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Efekt magnetokaloryczny w nieuporządkowanych strukturalnie stopach i związkach międzymetalicznych pierwiastków ziem rzadkich z metalami przejściowymi

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Abstract

The magnetocaloric effect is a phenomenon due to which the magnetic material changes its temperature under the external magnetic field. The aim of doctoral thesis was to analyze the physical properties of amorphous $Gd_{65}Fe_{15-x}Co_{5+x}Al_{10}X_5$ (x = 0, 5, 10; X = Al, Si, B) alloys and $Y_{1-x}R_xCo_2$ ($0 \leq x \leq 1$; R = Gd, Tb) Laves phases with emphasis on the physical quantities determining the magnetocaloric effect, *e.g.* changes of magnetic entropy or refrigerant capacity. An important aspect was to characterize the influence of structural disorder on these properties. By introducing structural disorder it was possible to observe magnetic ordering not observed in magnetically homogeneous counterparts, or observed there in a narrow range of compositions, *e.g.* spin glass type behavior or parimagnetism.

All of the samples were prepared by melt spinning technique after prior synthesis of master alloys by induction melting in Ar atmosphere. In the case of $Gd_{65}Fe_{15-x}Co_{5+x}Al_{10}X_5$ alloys (x = 0, 5, 10; X = Al, Si, B) X-ray diffraction patterns exhibited the presence of amorphous phase, except for the $Gd_{65}Fe_{15}Co_5Al_{10}Si_5$ alloy in which the nanocrystalline phase is present despite significant cooling rates during quenching process. In spite of inconsiderable modifications of composition, the Curie temperature changes noticeably from 150 to 195 K for $Gd_{65}Fe_{10}Co_{10}Al_{10}B_5$ and $Gd_{65}Fe_{15}Co_5Al_{10}Si_5$, respectively. Second order phase transition from ferri- to paramagnetic state is observed in the whole group of alloys. The refrigerant capacity was determined using the numerical integration method and the highest value of 748 J/kg (for a magnetic field change of 5 T) was determined for $Gd_{65}Fe_{10}Co_{10}Al_{10}B_5$ alloy. An analysis of physical properties of $Y_{1-x}R_xCo_2$ ($0 \leq x \leq 1$, R = Gd, Tb) Laves phases is the objective of the second part of dissertation. By using the Rietveld refinement, a regular $MgCu_2$-type structure (space group *Fd-3m*) was found. In the case of alloys containing Gd, the lattice constant increases from 7.215 to 7.250 Å, and for alloys containing Tb, the lattice constant decreases from 7.215 to 7.205 Å, with increasing R concentration. Curie temperatures were determined on the basis of magnetic measurements and are ranged from 74 to 407 K and from 38 to 205 K for $Y_{1-x}Gd_xCo_2$ ($0 < x \leq 1$) and $Y_{1-x}Tb_xCo_2$ ($0 < x \leq 1$), respectively. The refrigerant capacity values increase with the increase of Gd and Tb concentrations from 29 to 148 J/kg and from 57 to 222 J/kg for the respective compositions. Isothermal annealing carried out for the $Gd_{0.8}Y_{0.2}Co_2$ alloy allowed to indicate structural relaxation as responsible for a reduction of the value of refrigerant capacity by about 13% comparing to the as-quenched alloy. This indicates a significant role of structural disorder in shaping the magnetic properties of the investigated alloys. Second order phase transformations were observed in the analyzed Laves phases. On the basis of ac magnetic susceptibility and specific heat results, parimagnetic ordering is suggested to occure above the Curie temperature in Tb containing Laves phases.

Physical properties of the investigated alloys are strongly affected by the introduced structural disorder, which alters magnetic (magnetocaloric) properties in comparison with homogeneous alloys.