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Anomalous Resonance-Like Behavior of Giant Magnetoimpedance in a Glass-Coated Microwire LC-Resonator

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Recently, the discovery of a new magnetic phenomenon as giant magnetoimpedance (GMI) in soft ferromagnetic materials has promised to meet the increasing demand of rapid developments in the domains of computer peripherals, information apparatus, mechatronics such as automobiles and industrial robots, biomagnetic detection in human body, etc. [1]. In this case, the high field sensitivity of a sensor is required. Recent attempts have been devoted to improving the field sensitivity of GMI sensors based upon the ferromagnetic resonance effect and/or the electrical resonance from a *LC*-circuit [2].

In this work, we demonstrate that an anomalous resonance-like feature of GMI effect observed in a glass-coated microwire *LC*-resonator is very beneficial for the development of highly sensitive GMI sensors. Here, the *LC*-resonator consists of a magnetic microwire and two capacitive cylindrical electrodes at the ends of the microwire, where the electrodes act as the capacitors in the *LC*-resonance circuit. The glass coated amorphous $Co_{83.2}B_{3.3}Si_{5.9}Mn_{7.6}$ and $Co_{67}Fe_{3.8}Ni_{1.4}B_{11.5}Si_{14.6}Mo_{1.7}$ microwires prepared by the Taylor-Ulitovsky method have been used to construct the *LC*-resonators. The impedance measurements were performed in the high-frequency range of 100 - 1000 MHz and a varying dc magnetic field within ± 120 Oe. It has been shown that the shape of GMI curves varies drastically as the frequency increases. Remarkably, a multiple-peak GMI behavior has been observed in the studied frequency range. More noticeably, a drastic increase of GMI value has been found in the vicinity region of resonant frequencies. The maximum GMI ratio, due to the resonance of *LC* components, reached the high values of 35,000% and 24,000% at the resonance frequencies of 518.21 MHz and 146.25 MHz for $Co_{83.2}B_{3.3}Si_{5.9}Mn_{7.6}$ and $Co_{67}Fe_{3.8}Ni_{1.4}B_{11.5}Si_{14.6}Mo_{1.7}$ samples, respectively. The corresponding field sensitivities of GMI are about 20,000 %/Oe and 18,000 %/Oe. These results are of great interest in developing a new family of high-frequency and ultra-sensitive magnetic sensors. Furthermore, it has been demonstrated that the resonance in a glass-coated microwire *LC*-resonator always occurs at a specific intensity of the applied dc magnetic field. The sudden change of phase angle as large as 180° evidenced for occurrence of resonance. The extreme GMI effect in a constructed *LC*-resonator originates from the permeability changes of microwire and *LC*-resonance of circuit. The feature of a *LC*-resonance circuit can be used to design ultra-sensitive GMI-based magnetic sensors with a selected working frequency.

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Magnetic Dynabeads Dependence on MI Frequency Spectrum

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Development of a new generation of biosensors has been the subject of much research [1]. The GMI effect was recently considered to create a new type of biosensor for molecular recognition systems and selective detection. The difference in GMI profile was successfully measured with a non-biological model liquid material, commercial ferrofluid [2]. In this work, the ribbon was annealed in the open air, and a small field applied during the annealing. Magnetic Dynabeads M-280was dropped on the surface of the Co-based ribbons. The MI spectra measurements were performed using an HP4192A impedance analyzer with four terminal contacts. The intensity of driving current is 5 mA and sweeping frequency ranges from 1 kHz to 8 MHz. The transverse permeability spectra were extracted from MI spectra by numerical method [3]. The GMI response and permeability spectrum was measured in presence of commercial Dynabeads M-280. Much decrement of static permeability can be detected in with-bead ribbons. Frequency dependence of amorphous ribbons coated by microbeads and the potential applications for GMI-biosensor will be discussed further.

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