Magnetoimpedance for bio sensor application

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1. Introduction

Development of a new generation of biosensors has been the subject of much research [1]. The principal requirements of this generation are: high sensitivity, small size, low power consumption, stability of operation parameters, quick response, and low price. The idea using a magnetic field sensor in combination with magnetic particles working as magnetic labels for detecting molecular recognition events (antigen-antibody interaction) was first reported a few years ago [2]. Such a biosensor was based on magnetoresistance technology, and used magnetic microbeads for simultaneous characterisation of many biomolecular interactions. The GMI(great magnetoimpedance) effect was recently considered to create a new type of biosensor for molecular recognition systems and selective detection. This paper is a part of the latest development of the GMI-biosensor. A prototype was designed and fabricated using an amorphous ribbon. The GMI response was measured in presence of commercial Bangs. Lab. Bead CM01N.

2. Method

Samples used in the present study were commercial amorphous ribbon Co66Fe4B15Si15 with the size of 2 mm × 40 mm × 20 μm. A sensor prototype was designed and sequentially mounted for measurements with bath for magnetic bead solution on the board. The magnetoimpedance was measured by standard four point technique. The frequencies of sinusoidal driving current applied to flow along the ribbon axis were in the range of 0.1-10 MHz. An external magnetic field in the interval of -40 to +40 Oe was applied by a pair of Helmholtz coils in the plane of the amorphous ribbon. The GMI ratio profile was obtained by plotting $\Delta Z/Z$ (%) =[Z(H)-Zsat]/Zsat × 100 for the cycle field applied, where Zsat was the impedance at H=40 Oe. The impedance Z was measured by using an HP4192A impedance analyzer with four terminal contacts. Phosphate buffered saline (PBS) was used when necessary. Bang. Lab. CM01N suspension containing 3.3×10^{11} beads/ml in PBS, pH 7.4, containing 0.1% bovine serum albumin and 0.02% sodium azide (NaN_2) were used for preparation of 10 μl test solutions (volume for the GMI measurements) containing approximately 6.5×10^{9} beads/ml the Bang. Lab CM01N in the PBS. The Bang. Lab CM01N are 0.35 μm diameter magnetisable superparamagnetic polystyrene beads consisting of nanometer-sized iron oxide particles embedded in a polymer matrix with streptavidin coating.

3. Result and discussion

The response of the magnetoimpedance depends on a number of parameters: frequency and intensity of the driving current; angle between the external field H, and the ribbon long axis. Effect of these parameters on GMI response was evaluated first in a simple ribbon element circuit. Fig. 1 shows the change in the GMI ratio at different driving frequencies for the sample. The GMI response showed a strong dependency on the driving frequencies. To verify the sensitivity of the GMI-based magnetic sensor, we measured the magnetic impedance variation $\Delta Z/Z$ against different concentrations of magnetic particles dispersed in PBS solution. Fig. 2 shows the variation of magnetic impedance ΔZ/Z versus magnetic particle concentrations. Considering the results, we can appreciate this sensor sensitivity, which is very suitable for different biomolecules detection. It is clearly evident that as the number of labels (volume of solution) increase the GMI ratio also increased. However, when the magnetic labels on the sensor increases the change in output GMI also increased simultaneously but this is not linear. The non linear change of the output signal versus the number of magnetic labels may be blamed for the nonuniform of the area density of magnetic bead and the aggregation to become cluster of the magnetic beads.

4. Conclusion

A magnetoimpedance-based prototype of a biosensor with an amorphous ribbon sensitive element has been designed, and tested for the detection of small amounts of magnetic labels. The prototype responses were measured with and without commercial Bang. Lab. CM01N beads for optimum conditions defined during sensor calibration: frequency range of 1 MHz, exciting current intensities of Irms = 5 mA. The Bang. Lab. Magnetic beads concentration for testing was approximately 6.5×10^9 beads/ml in the PBS. Clear differences between the GMI response with magnetic beads and without them was found. The best sensitivity for this concentration was achieved in a field interval of -0.5 to +0.5 Oe in the current of 5 mA at a frequency of 1 MHz. GMI based biosensors may have application for detection of small amounts of biocompatible magnetic/magnetisable particles and their spatial distributions.

5. Reference

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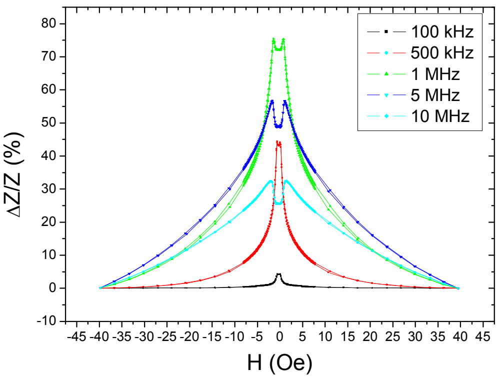

Fig. 1. The dependence of the GMI ratio of amorphous $Co_{66}Fe_4B_{15}Si_{15}$ ribbon at a various driving frequency under applied field of 40 Oe.

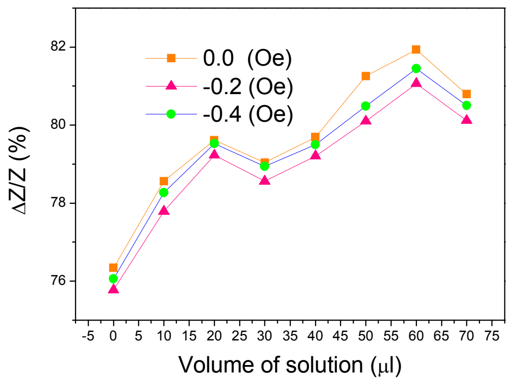

Fig. 2. The impedance response of the sensing element on the magnetic particles concentration.