Structure and magnetic characteristics of $Mn_{1-x}Fe_xNiGe$ (0,05 ≤ x ≤ 0,30) solid solutions

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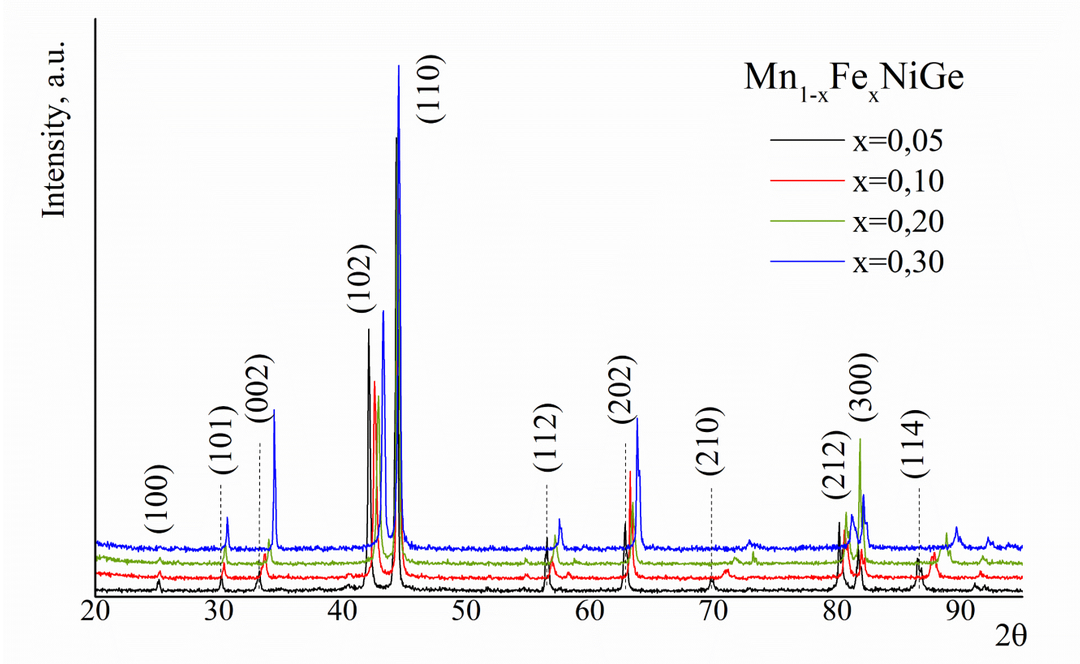
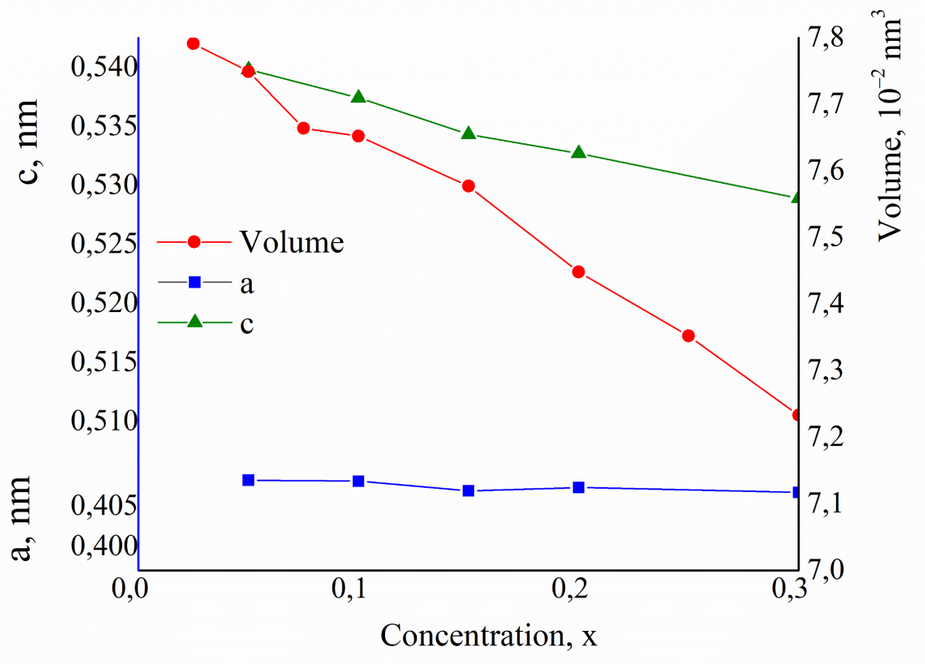
Description of investigation: Intermetallic alloys and solid solutions having magnetostructural phase transitions are of interest for theory and practice due to the presence of magnetoresistance, magnetocaloric effect, magnetostriction effects. MnNiGe-based alloys and solid solutions are convenient model objects for studying static and dynamic distortions of the crystal lattice, since magnetostructural transformations of both the first and second kind realized in them. The features of the relationship of magnetic properties and changes in the crystalline structure of solid solutions $Mn_{1-x}Fe_xNiGe$ ($0.05 \le x \le 0.30$) are studied. It has been established that MnNiGe is an antiferromagnet with a Neel temperature $T_N \approx 346$ K. Substitution of Mn atoms with iron ones causing a decrease in the parameters of the MnNiGe unit cell leads to the emergence of a ferrimagnetic state and in some cases to a manifestation of ferromagnetic ordering of magnetic moments.

Methods and Results: Polycrystalline samples of $Mn_{1-x}Fe_xNiGe$ ($0.05 \le x \le 0.30$) solid solutions were synthesized by solid-phase reaction method. The mixture with the required ratio of the powders of the initial elements in evacuated quartz ampoules was heated to a temperature of 1323 K. The resulting sintered samples were subjected to homogenizing annealing at 1223 K, followed by quenching. For the studies, the compositions $Mn_{1-x}Fe_xNiGe$ were synthesized with a concentration step of 5. The crystal structure and phase composition studies of the samples after each stage of the synthesis was carried out at room temperature by X-ray diffraction in Cu Kα - radiation. The temperature dependences of the specific magnetization σ = f(T) and the reciprocal of the magnetic susceptibility 1/χ = f(T) were studied in a magnetic field with an induction B = 0.86 T by the ponderomotive method in the temperature range of ~ 80 – 800 K.

X-ray diffraction patterns of obtained after all stages of the synthesis $Mn_{1-x}Fe_xNiGe$ solid solution powders

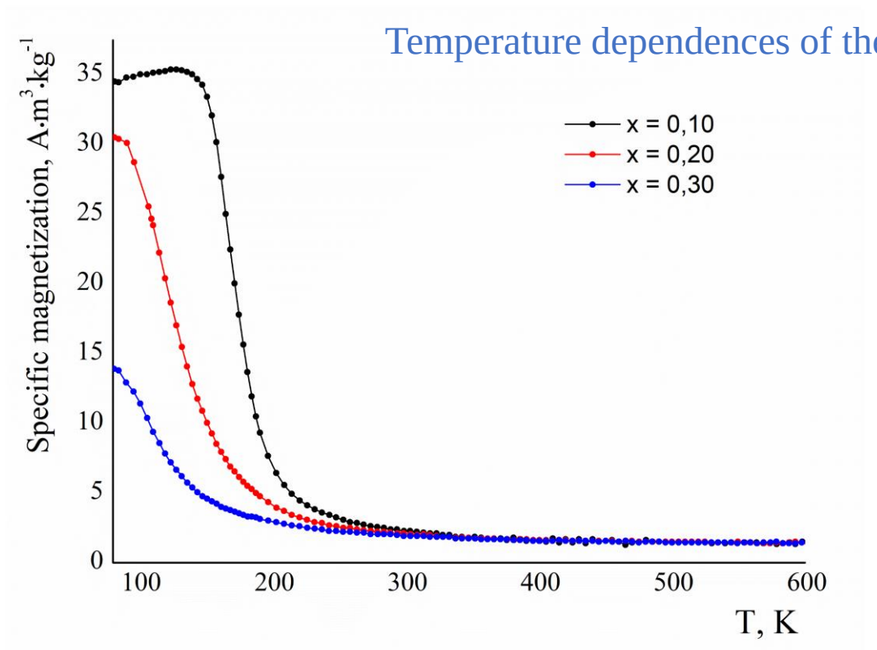


Concentration dependences of parameters a = f(x), c = f(x), V = f(x) change of the hexagonal unit crystal cell of $Mn_{1-x}Fe_xNiGe$ solid solutions



Ni_2In ($B8_2$) type structure of the $P6_3/mmc$ space group

Temperature dependences of the specific magnetization in a magnetic field of 0.86 T



x	σ_{80K}, A·m²·kg⁻¹	T_C, K	μ_{80K}, μ_B
0.05	13.69	272	0.46
0.10	34.53	183	1.15
0.15	36.07	153	1.20
0.20	30.55	148	1.02
0.25	20.38	143	0.68
0.30	13.90	137	0.46

Conclusions: Solid solutions of $Mn_{1-x}Fe_xNiGe$ system in the concentration range $0.05 \le x \le 0.30$ by the solid state reaction method were synthesized. X-ray diffraction studies have shown that the samples are single-phase at room temperature. It was found that an increase in the concentration of iron in solid solutions leads to a decrease in the size of the unit crystal cell. It is revealed that the temperature of the phase transformation "magnetic order - magnetic disorder" of the studied samples decreases with an increase in the concentration *x* of substitution of manganese by iron ions from 272 K for $Mn_{0.95}Fe_{0.05}NiGe$ to 137 K for the $Mn_{0.70}Fe_{0.30}NiGe$ solid solution.