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EFFECT OF LATTICE COMPRESSION ON MAGNETIC PROPERTIES OF THE MnNiGe-BASED MAGNETOCALORIC ALLOYS. I. EXPERIMENT

The results of magnetic and X-ray studies of the $Mn_{1-x}Cr_xNiGe$ alloys ($0 < x < 0.25$) are presented. These materials are positioned as new «green» magnetocaloric materials to be used in magnetic refrigerators. It is shown that the substitution of Mn atoms by Cr in the basic metamagnetic MnNiGe compound (together with other factors that compress the lattice) results in emergence and stabilization of the ferromagnetic state with the Curie point near the room temperature. The domain of existence of the ferromagnetic phase depends on the concentration of Cr and can be limited to a lower temperature. In this case, at cooling, the sequence of magnetic phase transitions from paramagnetic to ferromagnetic and further to metamagnetic state is realized. With solid-state quenching from annealing temperature $T_{ann} \approx 850$°C, the nature of magnetic phase transition from paramagnetic to ferromagnetic state can be changed from the isostructural 2^{nd} order phase transition to the magnetostructural abrupt 1^{st} order phase transitions, which are characterized by large entropy jumps, hysteresis, etc. This occurs when the value of giant magnetocaloric effect that accompanies magnetic field induced order–disorder phase transitions corresponds to the level of the best-known today magnetocaloric materials.

Keywords: ferromagnetics, magnetocaloric effect, magnetostructural transition

Fig. 1. Temperature dependences of magnetization of the $Mn_{1-x}Cr_xNiGe$ alloys in magnetic field with induction $B = 0.97$ T at slow cooling from the annealing temperature $T_{ann} =$ = 850°C (*а*) and water quenching from the same temperature (*б*): □ – $x = 0.04$, △ – 0.11, ○ – 0.18

Fig. 2. Temperature dependences of magnetization of the hardened $Mn_{0.89}Cr_{0.11}NiGe$ alloy in magnetic field with induction *B*, T: ○ – 0.1, △ – 14

Fig. 3. Parts of X-ray diffractograms of the hardened $Mn_{0.89}Cr_{0.11}NiGe$ (I) and $Mn_{0.82}Cr_{0.18}NiGe$ (II) alloys in PM (*а*) and FM (*б*) states at the temperature *T*, K: I: *а* – 280, *б* – 170; II: *а* – 380, *б* – 300

Fig. 4. Evolution of the content of hexagonal phase in $Mn_{0.89}Cr_{0.11}NiGe$ in the course of magnetostructural PM–FM transition

Fig. 5. Curves of isothermal magnetization of the hardened $Mn_{0.89}Cr_{0.11}NiGe$ alloy in the ground state and near the temperature of the first order FM–PM magnetostructural phase transition

Fig. 6. Temperature dependence of isothermal entropy jump in the hardened $Mn_{0.89}Cr_{0.11}NiGe$ alloy at varied limits of magnetic field changes in the course of magnetization of the sample