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Magnetic properties and High –frequency GMI effect in glass-coated amorphous wires

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Amorphous magnetically soft microwires attract great attention during last decade owing to their excellent magnetic properties and extremely thin dimensions [1,2]. The last strong tendency in miniaturization of the magnetic sensing elements has resulted in the development of the thinner wires produced by the Taylor-Ulitovsky method (1 30 μm in diameter). Recent significant progress in tailoring of magnetically soft Co-rich glass coated microwires fabricated by this method enabled to enhance significantly the GMI ratio (up to about 600%) [1]. The giant magneto-impedance, GMI, attracted growing attention since 90-th especially owing to the large sensitivity (up to 600%) of the electrical impedance to the DC magnetic field, when the relatively high- frequency electrical current flows along the magnetic conductor [3].

In this paper we report novel results on hysteretic properties and GMI effect at high frequency region (between 10 MHz and 500 MHz) in different families of amorphous microwires (Fe-rich, Co-rich and Co-Fe-rich with nearly-zero magnetostriction constant) fabricated by the Taylor-Ulitovsky method [2].

The GMI effect is related intrinsically with the hysteresis loops of the samples. As can be observed, the chemical composition of glass-coated microwires drastically affects their magnetization curves: the hysteresis loop changes from rectangular for Fe-rich compositions to almost unhysteretic in Co-rich compositions. Both hystersis loops and GMI effect depend also on microwires diameter.

The magnetic field dependence of the impedance has been also measured in 3 different thin glass-coated microwires at the same frequency range (10-500 MHz). At 10 MHz the GMI of Fe-rich microwires is smaller than in conventional wires, but increasing the frequency GMI effect significantly increases. The shape of the Z(H) shows roughly the decay with DC applied magnetic field. Small maximum can be appreciated at about 500 MHz. Co-rich microwires exhibit much higher GMI effect at all frequencies and the shape of the Z(H) dependence is typical for the materials with circular magnetic anisotropy, i.e. with the a maximum at certain dc axial magnetic field.

The main features in $\Delta Z/Z(H)$ dependences for 3 different compositions of amorphous glass-coated thin wires can be summarized as following: i) GMI ratio increases with frequency between 10 and 500 MHz in all compositions of glass-coated microwires; ii) even Fe-rich cold-drawn amorphous wires exhibit considerable GMI effect at elevated frequencies.

A remarkable difference in magnetic field dependence of the GMI effect can be attributed to the magnetostriction constant. Thus, Fe-rich microwires possess highest magnetostriction constant (of the order of $20\cdot10^{-6}$) [2]. Alternatively, Co-rich compositions possess lower and negative magnetostriction constant of the order of $-3\cdot10^{-6}$ [2]. Finally Co-Fe-rich possess vanishing magnetostriction constant of the order of $-(1\text{-}3)\cdot10^{-7}$ [2].

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DC04

Investigation of field variation in multi-pole magnetic components

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The performance of magnetic encoders is now comparable tothat of optical types in many precise control applications. A magnetic encoder consists of a magnetic sensor and a multi-pole magnetic component with a fine magnetic pole pitch. Using traditional methods, a finemagnetic pole pitch of less than 1mm was very difficult to achieve and a complicated magnetization system was required [1-3]. Nowadays more and more electric devices can be placed on a printed circuit board (PCB). Consequently, the wire circuit density is thus demanded higher and higher than before. Alinear wire circuit pattern was designed with a periodic structure, which provides a loop allowing the current to flow in opposite directions to induce different magnetic fields among the wire circuit. Correspondingly, an alternate and regular magnetic field distribution is generated according to Ampere's law. Thus, a multi-pole magnetic component with a fine magnetic pole pitch of less than 1mm was accomplished.

Different 9-pole, 19-pole and 29-pole magnetic components were designed and fabricated on the PCB with the same pitch size of 500m. The field distributions of three central magnetic poles along the bisection line at the detection spacing of 200m and 300m above the surface were measured. The magnetic flux density in the z direction decreases significantly with an increase of the detection spacing. Additionally, the explicit boundaries between magnetic poles were found, indicating that the pitch size is 500m. Other 9-pole and 19-pole magnetic components with a smaller pitch size of 400m were also fabricated for the further investigation. The field measurements are not only along the bisection line but including 2mm offsets from the bisection line. After measurements, the field variation in the multi-pole magnetic component only changes slightly at ±2mm offsets. These characteristics are useful to the subsequent detection and processing of signals.

The field formulae for computing the induced magnetic field in the multi-pole magnetic component were derived [4]. They are easily programmed and employed to calculate the magnetic flux density. As a comparison, the calculated values of magnetic flux density in the z direction agree with the measurement data. PCB technology provides a simple way to fabricate the fine magnetic pole pitch of less than 1mm without the complicated magnetization system. This approach is also a cost-effective method to enable mass production easily. The related details of the field variation in different multi-pole magnetic components will be investigated and discussed in this paper.

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