ABSTRACT

Magnetic materials consisting of nanocrystalline phases in amorphous matrix have attracted considerable research interest owing to their excellent combination of soft magnetic properties, such as low coercivity (H_c), high permeability (μ') and saturation magnetic induction (B_s), low saturation magnetostriction (λ_s), etc. Their excellent response to small applied magnetic fields has been exploited in large scale for low field sensor applications. The magnetoimpedance (MI) phenomenon is yet another property that exploits ac electromagnetic property of these materials at very low magnetic fields. In particular, nanocrystalline materials obtained through partial crystallization of their amorphous precursors have emerged as the suitable candidates. However, the magnetic properties in these materials are greatly dependent on shape and size of the microstructures, nature of the amorphous matrix, and the processing techniques, etc. Therefore, there is a need to control the grain growth and its homogeneous distribution to minimize the magnetic anisotropy of the material, so that one can achieve superior soft magnetic properties and thus the improved MI performance. Therefore, the main objective of the present work is to systematically investigate the role of structural modifications on the electrical and magnetic properties and MI effect in rapidly solidified metallic glass ribbons.

In this work, we report a comprehensive description of microstructure controlled MI effect in CoFeCuZrB and FeSiCuNbB ribbons. Our investigation includes influence of annealing under different environmental conditions and dc joule heating on magnetic properties and MI effect. The microstructures with the annealing conditions have been studied through X-ray diffraction and electron microscopic measurements. From the detailed experimental data analysis, it is shown that the development of ultrafine crystallites (α-CoFe and Fe_3Si in Co- and Fe-based ribbons, respectively) in the heat treated ribbons result in suitable combination of electrical and magnetic properties (skin depth), which provide large MI effect. Additionally, the studies on influence of measurement geometry (contact and non-contact methods) on the MI show that the MI performance is sensitive to the geometry. These studies provide physical insights for developing high performance MI sensors.

Keywords: Microstructures, Nanocrystallization, Magnetic properties, Magnetoimpedance, Measurement geometry