AMORPHOUS-CRYSTALLINE TRANSFORMATION OF Fe-B ALLOYS[1]

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In the presented paper the amorphous-crystalline transformation of amorphous $Fe_{100-x}B_x$ alloys ($13 < x < 25$) is studied by measuring the temperature dependence of the coercive force and using the transmission electron microscopy. The results indicate the dependence of the amorphous-crystalline transformation on the boron content and the technological parameters of the alloy preparation. Various mechanisms of crystallization are discussed.

ПЕРЕХОД АМОРФНОГО СОСТОЯНИЯ В КРИСТАЛЛИЧЕСКОЕ ДЛЯ СПЛАВОВ Fe-B

В данной работе изучены переходы аморфного состояния в кристалическое в случае аморфных сплавов $Fe_{100-x}B_x$ ($13 < x < 23$) при помощи измерения температурной зависимости коэрцитивной силы и использования просвечивающего электронного микроскопа. Результаты свидетельствуют о зависимости перехода аморфного состояния в кристаллическое от содержания бора и технологических параметров приготовления сплава. Обсуждаются разные механизмы кристаллизации.

I. INTRODUCTION

It is thought that the mechanism of amorphous-crystalline transformation in Fe-B alloys depends on the boron content [1]. In the hypo-eutectic alloys the crystallization takes place in two discrete steps during which first α-Fe crystallizes from the amorphous matrix and then the Fe_3B compound. In the hyper-eutectic range these two steps cannot be separated. In this paper the crystallization of

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amorphous $Fe_{100-x}B_x$ $(13 < x < 25)$ is studied by measuring the temperature dependence of some magnetic quantities and using transmission electron microscopy.

II. EXPERIMENTAL

The investigations were performed on amorphous ribbons prepared by the spinning wheel method. In individual cases the time dependence of the coercive force was measured (at an annealing temperature chosen below the crystallization temperature) using an astatic magnetometer in which the samples were heat treated too. The microstructure of the samples was studied by a JEM-7 transmission electron microscope. We used the possibility to heat the sample by an electron beam in the chamber of the microscope to observe the crystallization process also continuously.

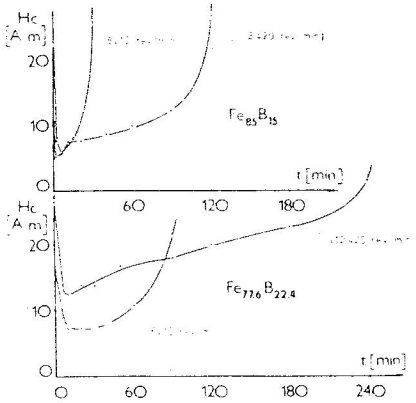

Fig. 1. Dependence of the coercive force on the time of annealing under a crystallization temperature for samples prepared at different melt cooling rates.

III. RESULTS AND DISCUSSION

The time dependence of the coercive force of the samples $Fe_{85}B_{15}$ and $Fe_{77.6}B_{22.4}$ annealed at given temperatures are shown in Fig. 1. At each concentration two different cooling rates for preparing the ribbons were used, corresponding to 6210 rev/min and 12 420 rev/min of the cooling disc. The initial points of the $H_c(\tau)$ curves give the values for the as cast states. The H_c is proportional to the cooling rate in agreement with results of [2]. Raising the cooling rate more internal stresses are quenched. This can be seen also from the rapid initial decrease of the $H_c(\tau)$ curves for a higher cooling rate; at a lower cooling rate this decrease is slower. The increasing part of the curves seems to be connected with different mechanisms of a short-range ordering.

The electromicroscopic investigations show that the first crystalline regions appear after a relatively long annealing time on the increasing part of the $H_c(\tau)$ curve only. These parts originating during the heat treatment have a monocrystalline character. Fig. 2 shows the microstructure of the sample heat treated as indicated by point A in Fig. 1. In the hypereutectic concetration range various mechanisms of crystallization could be detected in which a two phase decomposition of the amorphous matrix (in α-Fe and Fe_3B) appears. These have been investigated on the samples heated with an electron beam in the microscopy chamber. The crystallization may begin by heterogeneous nucleation connected with the lamellar growth [3] of nuclear centres, after that the Fe_3B lamellas will

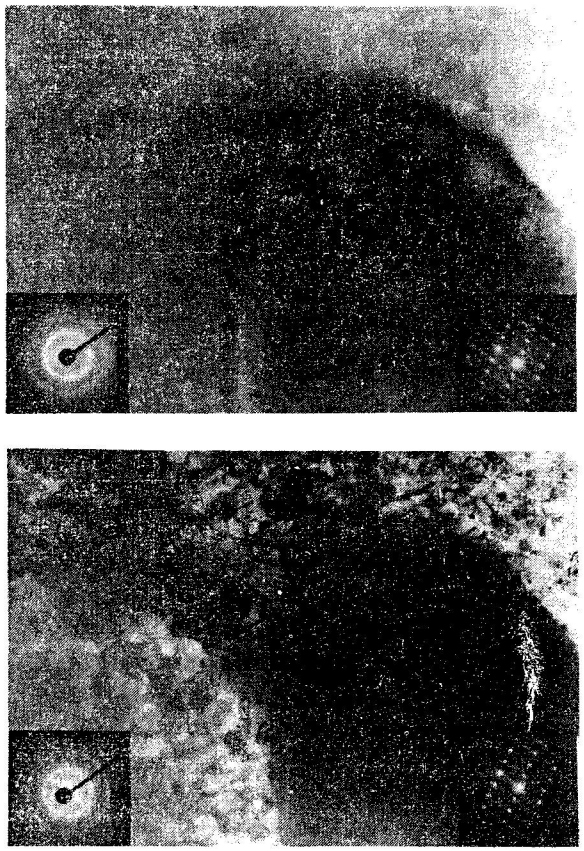

Fig. 2. Microstructure of the $Fe_{77.6}B_{22.4}$ sample after heat treatment corresponding to point A in Fig. 1 (Fig. 2a) and after its crystallization (Fig. 2b).

coagulate in the α-Fe matrix. It seems that this mechanism is probably influenced by surface diffusion and is typical for the lower cooling rate. The second observed mechanism was the forming of polyhedral grains by homogeneous nucleation in the amorphous matrix. This is typical for the higher cooling rate of ribbon preparing; it is connected with a frontal shift of the phase boundary. Some results show that before the crystallization of α-Fe small spherical particles of Fe_3B are formed, which persist also after the crystallization of the matrix.

The observed mechanisms of crystallization support the assumption of the chemical inhomogeneity of the amorphous ribbons.

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