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MICROSTRUCTURE AND CRYSTAL GROWTH IN THERMALLY TREATED $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ ALLOY

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Abstract
Thermal treatment of $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ amorphous alloy induces structural changes, including crystallization of several different phases and subsequent crystal growth. X-ray diffraction combined with differential scanning calorimetry were used to investigate these, to determine kinetic parameters and mechanism of individual steps, and the dimensionality of crystal growth using Matusita-Sakka method and texture analysis. It was found that after the alloy becomes fully crystalline, crystal growth of individual phases is, in general, impeded, leading to decreased dimensionality of growth. However, this does not impact the texture, due to lack of preferred direction of crystal growth.

Introduction

Metallic glasses (amorphous metallic alloys) are materials characterized by homogenous and isotropic structure with absence of the long-range order, which possess isotropic physical and mechanical properties. Iron based amorphous alloys have attracted much attention in recent times, because of their favorable physical properties. These materials are kinetically and thermodynamically metastable, usually stable at room temperature and can be transformed to polycrystalline materials at higher temperatures. During the crystallization process, microstructure of the alloy changes from amorphous, through hybrid amorphous/crystalline, to purely crystalline structure. Since hybrid amorphous/crystalline materials often have functional properties superior to those of purely amorphous and purely crystalline materials, control of crystallization process of these materials can lead to creation of materials with targeted properties.
The goal of this work was to study influence of thermal treatment on microstructure and crystal growth in $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ alloy.

Results and Discussion

Amorphous alloy $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ was prepared in form of a ribbon by melt spinning method. The thermal stability and kinetic parameters of the alloy had been investigated in 25-800^{o}C temperature range using DSC. XRD of thermally treated alloy samples was also used, to determine phase composition and perform texture analysis. The alloy was stable up to about 500^{o}C after which two exothermic crystallization peaks are observed in DSC, at around 500^{o}C and 680^{o}C, respectively. Crystallization occurs in a multi-step process. To investigate each

individual step of these processes, complex experimental peaks were deconvoluted using Origin software package. In order to determine kinetic parameters (apparent activation energy, Ea and pre-exponential factor, A) of processes of crystallization, we used Kissinger's [1] and Ozawa's [2] methods. It was observed from Table 1 that the values for Ea and A obtained by these two methods are in good correlation.

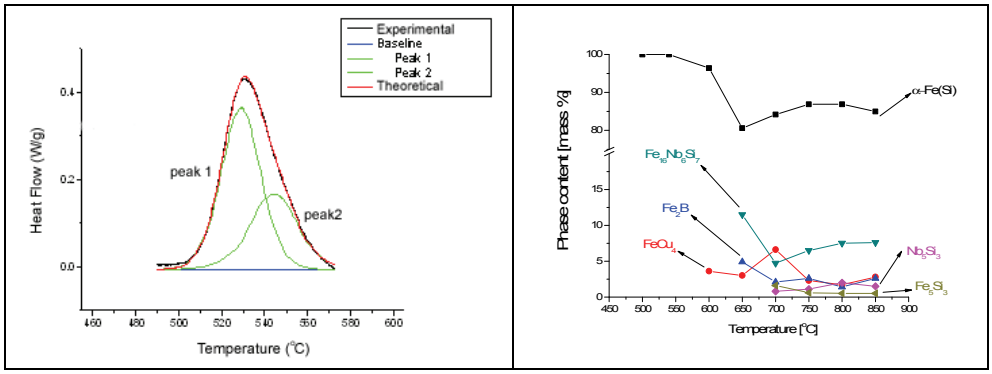

Figure 1. Deconvolution of first experimental DSC peak (left) and phase content of individual crystal phases in thermally treated alloy samples (right).

Table 1. Kinetic parameters of individual steps for the first experimental DSC peak determined by Kissinger's and Ozawa's methods.

		KISSINGER		OZAWA	
		Ea[kJ/mol]	A[min^{-1}]	Ea[kJ/mol]	A[min^{-1}]
Experimental peak 1	Peak 1	(316 ± 11)	(1.6 ± 0.1)•10^{20}	(313 ± 10)	(1.1 ± 0.1)•10^{20}
	Peak 2	(248 ± 13)	(2.5 ± 0.2)•10^{15}	(249 ± 13)	(2.8 ± 0.2)•10^{15}

Crystal growth of α-Fe(Si) phase occurs in two distinct stages: first stage includes nucleation and subsequent growth from amorphous phase, which occurs three-dimensionally (m=2.7 in Matusita-Sakka method [3]), while the second stage occurs in fully crystallized alloy, where its crystal growth is impeded by presence of other crystalline phases. This means that, in the second stage, the growth of α-Fe(Si) is prevented on interphase boundaries, which is exhibited as the value of m=1.7 in Matusita-Sakka calculation. However, since there is no preferred direction of growth, there is no significant change in texture of α-Fe(Si) phase, even though the growth is nominally not three-dimensional.

The growth of Fe_2B phase also exhibits two distinct stages, due to different sources of crystallization. Initial crystallization of Fe_2B occurs from the amorphous phase, while, later, it also crystallizes from metastable Fe_3B phase [4]. The crystal growth from amorphous phase occurs three-dimensionally, while the growth from metastable Fe_3B phase occurs two-dimensionally, as suggested by change in dimensionality of crystal growth observed using Matusita-Sakka method.

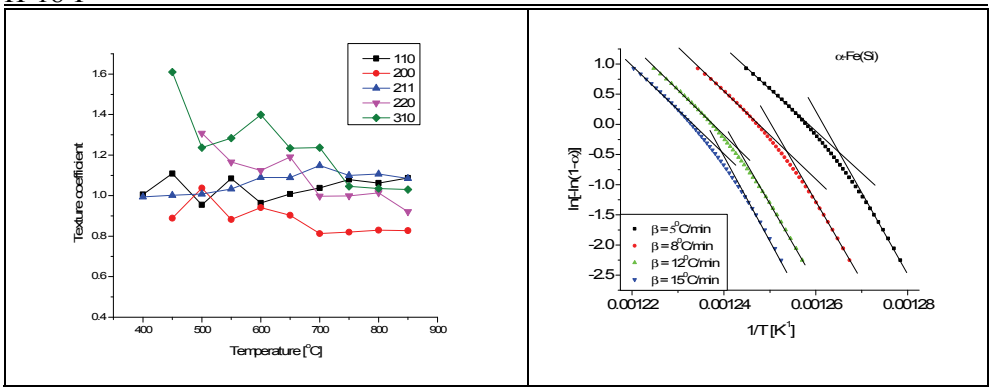

Figure 2. Texture analysis (left) and Matusita curves (right) for α-Fe(Si) phase.

Conclusion

Thermally induced crystallization and crystal growth in $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ amorphous alloy shows that crystallization and growth occurs in two temperature regions: around 500 and 680°C. There are multiple stable and metastable phases observed and it is shown that dimensionality of their crystal growth depends on the degree of crystallization of the alloy, with impeded growth in fully crystallized alloy.

References

[1] H. E.Kissinger, Anal. Chem., 1957, 29, 1702-1706.
[2] T. Ozawa, J. Therm. Anal., 1970, 2, 301-324
[3] K. Matusita, S. Sakka, J. Non-Cryst. Solids, 1980, 741, 38-39
[4] V. A. Blagojević, D. M. Minić, T. Žak, D. M. Minić, Intermetallics, 2011, 19, 1780-1785

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