MAGNETIC ORDER AND MAGNETIC BEHAVIOR OF THE POLISHED AMORPHOUS EUTECTIC ALLOYS Tb₆₅Cu₃₅ AND Er_{69.5}Cu_{30.5}. INFLUENCE OF A MAGNETIC FIELD

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Abstract. – Susceptibility, magnetization and small angle neutron scattering measurements have been made at various temperatures on polished amorphous alloys. The influence of applied magnetic field is described in terms of magnetic domains. The evolution with temperature of the magnetic order is discussed. The comparison between Tb and Er alloys shows two different behaviors.

1. Introduction

The nuclear and magnetic orders, magnetic behavior of the eutectic amorphous alloy Tb₆₅Cu₃₅ have previously been reported [1, 2]. The polishing effect (increase of magnetic domain size in the bulk, orientation of their magnetization perpendicular to the polishing direction in a surface layer of 1200 Å thickness with alternance of the direction of magnetization, every 4000 Å) is spectacular. Here we report the influence of magnetic field and temperature on this asperomagnetic alloy. We further show that Er_{69.5}-Cu_{30.5} amorphous alloy does not have the same kind of order as Tb₆₅Cu₃₅.

2. Experimental

These alloys have been prepared by planar flow casting as sheets of 50 μm thickness. The sheets have been polished with fine sand paper along the axis of the tape. The samples are made of several sheets piled together, the polishing directions being parallel. The susceptibility has been measured with a Faraday balance ($H \sim 0.1$ T). The magnetization measurements have been performed by the extraction method (SNCI-CNRS, Grenoble, Fr.). Small angle neutron scattering (SANS) measurements (Institut Laue Langevin, Grenoble, Fr-D11 spectrometer) were carried out on Tb₆₅Cu₃₅ sample cooled to 4 K under a 5 T magnetic field, applied in sheet plane perpendicular to the polishing direction. No field was applied during the measurements. Patterns have been recorded for

$$8 \times 10^{-4} < q (= 4\pi \sin \theta / \lambda) < 10^{-1} \text{ \AA}^{-1}$$

at various temperatures from 4 to 220 K and again at 4 K with a plane detector of 64 × 64 cells ($\lambda = 5$ and 12 Å). The Er-alloy has been polished but not field cooled. In all cases the neutron beam was perpendicular

to the sheet plane and the polishing direction was kept horizontal.

3. Results

For both eutectic alloys close in composition, the susceptibility measurements are similar with an asymptotic Curie temperature (θ) clearly positive (80 and 20 K for Tb- and Er-alloy respectively). In the same way these alloys give a SANS similar at 300 K on which is superimposed at 4 K a magnetic scattering very different for the two alloys.

Tb₆₅Cu₃₅ alloy

This alloy shows at 4 K magnetic loops, practically independent of applied field direction, not easy to be saturated (7 T), a high value of remanent magnetization ($3.5 \mu_B/\text{Tb}$) and jump of magnetization as in [3].

Figures 1 and 2 show that at 220 K the nuclear SANS is weak and almost isotropic. But at 4 K the sample annealed at 220 K exhibits two peaks symmetric with respect to the incident beam and superimposed on an intense almost isotropic hump. These measurements confirm quantitatively those observed on another sample [2]. On the other hand the sample cooled under field does not give any peak and shows an anisotropic scattering. Let us remember that without polishing the set of scattering does not exist or is very weak [2]. The scattering at larger q values is not represented and does not seem to be highly affected by the field. This scattering is due to the presence of composition heterogeneities [1].

Figure 2 exhibits the relaxation of magnetic order as T increases from 4 to 60 K for field cooled sample and allows us to compare both pattern at 4 K before and after annealing at 220 K. Above 100 K the scattering at low q is weak.

Fig. 1. - Isointensity curves for polished $\text{Tb}_{65}\text{Cu}_{35}$. The numbers represent intensities on the same scale: (a) at 4 K cooled under magnetic field (b) at 220 K and (c) at 4 K after annealing at 220 K. The section A leads to figure 2.

Fig. 2. - Nuclear and magnetic cross section as a function of q in the horizontal plane perpendicular to the applied field in field cooled samples $\text{Tb}_{65}\text{Cu}_{35}$. Cross section is given in μ_B^2 per Tb atom.

$\text{Er}_{69.5}\text{Cu}_{30.5}$ alloy

This alloy leads to very different results: small hysteresis loops and only a noticeable scattering for hi-

gher q values indicating the presence of heterogeneities. Thus it is not possible to attempt a comparison between the magnetic behavior of both alloys.

4. Discussion

The applied magnetic field orients the magnetization of the domains, increasing their size in the surface layer suppressing the periodicity of 4000 Å (disappearance of the peaks) as well as in the bulk (concentration of the scattering towards weak q values) leading to domains of at least 1 μm .

The scattered intensity depending on the angle between the magnetization and the moment transfer q , the anisotropy of the scattering gives very easily a measure of the dispersion of magnetization around the field direction ($\sim \pm 25^\circ$). This dispersion is the same as that which corresponds to the remanent magnetization ($3.5 \mu_B/\text{Tb}$). This leads to a domain magnetization ($M_D = M_{\text{rem}}/\cos 25^\circ$) of the order of $3.8 \mu_B/\text{Tb}$ which is smaller than $5 \mu_B/\text{Tb}$, corresponding to the magnetization of three neighbouring shells, deduced from disordered magnetic scattering of neutron diffraction patterns [4], but which is large for the magnetization of large domains.

Above 80 K this scattering vanishes; there is no more long-range order in agreement with the θ value. There is principally scattering at high q values showing the existence of medium-range order which does not exist at 220 K, in agreement with neutron diffraction measurements which show at 150 K only a very weak order between the first neighbours [4].

Acknowledgements

We thank Dr. J. Bigot (CECM-CNRS Vitry sur Seine, France) for preparing the samples and Drs. J. C. Picoche and M. Guillot for their help during the magnetization measurements (SNCI-CNRS Grenoble, France).

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