INTRODUCTION

Rare-earth intermetallic compounds with the Laves phase structure [1] possess remarkable magnetic properties. Magnetic materials developed on their basis are widely used as magnetostrictors [2]. Multi-component systems based on rare-earth Laves phases, especially those diluted with nonmagnetic atoms [3–6], have recently attracted the interest of investigators specializing in metal physics.

This work is aimed at the synthesis of the alloys that represent diluted Laves phases in the quasi-binary system Nd(Fe1 – xAlx)2 and the study of their structural and magnetic properties.

EXPERIMENTAL

The Nd(Fe1 – xAlx)2 alloy was synthesized at a high pressure of 8 GPa in a “toroid” type apparatus via quenching from a melt while passing an electric current through anvils that contained the sample. The apparatus and method of synthesis were described in detail in [7]. X-ray investigation was carried out on powdered samples using a DRON-3M diffractometer. The recording was performed in an automatic mode using filtered FeKα radiation.

Mössbauer spectra were measured with an MS 1104Em spectrometer with a low-temperature cryostat. Data processing was carried out with the use of Univem MS software.

As a result, it was established by X-ray structural analysis that, in the concentration region 0 ≤ x < 0.1, the alloys Nd(Fe1 – xAlx)2 are single-phase and isotopic with the cubic Laves phase of the C15 type. As the aluminum concentration increases, the diffraction lines, which correspond to a cubic lattice, in the X-ray diffraction patterns broaden, which indicates the onset of structural transformation in the alloys. In the region 0.2 < x < 0.5, there are lines that are definitely identified as hexagonal syngony of the Laves phase of the C14 type. Subsequent substitution of aluminum atoms for iron ones leads to the formation of the two-phase region (0.5 < x < 0.8) in the system, consisting of hexagonal (C14) and cubic (C15) phases. Finally, in the range of 0.8 < x ≤ 1, a cubic structure C15 is formed.

Figure 1 shows a diagram of the phase composition of the alloys and unit cell parameters as a function of the concentration.

The Mössbauer spectra for the concentration x = 0.1 are presented in Fig. 2.

RESULTS AND DISCUSSION

Mössbauer spectra were processed by the Univem MS program as a superposition of sextets that are responsible for the magnetically ordered state and doublets that characterize the paramagnetic state.

It is known that the initial compound NdFe2 is ferromagnetic with the direction of the easy magnetization axis along the crystallographic axis [111]. For the NdFe2 compound, the magnitudes of hyperfine magnetic fields at the Fe57 nuclei and the Curie temperature are well known from published data [8]. Iron atoms in this compound are found in two magnetically nonequivalent positions, with the ratio of these atoms

METHODS OF MATERIALS PROPERTIES ANALYSIS

X-ray and Mössbauer Study of the Diluted Laves Phases Nd(Fe1 – xAlx)2


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Abstract—The alloys Nd(Fe1 – xAlx)2 (at concentrations x = 0–1) are synthesized under high pressure. The phase composition and crystallographic structural characteristics of the alloys are determined as a function of the concentration x. Mössbauer spectroscopy is used to study hyperfine magnetic interactions in the temperature range from 90 to 400 K. The temperature and concentration dependences of the magnetic characteristics of the alloys are determined.

Keywords: X-ray structural analysis, lattice parameters, Mössbauer spectra, phase transition, hyperfine magnetic field, Laves phase.

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of 3:1. This, in turn, leads to the appearance in the Mössbauer spectrum of two partial spectra with the ratio of intensities of 3:1.

The spectrum of the sample Nd(Fe$_{0.9}$Al$_{0.1}$)$_2$, shown in Fig. 2, can be represented as a sum of several sextets corresponding to different atomic configurations. It is known that, in the cubic lattice of the Laves phase, C15 has six iron atoms in the nearest environment [9]. With the uniform distribution of impurity atoms in the lattice C15 according to the formula of the binomial distribution $P^m_6(x) = \binom{6}{m} x^m (1-x)^{6-m}$, the probability of finding $m$ aluminum atoms in the nearest environment of the iron atom for the composition $x = 0.1$ should be equal to 53% for $m = 0.35$% for $m = 1$, and 9.8% for $m = 2$. The same ratio should occur between...

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**Fig. 1.** Phase composition and the unit cell parameters of the Nd(Fe$_{1-x}$Al$_x$)$_2$ system in the concentration range $x = 0–1$.

**Fig. 2.** Mössbauer spectra of the alloy Nd(Fe$_{0.9}$Al$_{0.1}$)$_2$ at temperatures of 100–450 K.