

Martensitic transformations in epitaxial Ni-Mn-Sn thin films

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Off-stoichiometric Ni-Mn-X (X = In, Sn, Sb) Heusler alloys with high Mn excess (9 – 12 at. %) show martensitic transformation in ferromagnetic phase [1]. The result of such magnetostructural coupling are effects of high application significance: giant magnetocaloric effect [2], large magnetoresistance [3] and magnetic shape memory [4]. In contrast to Ni-Mn-Ga [5] there was no observation of well defined martensitic transformation in epitaxial Ni-Mn-Sn thin films.

Ni₅₀Mn₃₅Sn₁₅ thin films were deposited from Ni₅₀Mn₃₇Sn₁₃ alloy target on MgO(100) substrate at 670 K by magnetron sputtering method in UHV conditions ($p_{\text{base}} = 10^{-8}$ mbar) with Ar pressure $p_{\text{Ar}} = 10^{-4}$ mbar. The thickness and the composition of the films were controlled by XRF method. To increase the degree of chemical order of the films, samples were annealed for 3600 s at 1000 K in UHV. Epitaxial growth was confirmed by XRD measurements. The temperature dependence of magnetization were carried out using PPMS in the 4 K – 350 K temperature range and in a 10 kOe field parallel to the film plane. Electron transport measurements were realized with 4-points method in the 4 K – 170 K range in 0 kOe and in 50 kOe field.

In order to verify the influence of the martensitic transformations on magnetic properties of Ni₅₀Mn₃₅Sn₁₅ film, the temperature dependence of magnetic moment was measured. The transformation temperatures are: $M_s = 118$ K, $M_f = 38$ K, $A_s = 64$ K and $A_f = 148$ K. The transition temperatures are lower and the temperature range are much wider than for similar bulk systems [4]. It can be connected to a composition gradient in the sample volume or stress induced from the substrate [6,7].

The electrical resistance of the film versus temperature exhibits pronounced jumplike behaviour, related to a structure change due to the martensitic transformation. There is a noticeable difference between temperature dependence of resistance data collected at 0 kOe and 50 kOe. The martensitic transformation temperature decreases by 15 K when 50 kOe external field is applied. The magnetoresistance amplitude $MR = 21\%$ at 80 K, which is 1.5 times smaller than for bulk samples [8].

We present a method of producing epitaxial Ni-Mn-Sn thin films with well defined martensitic transformation. The films show large magnetoresistance and martensite to austenite phase transformation induced by magnetic field.

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