

ANOMAL THERMAL DILATATION OF AMORPHOUS $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$

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Abstract

The development of crystallization of amorphous $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ during its thermal dilatation was observed. For this purpose, a series of samples with different concentrations of crystal phase were prepared. All these samples were obtained by heating to different temperatures above the temperature of the crystallization beginning. The heating rate was 10 K/min. By repeated treatment of this samples it was found that even a small concentration of crystal seeds influences much the development of the crystallization. It was found that the concentration of crystal phase shifts the crystallization beginning towards the lower temperatures. The lower concentration of crystal phase has much intensive influence to this shift.

Introduction

Due to thermal dilatation investigation of amorphous metal alloys a series of characteristic parameters were discovered. For example, the temperature dependence curve of dilatation enables the estimation of Curie temperature position /1/, the

"glass" temperature, the temperature of origin of the crystallization T_x .

Experimental investigation of thermal dilatation of ferromagnetic alloys /2/ such as $Fe_{40}Ni_{40}B_{20}$ could in a way be applied on thermal dilatation investigation of amorphous samples and used as a key for explaining the "invar" effect. The crystallization in the dilatation process results in a drastical shrinkage of the sample. Due to this, the thermal dilatation curve shows the temperature interval wherein the sample is amorphous. We have investigated the structural relaxation of the amorphous alloy $Fe_{40}Ni_{40}B_{20}$ by thermal dilatation method using an apparatus we have constructed for this purpose. The investigation of the sample behaviour in the zone of crystallization was performed by partial annealing of samples which were still partial crystalline. The following of the crystallization process (the decay of the amorphous phase) is interesting for relaxation mechanism investigation /3/.

Experimental and results

The amorphous samples we used were ribbons cca 10 mm long, 0.5 mm wide and 30 μm thick. They were heated in He atmosphere by a rate of 10 K/min. This continual temperature increasing was interrupted when desired temperature was reached; then the sample was suddenly cooled. On such annealed sample the thermal dilatation was measured, then it was heated again and left to crystallize finally. The repeated treatment with

a new sample was performed with a changed annealing temperature. The annealing temperatures were in a narrow range within the amorphous - crystal transition had happened.

The apparatus for thermal dilatation measurements has a LVDT displacement transducer made by Penny and Giles. Its accuracy is 100 mV per 0.01 mm./4/

The errors arising in this experiment are due to the loading of the sample which is not greater than 0.2 N. This loading is necessary because the sample has to hang vertically. At the same conditions, the variation in shrinkage due to crystallization was found not to be greater than $\pm 2\%$.

In order to investigate the influence of the "carried in" seed of crystallization to further process of crystallization we observed only the part of the figure 1 in the temperature range from 350 C to 450 C.

Figure 1 shows that the beginning of the crystallization (inflexion point) appears on T_1 . Each thermal treatment by heating rate of 10 K/min and sudden cooling to $T < T_1$ leaves the state $\Delta l(T)$ above T_1 unchanged. However, heating to the temperature $T \gg T_1$ has a strong influence on kinetics of the process above it. In this case the repeated heating gives a shift in dilatation "peak" from T_2 to T'_2 towards lower temperatures (fig. 1 a). The increasing the temperature T_2 during partial annealing influences, as expected, the shrinkage of the sample at the repeated crystallization (fig. 1 b). So one can obtain a family of curves shown on fig. 2 . Next to each

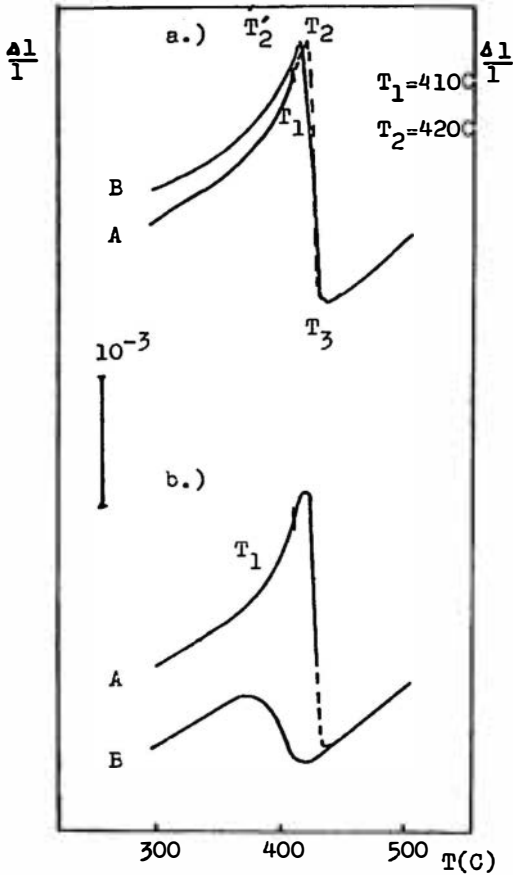


Fig. 1 Crystallization (curve B) curve of partial crystalline (curve A) $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ sample observed by thermal dilatation.

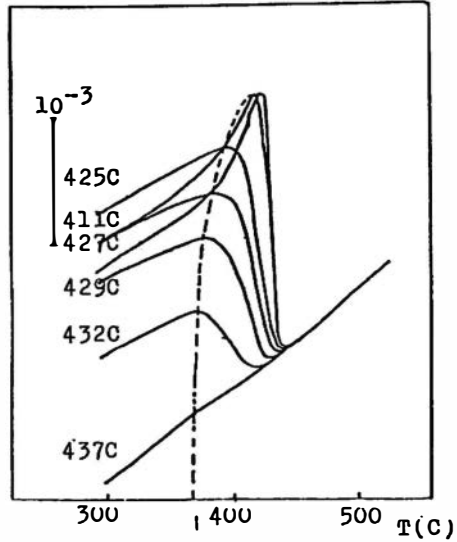


Fig. 2 The family of curves of $\text{Fe}_{40}\text{Ni}_{40}\text{B}_{20}$ complete crystallization.

curve the temperature of initial annealing is marked. Figure 2 shows a very small influence of considerable increasing of temperature T_1 on further shifting of the "new" dilatation peak, which asymptotically approaches the temperature of cca 372 C.

Acknowledgements

The authors wish to thank to dr. B. Leontić and dr. E. Šabić for very useful advices, as well as for the samples prepared in their laboratory. Thanks are also due to Scientific Research Fund SRBiH for their financial support.

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