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Microstructure and high-frequency soft magnetic properties of nanocrystalline $(Fe_{0.5}Co_{0.5})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ alloys

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Abstract –In this paper, we prepared $(Fe_{50}Co_{50})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ amorphous ribbons, which were annealed under different temperatures. X-ray diffraction (XRD) and Transmission Electron Microscope (TEM) methods were used to analyze its phase characteristics and micro morphology. Soft magnetic properties were tested by soft magnetic properties measuring system. Good integrated magnetic properties can be obtained when the alloys were annealed in a temperature range of 500℃ ~ 520 ℃. The permeability of $(Fe_{50}Co_{50})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ is not as high as Finemet, but its cut-off frequency can reach up to 130 kHz. Therefore, the Co-doped Finemet alloy is very promising for the application in high frequency field.

Nanocrystalline magnets are being investigated for the applications of transformers, inductors, etc., where low coercivity, large saturation induction, large resistivity and good thermal stability are needed. Finemet ($Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$) alloy exhibits excellent soft magnetic properties in its nanocrystalline state, which is obtained from its amorphous precusors after a suitable heat treatment [1-2]. Several studies on the effects of addition of different elements on its magnetic and structural properties have been carried out since its discovery. In particular, the effect of Co has been studied in the last years. The microstructure and soft magnetic properties of Co substituted Finemet alloy play a significant role in broadening its applications which requires much higher performance of soft magnetic materials, especially in high frequency field [3-5]. In order to improve the high-frequency soft magnetic properties, we doped proper amount of Co in Finemet alloy ($Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$).The aim of this work was to study the effect of partial substituting Fe by Co on the microstructure and high-frequency soft magnetic properties of the doped Finemet alloy.

The $(Fe_{50}Co_{50})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ amorphous ribbons were prepared by single-roller melt-spinning process under argon atmosphere. In order to get the nanocrystalline alloy, the amorphous $(Fe_{50}Co_{50})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ ribbons were annealed under different temperatures. X-ray diffraction (XRD) and Transmission Electron Microscope (TEM) methods were used to analyze phase characteristics and micro morphology of the alloy, respectively. Soft magnetic properties of the alloy were tested by alternating current soft magnetic properties measuring system.

It can be seen clearly that the grain size and the volume fraction of the nanocrystalline phase increase with increasing annealing temperature according to the TEM images and XRD analysis. The nanocrystalline α-Fe(Co) grains disperse in the residual amorphous matrix and the microstructure is a typical two-phase structure. Good integrated magnetic properties such as relatively good soft magnetic properties and high relaxation frequency was obtained when the alloys were annealed in a temperature range of 500℃ ~ 520 ℃. The permeability is not as high as Finemet, but its cut-off frequency is largely increased and it can reach up to 130kHz. Therefore, this Co-doped Finemet alloy is very promising for the application in high frequency field. In addition, the effect of partial substitution of Fe by Co on the microstructure and magnetic properties of the $(Fe_{50}Co_{50})_{73.5}Cu_1Nb_3Si_{13.5}B_9$ alloys annealed in various temperatures will be discussed in details.

References

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