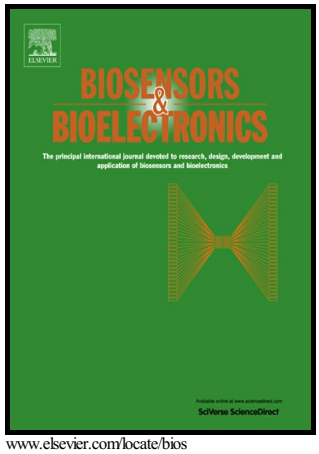

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Modelling of magnetoimpedance response of thin film sensitive element in the presence of ferrogel: Next step toward development of biosensor for in-tissue embedded magnetic nanoparticles detection

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Abstract

In-tissue embedded magnetic nanoparticle (MNPs) detection is one of the most interesting cases for cancer research. In order to understand the origin, the limits and the way of improvement of magnetic biosensor sensitivity for the detection of 3D mezoscopic distributions of MNPs, we have developed a magnetoimpedance biosensor prototype with a [Cu (3 nm)/FeNi(100 nm)]$_5$/Cu(500 nm)/[FeNi(100 nm)/Cu(3 nm)]$_5$ rectangular sensitive element. Magnetoimpedance (MI) responses were measured with and without polyacrylamide ferrogel layer mimicking natural tissue in order to evaluate stray fields of embedded MNPs of γ-Fe_2O_3 iron oxide. A model for MI response based on a solution of Maxwell equations with Landau-Lifshitz equation was developed in order to understand the origin of the prototype sensitivity which reached 1.3 % of $\Delta Z/Z$ per 1 % of MNPs concentration by weight. To make this promising technique useful for magnetically labeled tissue detection, a synthesis of composite gels with MNPs agglomerates compactly located inside pure gel and their MI testing are still necessary.

Keywords: Magnetic biosensor; Magnetic nanoparticles detection; Ferrogels; Biomimetic materials; Magnetoimpedance; Magnetic multilayers

1. Introduction

Magnetic biosensing for biomedical engineering is a rapidly growing area of multidisciplinary research focused on the development of new techniques for the evaluation of properties of biological objects. It is the magnetic properties of biological objects that attract special attention [Glazer, 1999; Baselt, 1998; Shanmugam, 2009; Grossman, 2012]. Nanomaterials and magnetic nanoparticles have been widely studied for their biomedical application [Chen, 2018; Rusakov, V., 2018]. Significant efforts have been made for the development of a magnetic field sensors adapted for biosensing [Ferreira, 2002; Miller, 2002; Besse, 2002]. Modern measuring devices allow a quantified evaluation of small changes in the magnetic susceptibility, in the effective magnetic anisotropy in the living system, or in magnetic field values created by the extracellular electric currents. However, there is a need to improve