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RE-DEPENDENT STRUCTURE AND PHASE TRANSFORMATIONS IN Fe-Ga FUNCTIONAL ALLOYS

The discovery of an increase in the magnetostriction of α-Fe upon partial replacement of iron by gallium [1] gave rise to a large number of studies in which a similar effect was sought in a variety of binary and ternary iron-based alloys. An interesting structural topic is the study of the effect of rare earth alloying of Fe-Ga alloys. Alloying Fe-Ga alloys with small amounts of rare earth elements (RE) leads to an improvement in the magnetostrictive properties of these alloys. The physical and technical properties of these functional materials largely depend on their specific atomic structure, the volumetric content of various structural phases and their microstructural state [2].

The work carried out studies of the evolution of the phase composition and microstructure of cast alloys Fe100-(x+y)GaxREy, (with x ≈ 27 at.%), where the elements Er and Yb (y = 0.5 and 0.2 at.%) were used as rare earth metals. The results were obtained in neutron diffraction experiments carried out in two modes: with high resolution in terms of interplanar distance and with high intensity during continuous scanning in temperature under heating to ~900℃ and subsequent cooling with □2 ℃/min. Information about the microstructural state of alloys was obtained using the Williamson-Hall and Pielaszek methods, which make it possible to estimate the characteristic sizes and size distribution of coherent scattering regions by analyzing the profiles of diffraction peaks.

Table 1 shows the sequences of phase transformations of the first and second order during heating and cooling of cast Fe100-(x+y)GaxREy alloys. It was found that an increase in the amount of RE in alloys leads to suppression of the formation of FCC (A1, L12) and HCP (A3, D019) structures during thermal exposure.

Sample composition, at.% Heating Cooling

Fe72.36Ga27.4Er0.24 D03 → L12→ D019 → B2 →A2 A2 → B2 → D03 → L12+D019

Fe73.1Ga26.7Yb0.2 D03+L12 → L12 → D019+A1 → A2+L12 A2+L12→ L12+B2 → L12+D03+D019

Fe72.1Ga27.4Er0.5 D03 → D03+A1 → D03+A3 → A2 A2 → D03

Fe72.8Ga26.7Yb0.5 D03 → A2 A2 → D03

Tab.1. Phase transitions detected in ternary Fe alloys during in situ neutron studies upon heating and cooling. The table shows the phase transitions between BCC (A2, B2, D03), FCC (A1, L12), and HCP (A3, D019) structures.

In the initial state, the microstructure of the Fe100-(x+y)GaxREy alloys with RE = Er and Yb in an amount of 0.5 at.% was a structurally disordered matrix of the A2 type with clusters, which are coherent inclusions of the ordered D03 phase. Moreover, coherent inclusions in the alloy with Er are 2 times greater than in the alloy with Yb. Analysis of the microstructure of alloys with a smaller amount of RE ≈ 0.1 –0.25 at.% in the initial state showed the absence of clusters, but the presence of broadening of the peaks was established, which is associated with the presence of microstrains in the material. This work is a continuation of our studies [3] of Fe-Ga-RE alloys with 19 at.% Ga.

Section

Energy and materials science (Section 2)

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