to the bath with the concentration varying in the range of 0.1-1.5 μmol/L. Galvanostatic deposition was carried out by applying the current density of 20-100 A/m^2. Magnetic property of thin films was measured with Vibrating Sample magnetometer (VSM) and alternating gradient magnetometer (AGM), and the surface planarity was observed by an AFM (atomic force microscopy) in an area 1 μm2. Crystalline orientation and grain size were determined by XRD (X-Ray Diffractometer). Magneto impedance (MI) effect of the thin films was measured using a high frequency impedance analyzer.

The magnetic properties and magneto-impedance varied with the sample geometry, materials used as a seed layer, and the concentration and species of the organic additive. We observed a strong correlation between the improvement of surface planarity and reduction of coercivity in proportion to the concentration of the additive. Within the range of the additive concentration, the surface roughness could be reduced from ~10 nm to ~2.6 nm. Accordingly, coercivity (Hc) was reduced from ~3 Oe to ~0.01 Oe. The reduction of coercivity led to an increase of magneto-impedance ratio (MIR) up to 20% and the amount of the change varied depending on the sample geometry. This improvement is attributed to the increased nucleation and surface diffusion caused by the additives contained in the electroplating electrolytes. The XRD analysis demonstrated that, while the improvement of surface planarity evidently reduced coercivity, a smaller grain size should be accompanied by a further reduction in coercivity. The improved magnetic properties can be utilized for the fabrication of various magnetic devices and sensors.

REFERENCES

[1] M. Knobel and K. R. Pirota, *J. Magn. Magn. Mater.*, 242-245 (2002) 33-40.
[2] G. Herzer, IEEE Trans. Magn., 26, 1397 (1990).