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LC Filter-Type Magnetoimpedance Sensors with Multilayer Film Structure

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Magnetoimpedance (MI) sensors have been attracting great attention because of their applicability in magnetic sensor area. To make a MI sensor highly sensitive, the development should be gone on not only optimization of the sensor materials and structure but also improvement of their signal conditioning method. Since MI effect of a magnetic pattern be described by change of lumped circuit components, especially *R* and *L*, the sensor element could be treated as it is a part of sensor signal conditioning circuit. *Kim et al.*[1] had examined whether the *LC* high pass fiter (HPF) circuit could be useful for enhancing the sensitivity of MI sensors fabricated with Co base amorphous ribbon, and reported that 2.5 times larger output change had been obtained than that of using a conventional bridge circuit with constant current excitation. However, it is hard to makea integrated sensor with small size and high quality factor using a ribbon material. In this study, we had fabricated the multilayer film, *a*-CoNbZr/Au/*a*-CoNbZr, patterns with the lengths ofl, 2, 5 and 10 mm to investigate the magnetic field sensitivity of LC filter-type MI *sensors constructed with film elements. Figure 1 shows the microscope image* of a fabricated sensor element with 1 mm length, in which the amorphous CoNbZr films and Au film were deposited to form a multilayer onto a silicon substrate by using RF sputtering. In this structure, the electrical resistance is lower than that of single magnetic film at the frequency when the skin effect does not appear, because current flows through the Au film, which is sandwiched with *a*-CoNbZr films, resulting relatively low electrical resistance. The higher quality factor of filter circuit could be achieved with the lower resistance. The HPF configurations with 3-stage, which had been designed by the Butterworth filter design method, were constructed using both the film patterns and SMD type capacitors with 2 mm long.Fig. 2 shows the external magnetic field dependence of output change of a LC filter type MI sensor with 2 mm long measured with a network analyzer at 100 MHz, where $S_{21\text{-}0}$ was the transmittance parameter measured without magnetic field. The output increased to reach the peak value with increase of magnetic field to around 20 Oe, which was almost same with the anisotropic field of the multilayer film pattern, and the measured maximum change ratio is 49%.

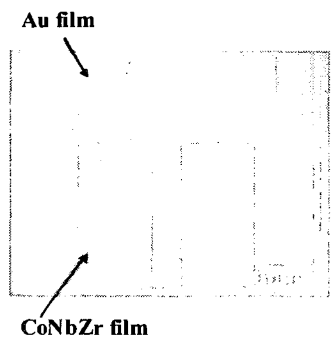

Fig. 1. Fabricated sensor element with a multilayer structure.

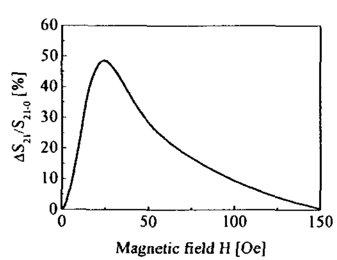

Fig. 2. Magnetic field dependence of output of LC filter type MI sensor.

REFERENCES
[1] Seung-Dae Kim, *et al.*, J. MMM, Vol. 304, pp. e391-e393, (2006).

RC06

Role of Negative Feedback on the Performance of Magnetic Sensor Using Asymmetric GMI Effect

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Recently sensitive micro-magnetic sensors are strongly required to grade up technologies for automation, motorization, computerization, and bio-engineering through intelligent measurement and control systems. The Giant MagnetoImpedance (GMI), the huge change of ac impedance of soft magnetic conductorsupon application of dc magnetic field, attracts much attention of research teams all over the world because of its perspective applications in the field of sensing [1-3]. The present paper gives the comprehensive analysis of the Asymmetric Giant MagnetoImpedance (AGMI) sensor's performance with negative feedback loop. Asymmetrical behaviour of the GMI is required for linear magnetic field sensors as the sensitivity and linearity for magnetic field are the most important parameters in the practical application of GMI to magnetic sensors, and this has been realized by magnetic field annealing in amorphous ribbon [4-6]. A novel AGMI sensor was developed and the performance of the sensor was carefully studied with and without applying negative feedback. The sensor uses *5 mm × 1 mm × 20 μm* $Co_{66}Fe_4Si_{15}B_{15}$ *ribbon as a sensing element. The GMI sensor consists of a crystal oscillator,* voltage to current converter for providing the current to the sample, a differential amplifier, successive amplifier stages, multiplier, zero compensation circuit and cascaded low-pass filters (LPF) and gain stages. As the high frequency current passes through the sample under the application of static magnetic field voltage is induced in the sample. This voltage is picked up by differential amplifier and rectified using LPF. The final dc output of the sensor is given by, $V_o = AH_{ex}$, where A is the transfer function of the sensor. The output voltage Vo is applied to the coil as negative feedback through Rfand obtains highly linear and quick response field detection features, mainly the output of the sensor is independent of sensor transfer function A, as it purely depends on transfer function of the feedback coil, B. This is shown by the expression as follows: $V_o = \frac{A}{1+AB}H_{ex} \cong \frac{1}{B}H_{ex}, (AB >> 1)$. From this expression, the circuit is independent of thermal noise and contact resistance noise (due to Ohmic contacts) due to negative feedback. The results showed for high sensitivity and good resolution with negative feedback. The sensitivity of the element was found to be 20 *V/Oe*. Angle sensitivity was found to be 55 *mV/degree.*

REFERENCES
[1] K. Mohri, T.Uchiyama, L.P. Shen, C.M. Cai and L.V. Panina, J. Magn. Magn. Mater.,249, (2002), 351-356
[2] X. P. Li, Z. J. Zhao, T. B. Oh, H. L. Seet, B. H. Neo, and S. J. Koh, Phys. Stat. Sol.(a), 201(8), (2004), 1992-1995
[3] K. Mohri, T.Uchiyama, L.P. Shen, C.M. Cai, L.V. Panina, Sensors and Actuators A, 91, (2001), 85
[4] C.G. Kim, K.J. Jang. D.Y. Kim, S.S. Yoon, Appl. Phys. Lett. 75 (1999) 2114
[5] C.G. Kim, K.J. Jang. D.Y. Kim, S.S. Yoon, Appl. Phys. Lett. 76 (2000) 1345
[6] CheolGi Kim, K.J. Jang,H.C. Kim, and S.S. Yoon, J. Appl. Phys., 85 (1999) 5447