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The change of magnetic properties by ion irradiation in the Co-based amorphous ribbon

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Introduction

The giant magneto-impedance effect (GMI) in amorphous ribbons is of growing interest in the information technology and high sensitivity sensor applications [1]. Magneto impedance (MI) is the change of impedance under magnetic field. The high permeability and their strong dependence on the bias magnetic field are the origin of the GMI effect. The GMI properties of amorphous ribbon can be modified by the heat treatment or ion irradiation, which induce a structural relaxation and/or create the appropriate anisotropy. In an attempt to gain further control of such properties, the present experiment investigates the physical effects of ion Implantation or ion irradiation on the magnetic properties of amorphous ribbon, having appropriate composition Co66Fe4B15Si15. Earlier studies of radiation effects on magnetic alloys concentrate mainly on neutron irradiation of bulk materials [2]. Ion irradiation has an advantage in forming a meta stable alloy, which has different characteristics from that of thermodynamically stable one, by putting inert ions amorphous ribbon. When energetic ions with energy of several tens of keV penetrate a thin film, the collision cascade cause displacements of the target atom, produce a new mixed phase through the intermixing of cobalt [3], boron and silicon substrate, and get a meta stable one as a result of rapid quenching. In this experiment, Co-based amorphous ribbons were irradiated with a variety of ion species, energy and dose, selected to help identify the specific contributions to magnetic effects made by ionization (electronic) energy deposition by the ions, collisional loss of ion energy (displacement damage to the NiFe lattice), and implantation of various atomic species in the ribbons.

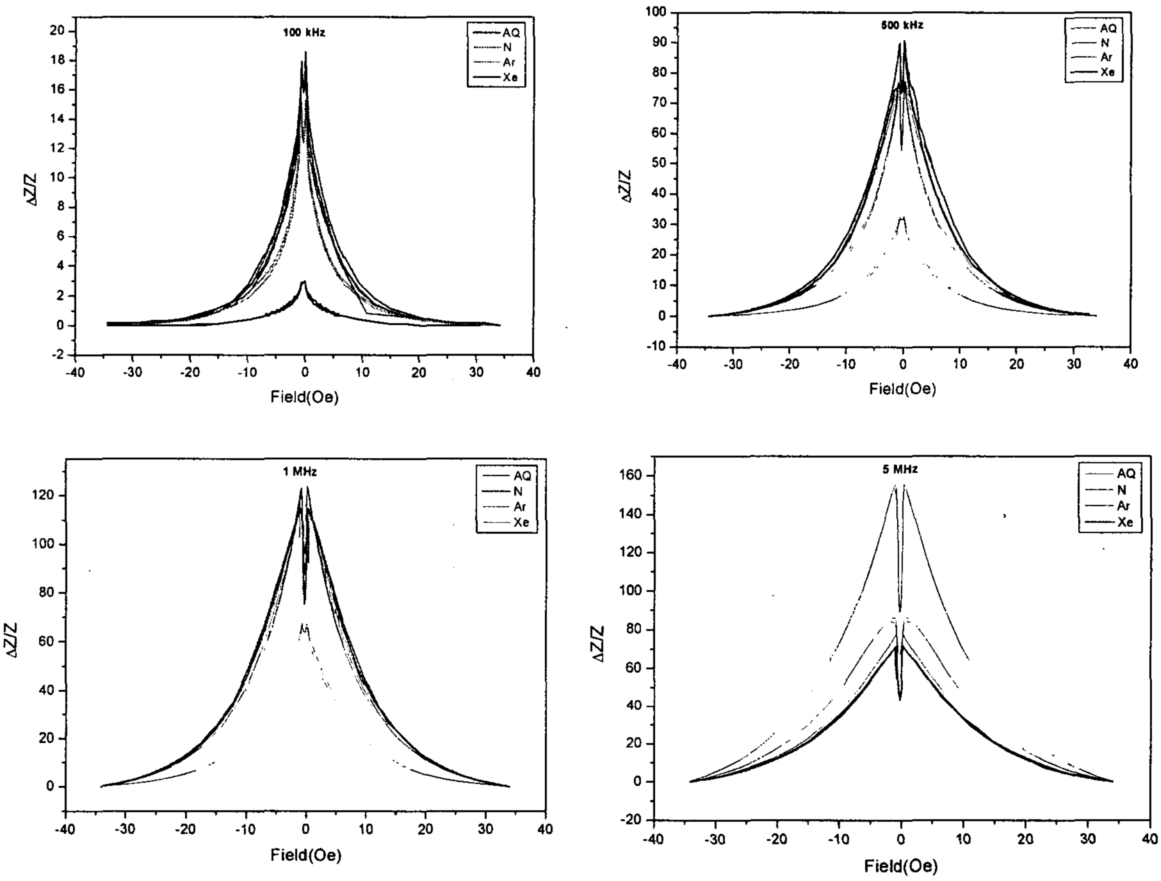
Experimant

Sample used in the present study were commercial amorphous ribbon Co66Fe4B15Si15, in the size of 2 mm x 40 mm x 20m. They were ion irradiated with Ar, N, Xe ions which have an energy of 70 keV by using high current ion implantor in a vacuum. The kinetic energy of the ions were designed to match the calculated mean projectile range of them to the total thickness of the samples by using the TRIM code [4] and the ion dosages was set to 1.0x1016 ion/cm2 at a beam flux of 3.70A/cm2. The GMI ratio profile was obtained by plotting Z/Z(%)=(Z(H)-Zsat)/Zsatx 100 for the cycle applied field, where Zsatwas the impedance at H=16 Oe. The impedance Z was measured using a HP4192A impedance analyzer with four terminal contacts.

Results and discussion

Fig. 1 show the GMI profile at various frequencies f of AC driving current for the samples before irradiation and after irradiation with N, Ar and Xe ions. Irradiation by Xe ion of 1x1016 n/cm2 at 100 kHz applied frequency lead to an increase of the GMI ratio Z/Z by more than 9 times of peak magnitude without changing the overall configuration of ratio profile in the whole bias magnetic field range -35Oe<H<35Oe. Further increase of measuring frequencies results in quite different behavior with irradiated ions. At higher frequencies with 5 MHz and 10 MHz, N and Xe ion did not alter the magnitude significantly. But, below the frequency of 5 MHz, the GMI ratio significantly increased by ion irradiation. The most significant increase of the GMI ration in this frequency region is found in the Xe ion irradiated sample. It is worth to note that the slope $d(\Delta Z / Z) / dH$ obtained from the ion irradiated sample is steeper in comparison to unirradiated sample. In case of Ar ion, the GMI ratio significantly increased of overall frequencies region. The GMI ratio depends on the irradiated ion species and applied frequencies.

It is instructive to observe the gradual appearance of the double-peak structure with ion irradiation, which reflects the increasing anisotropy field Hk. Furthermore, the depth of a ridge of the GMI ratio increase with increasing the frequency of applied driving current.



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