RELAXATION STUDIES OF THE REMANENT MAGNETIZATION IN THE SPIN GLASS LIKE STATE OF AMORPHOUS Fe90 (ZrxScy)10 ALLOYS

M. Braun, K. Schletz, E. Wassermann, M. Ghafari

To cite this version:
M. Braun, K. Schletz, E. Wassermann, M. Ghafari. RELAXATION STUDIES OF THE REMANENT MAGNETIZATION IN THE SPIN GLASS LIKE STATE OF AMORPHOUS Fe90 (ZrxScy)10 ALLOYS. Journal de Physique Colloques, 1988, 49 (C8), pp.C8-1165-C8-1166. <10.1051/jphyscol:19888535>. <jpa-00228745>

HAL Id: jpa-00228745
https://hal.archives-ouvertes.fr/jpa-00228745
Submitted on 1 Jan 1988

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
RELAXATION STUDIES OF THE REMANENT MAGNETIZATION IN THE SPIN GLASS LIKE STATE OF AMORPHOUS Fe$_{90}$ (Zr$_{x}$Sc$_{y}$)$_{10}$ ALLOYS

M. F. Braun (1), K. P. Schletz (1), E. F. Wassermann (1) and M. Ghafari (2)

(1) Laboratorium für Tieftemperaturphysik, Universität Duisburg D-4100 Duisburg 1, F.R.G.
(2) Laboratorium für Angewandte Physik, Universität Duisburg D-4100 Duisburg 1, F.R.G.

Abstract. – Field cooled (FC) and zero field cooled (ZFC) magnetization measurements have been performed on amorphous Fe$_{90}$ (Zr$_{x}$Sc$_{y}$)$_{10}$ (x = 100, 80, 60, 50, 20, 0 at%) alloys. The time dependence of the thermoremanent magnetization has been studied up to $5 \times 10^5$ s with a SQUID-magnetometer. Depending on the ratio of the Zr and Sc concentration different relaxation behavior in the low temperature SG-phase is observed.

Introduction

The magnetic properties, and especially those in the spin-glass like (SG) state of melt spun amorphous Fe$_{90}$ (Zr$_{x}$Sc$_{y}$)$_{10}$ alloys, have attracted attention because the understanding of Fe-rich amorphous alloys and SG-systems is not complete. Magnetization measurements of a-Fe$_{90}$ (Zr$_{x}$Sc$_{y}$)$_{10}$ show that the Curie-temperatures, $T_c$, depend on the Zr/Sc concentration ratio. At low temperatures all investigated samples exhibit a SG-like state. This low temperature phase was studied by Mössbauer and long time thermoremanent magnetization (TRM) measurements ($500 \text{ s} < t < 5 \times 10^5 \text{ s}$).

Results and discussion

The a – Fe$_{90}$Zr$_{10}$ sample becomes ferromagnetic below $T_c = 220 \text{ K}$ [1] which is the highest $T_c$ among the investigated samples. Nearly the same transition temperature is observed for a – Fe$_{90}$Zr$_8$Sc$_2$ ($T_c = 210 \text{ K}$; Fig. 1). $T_c$ decreases with increasing Sc concentration as can be seen from figure 2 for a – Fe$_{90}$Zr$_2$Sc$_8$ and the ferromagnetism becomes weaker as can be seen from the low field magnetization. Mössbauer measurements on Fe$_{90}$Sc$_{10}$ [2] show clusters (size 200 μm) which suggest superparamagnetic behavior at higher and a cluster-glass like state at lower temperatures. The transition temperature $T_f$ of the SG-like state increases with increasing Sc concentration. The lowest freezing temperature $T_f = 14 \text{ K}$ [1] is observed in the a – Fe$_{90}$Zr$_{10}$ sample and the highest freezing temperature $T_f = 50 \text{ K}$ in a – Fe$_{90}$Sc$_{10}$.

Long time TRM ($t$)-measurements reveal a dif-

Fig. 1. – FC and ZFC DC-magnetization of amorphous Fe$_{90}$Zr$_8$Sc$_2$ in an applied field of $B = 2 \text{ mT}$.

Fig. 2. – FC and ZFC DC-magnetization of amorphous Fe$_{90}$Zr$_{10}$Sc$_8$ in an applied field of $B = 2 \text{ mT}$.

Fig. 3. – TRM ($t$) of amorphous Fe$_{90}$Zr$_{10}$ plotted in a logarithmic time scale.
Fig. 4. – TRM (t) of amorphous Fe₉₀Sc₁₀ plotted in a logarithmic time scale.

ference in the SG-like states of a – Fe₉₀Zr₁₀ and a – Fe₉₀Sc₁₀. Figure 3 shows TRM (t) of a – Fe₉₀Zr₁₀ using a logarithmic time scale. Obviously a logarithmic relaxation law does not describe the results correctly. Better fits to TRM (t) data are obtained by the stretched exponential law [3] as will be shown in a separate publication [4]. On the other hand, as seen in figure 4 the TRM (t) for a – Fe₉₀Sc₁₀ follows a logarithmic time law, at least within the time interval investigated. This can be either understood by assuming a slower relaxation in the cluster-glass range of a – Fe₉₀Sc₁₀ or a completely different microscopic behavior as compared to a – Fe₉₀Zr₁₀.

The combined time-temperature-scaling [5] is used to analyse the relaxation behavior for time scales not accessible by measurements. Figure 5 shows the TRM measurements for a – Fe₉₀Zr₁₀ at different temperatures T = const below Tᵢ in the time-temperature scaling plot with τ = 10⁻¹² s. The TRM (t) data at different temperatures T fit to a so-called “master curve” [5] which however for a – Fe₉₀Zr₁₀ is not continuous. This discontinuity between the ranges T ≤ 8 K and T ≥ 9 K is caused by a second low temperature SG-like phase, which has been observed by other authors as well [6]. Use of the time-temperature scaling for a – Fe₉₀Sc₁₀ does not result in a “master curve” because each cooling treatment results in a different cluster arrangement, i.e. different remanence. At the same time this reveals the different ground state properties of the SG-like a – Fe₉₀Zr₁₀ on one hand and the cluster glass like a – Fe₉₀Sc₁₀ on the other hand.

Acknowledgments

This work was supported by the DFG Sonderforschungsbereich 166, Duisburg-Bochum.