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Magnetic Properties and Superparamagnetic Behavior in Fe-Zr-Cu-B

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Nanocrystalline materials produced by a crystallization starting from the amorphous state are interesting objects for the fundamental studies of magnetism because they exhibit excellent soft magnetic properties and show a variety of magnetic phases at elevated temperatures[1]. The optimum softness of magnetic properties has been explained in terms of a reduction of the magneto-crystalline anisotropy due to ferromagnetic exchange interactions between nanocrystallites through the remaining amorphous matrix[2]. One of the interesting characteristics is that the nanocrystalline materials show an interaction between particles even at temperatures higher than the Curie point of the amorphous phase $T_{C(am.)}$[3,4]. However, since $T_{C(am.)}$ is far below the Curie temperature of the nanocrystallites, the interactions between grains disappears at high temperatures. Then the material can be studied from the point of view of free particles properties. It has been shown that these features depend on the size and the concentrations of crystals embedded in the amorphous matrix. In FINEMET type material grains, which are small enough to fulfill the requirements of the single domain state and separate one from another so that the magnetic interactions between them are negligible, the superparamagnetic behavior of α-FeSi grains embedded in paramagnetic amorphous matrix was observed[1]. For higher concentrations of grains, the magnetic interaction between grains becomes significant[3,4]. Recently, the increase of the Curie temperature of some Fe-Nb and Fe-Zr amorphous alloys undergoing nanocrystallization has been the subject of several studies[5-9]. The inhomogeneity of the amorphous phase, arising from the diffusion during the nanocrystallization[6] and the penetration of the crystallites exchange field caused by the crystallites into the amorphous phase[5], have been suggested as an origin of the observed increase in $T_{C(am.)}$ with respect to the expected value from the compositional change of the amorphous phase. Applying the appropriate heat treatment for the chosen composition it is possible to control the volume fraction of the nanocrystallites as well as the size of the grains. Consequently the magnetic properties of the nanocrystalline material can be adjusted for the specific studies. In the present work, the temperature dependence of the ac-susceptibility and the hysteresis loop on nanocrystalline $Fe_{86}Zr_7Cu_1B_6$ and $Fe_{85}Zr_7Cu_2B_6$ was measured. The ac-susceptibility was measured using a microfurnace and the hysteresis, a new type of hysteresigraph. The power supply is a 50 Hz high current source which is used to generate a magnetic field up to 300 kA/m. The aim is to study the magnetic properties of these materials and the expected superparamagnetic behaviors.

References

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