W-2

Application of DC current sensor using asymmetric giant magnetoimpedance in amorphous materials

Chungnam National University Y. W. Rheem*, B. S. Lee, C. G. Kim, C. O. Kim
Research Center for Advanced Magnetic Materials G. D. Kim

1. INTRODUCTION

Recently, many studies have been made on the giant magnetoimpedance (GMI) in soft magnetic Co-based amorphous wire and ribbons because they exhibit a highly sensitive MI effect. This GMI effect consists of a large change in the impedance of a magnetic conductor placed in the external magentic field, *H*.

Great interest has been paid to GMI phenomenon in its sensor applications; magnetic field, current, torsion, stress, etc. In the practical application of GMI, sensitivity and linearity for the magnetic field are the most important parameter.

In annealed Co-based amorphous samples in an open air, GMI exhibits a step-like change as a function of the applied magnetic field, which reveals the excellent sensitivity and linearity for magnetic field. In this study, we present the performance of DC current sensor using a GMI sample wound in the circular form.

2. EXPERIMENTS

The Co-based amorphous ribbons ($Co_{66}Fe_4B_{15}Si_{15}$) were annealed at temperature of 635 K is optimum in the development of surface crystallization. The field of 3 Oe was applied during the annealing of sample. The absolute value of impedance Z was measured by using a HP4192A impedance analyzer with four terminal contacts. The cyclic magnetic field was applied by a Helmholtz coil using a step-like changing current. For the DC current sensor in the circular form, the annealed sample of 70 mm long was wound ona cylindrical support, 10 mm radius. The feeding and sensing probes were connected to sample in same way as the four terminal methods. The DC current was applied to the axial direction of the sample form. The sample voltage output was measured by lock-in amplifier as function of applied DC current in various operating frequencies.

3. RESULTS AND DISCUSSION

The GMI sensor is based on the dependence of impedance Z on external magnetic field. Under the low field regime, the sensitive response to magnetic field without hysteresis answers the propose of technical application. Figure 1 shows the GMI ratio profiles under a cyclic magnetic field. Values as high as 30 % are obtained for the annealed sample and sensitivity of more than 35 % per Oe are obtained at low field. Figure 2 shows the GMI profile for the annealed sample wound the circular form. The profile is modified after winding the circular shape. The linearity for field is still good, but the profile shift to positive field direction. The maximum GMI ratio value is reduced down to 15 % and sensitivity to 22 % per Oe.

A DC current in a straight wire produces a circular magnetic field around the current axis. The direction of the field is determined by Ampere's right-hand law. The magnitude of magnetic field at a distance r cm from the current axis is given by $H=2i/10r$ *(Oe)*, where i is the current in amperes.

Figure 3 shows the performance of GMI sensor for applied current to produce the positive field. As the applied current increases up to 1 A, the circular field increases up to 0.19 Oe. As a result, the voltage output linearly increases with DC current. However, there is no voltage change when the direction of current is reversed, that is, the current induces the negative magnetic field on sensor sample. It indicates that the current direction can be determined when the sample with asymmetric GMI characteristics is used for sensor element.

Figure 4 shows the current sensitivity versus operating frequency. The sensitivity is nearly linear relationship with frequency. The sensitivity for current is 0.13 volt/A at 100 kHz operating frequency and increases up to 0.94 volt/A at 1 MHz operating frequency.

4. CONCLUSIONS

The performance sensitive DC current sensor has been tested based on asymmetric GMI effect in amorphous ribbon. The sensor voltage output increases with applied DC current up to 1 A with a good linearity. The sensitivity for current is 0.13 volt/A for 100 kHz operating frequency, and increases up to 0.94 volt/A at 1 MHz operating frequency. Finally, the asymmetric GMI, which reveals the excellent sensitivity and linearity for the magnetic field, is useful for sensor devices.

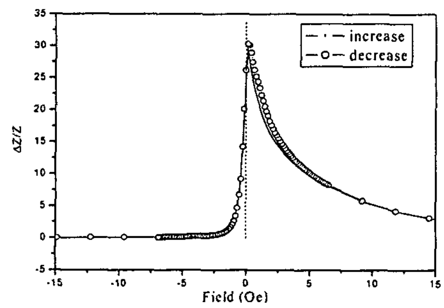

Fig. 1. GMI profile for the annealed sample.

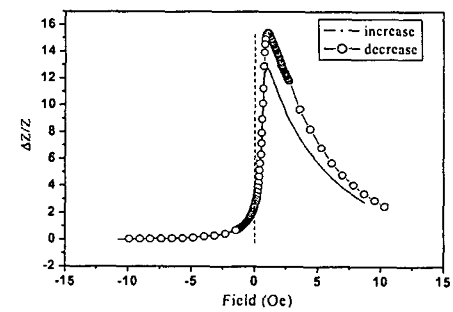

Fig. 2. GMI profile for theannealed sample wound the circular form.

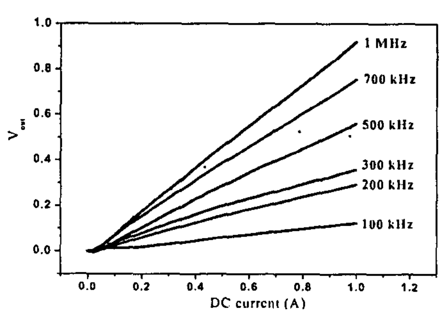

Fig. 3. Current sensing characteristics of the GMI sensor in positive field direction at various measuring frequencies.

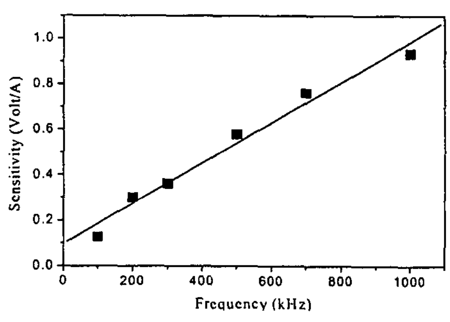

Fig. 4. Current sensitivity versus operating frequency.