ABSTRACT

Heusler alloys, having first order solid to solid martensite transition, transform from high temperature austenite phase to low temperature and low symmetry martensite phase with decrease of temperature. These alloys show a variety of multifunctional properties, e.g., magnetocaloric effect, magnetoresistance, shape memory effect etc. There are various kinds of interesting applications associated with these properties, like magnetic refrigeration, switching devices and actuators etc. Out of various kinds of interesting applications disordered Ni-Mn based Heusler alloys show large magnetocaloric effect and large magnetoresistance. The aim of this work is to optimize the composition of the samples to get large magnetocaloric effect near room temperature at relatively low magnetic field. For this we have chosen $Ni_{45}Mn_{44}Sn_{11}$ as parent sample and doped Al and In at Sn site. We have also prepared the ribbon form of the parent sample. Detailed investigations on the structural, magnetic, calorimetric, electronic- and magneto-transport properties of $Ni_{45}Mn_{44}Sn_{11-x}Y_x$, (where x = 0, x = 1 and 2 for Y = Al, x = 2, 4 for Y = In) ferromagnetic Heusler alloys have been carried out. The thesis also significantly contributes to the underlying physics behind (1) shift of martensite transition with the application of higher magnetic field (2) magnetic field induced change of austenite and martensite phase fraction in the vicinity of martensite transition temperature at isothermal condition and (3) arrest of austenite phase in the martensite phase in the magnetic field decreasing path. To illustrate these ideas, the arc melted samples are characterised by X-ray diffraction, FESEM and XPS to confirm the phase purity, surface morphology and chemical state, respectively. The compositions of the samples are confirmed by EDAX study. DSC measurements show large exothermic and endothermic peaks corresponding to martensite and reverse martensite transition, respectively, confirming the first order nature of the transition. The increase of austenite phase fraction with increase of temperature has been estimated from the DSC data for each sample. The isofield thermomagnetization curves show thermal hysteresis between FCC and FCW curve near martensite transition. A sharp drop in magnetization is observed in the vicinity of martensite transition. Magnetic field induced martensite to austenite phase conversion is observed from isothermal magnetization and resistivity data. As a result, there is sharp increase in magnetization and decrease in resistivity with increase of magnetic field. The estimation of transformed austenite phase fraction with the application of magnetic field at an isothermal condition is carried out for $Ni_{45}Mn_{44}Sn_9In_2$ sample. The arrest of austenite phase in the martensite phase is observed with decreasing field. As a result, the decreasing field magnetic field path has always higher magnetization and lower resistivity. The isofield martensite transition shifts towards lower temperature with increase of magnetic field, which confirms the stability of austenite phase with increase of magnetic field. The martensite transition increases with the increase of Al and In content in Sn site. The parent $Ni_{45}Mn_{44}Sn_{11}$ sample shows the martensite transition at 275 K. However, $Ni_{45}Mn_{44}Sn_{10}Al_1$, $Ni_{45}Mn_{44}Sn_9In_2$ and $Ni_{45}Mn_{44}Sn_7In_4$ samples show martensite transition at 293 K, 298 K and 315 K, respectively. The isothermal magnetic entropy change, refrigeration capacity and adiabatic temperature change have been calculated for each sample. Comparing these values we can conclude that $Ni_{45}Mn_{44}Sn_7In_4$ alloy can act as better magnetic refrigerant among all other studied samples.

Keywords: Heusler alloys, Martensite transition, Austenite phase, martensite phase, Magnetocaloric effect, Magentoresistance, Field induced transition, Ferromagnetism.