

Theoretical analysis of reverse hydrogen-induced diffusive phase transformation kinetics in $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$ alloy

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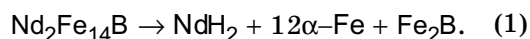
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Kinetics of the hydrogen induced reverse phase transformation in $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$ alloy at isothermal conditions was described. In terms of the Kolmogorov-Lyubov theory the kinetic diagram of this transformation was calculated. It is shown that kinetics of a reverse phase transformation is controlled by diffusion of Fe atoms in α -Fe matrix.

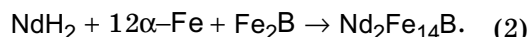
Описана кинетика индуцированного водородом обратного фазового превращения в сплаве $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$ в изотермических условиях. На основе теории Колмогорова-Любова рассчитана кинетическая диаграмма этого превращения. Показано, что кинетика обратного фазового превращения контролируется диффузией атомов Fe в матрице α -Fe.

Studies of phase transformation have always been one of the main standpoint areas of solid state physics, metal science, theoretical and practical materials science [1, 2]. The HDDR-process (hydrogenation-decomposition-desorption-recombination) developed recently is based on direct and reverse hydrogen-induced phase transformation in hard magnetic alloy of $\text{Nd}_2\text{Fe}_{14}\text{B}$ type [3]. This process allows to produce permanent magnets from these alloys with improved magnetic characteristics. In [4], the isothermal kinetic diagram of the hydrogen-induced reverse phase transformation in $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$ alloy was obtained experimentally. Today, however, there is no theory describing such phase transformation. The aim of this work is to describe the above-mentioned isothermal kinetic diagram theoretically using the Kolmogorov-Lyubov kinetic theory of phase transformation.

In hydrogen atmosphere, the hydrogen-induced direct phase transformation (decomposition) in $\text{Nd}_2\text{Fe}_{14}\text{B}$ alloy occurs according to the following scheme [3]:



The reverse phase transformation (recombination) in $\text{Nd}_2\text{Fe}_{14}\text{B}$ alloy occurs in vacuum according to the following scheme [3]:



Isothermal kinetic diagram for hydrogen-induced reverse phase transformation in $\text{Nd}_{15}\text{Fe}_{77}\text{B}_8$ (at. %) alloy was obtained in [4] by magnetometric measurements. This diagram is shown in Fig. 1. Basing on kinetic investigations [4, 5] and electron microscopy and X-ray diffraction studies [6] of the reverse phase transformation in $\text{Nd}_2\text{Fe}_{14}\text{B}$ type alloys, it was shown before that transformations of this type is a diffusive phase one in solid state and that the reverse transformation proceeds by the nucleation and growth mechanism.

As follows from Becker-Doering theory [7], plotting the dependence $\ln t_\xi$ on $1/T$, where t_ξ is the time required to attain a certain transformation degree ξ and T is the temperature, we can determine the effective energy of phase transformation process. To that end, the experimental data from Fig. 1 were re-plotted in $\ln t_\xi$ vs. $1/T$ co-ordinates (Fig. 2). Thus, the slopes of the straight