11th International Conference on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Characterization of the Magnitude Impedance of Ribbon-Shaped GMI Samples and their use in Transducers aimed at Biomedical Applications

E. C. Silva(1)*, L. A. P. Gusmão(2), E. C. Monteiro(1) and C. R. H. Barbosa(1)

(1) Post Graduate Program in Metrology, PUC-Rio, Rio de Janeiro, Brazil, edusilva@aluno.puc-rio.br
(2) Electrical Engineering Department, PUC-Rio, Rio de Janeiro, Brazil
* Corresponding author.

Abstract – This manuscript aims at presenting the characterization of the magnitude impedance of Giant Magnetoimpedance (GMI) ribbon-shaped samples ($Co_{70}Fe_5Si_{15}B_{10}$), of the Longitudinal Magnetoimpedance (LMI) type, as a function of the magnetic field longitudinal to the GMI samples length. It was analyzed the influence of the excitation current DC level and frequency, as well as of the ribbon length. The results indicate that the maximum sensitivity obtained, 2.52 Ω /Oe, enables the use of such elements as sensors, in transducers for biomedical applications, especially where it's desirable to measure very low fields.

The importance of GMI in the world's scientific scenery has been increasing, and several laboratories are accomplishing promising researches in several application areas. A recent example was the 2007 Nobel Award in Physics to the researchers Albert Fert and Peter Grünberg, who discovered the giant magneto-resistance, GMR [1]. The Post Graduate Program in Metrology (Post-MQI) of PUC-Rio, through the research line in Biometrology and in partnership with the Department of Physics of the Federal University of Pernambuco (UFPE), has been carrying out studies seeking the implementation of prototypes of magnetometers based on the magnitude characteristics of the Giant Magnetoimpedance (GMI) effect.

This work focuses on a particular case of GMI named Longitudinal Magnetoimpedance (LMI). The LMI phenomenon is induced by the application of an alternating current (I) along the length of a ribbon (or wire), which is submitted to an external magnetic field (H) parallel to it. The difference of potential (V) is then measured between the extremities of the ribbon [2]. All the measurements were made in $Co_{70}Fe_5Si_{15}B_{10}$ ribbon-shaped alloys with an average thickness of 60 µm and an average width of 1.5 mm. The AC current amplitude was kept in 15 mA, because it has been previously seen that such parameter did not affect significatively the GMI ribbon behavior.Thus, studies were accomplished with the described GMI ribbon, analyzing the influence of the excitation current DC level (0 mA to 100 mA) and of the frequency (100 kHz to 10 MHz). Also, it has been investigated how the ribbon length (1 cm, 3 cm, 5 cm and 15 cm) affects the sensitivity and which is the best polarization field [3].

Table 1 presents the GMI ribbons maximum sensitivity, for each one of the tested lengths, and considering only their respective best conditioning situation (i.e., the optimal applied current). The column called "equivalent sensitivity" has been added in table 1 for a fair comparison between the performances of the ribbons with different lengths, relating them with the 15 cm ribbon.

Thus, as a result of the high magnitude sensitivities, transducers have been developed, based on the magnitude variation of the GMI effect, using 2 GMI ribbons of 5 cm each as sensor elements. It can be mentioned the transducer for localization of needles inserted in the human body (which sensitivity was 35 V/Oe), and the transducer for measurement of arterial pulse waves (which sensitivity was 7 mV/Pa).

Table 1: Optimal Magnitude Sensitivity by Ribbon Length.

Ribbon Length (cm)	Applied Current (mA)	Sensitivity (Ω /Oe)	Equivalent Sensitivity (Ω /Oe)
1	80 + 15 sin (2π10MHz t)	0.09	1.35
3	80 + 15 sin (2π10MHz t)	1.42	7.10
5	80 + 15 sin (2π10MHz t)	4.20	12.60
15	80 + 15 sin (2π10MHz t)	11.59	11.59

References

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