Films of Heusler alloys

J. Dubowik[1], I. Gościańska[2], A. Szlaferek[1], and Y.V. Kudryavtsev[3]

[1]*Institute of Molecular Physics, Polish Academy of Sciences*
M. Smoluchowskiego 17, 60-179 Poznań, Poland
[2]*Department of Physics, A. Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland*
[3]*Institute of Metal Physics, National Academy of Sciences of Ukraine*
Vernadsky 36, Kiev 03142, Ukraine

Heusler alloys X_2YZ are a class of materials with various physical properties. Depending on composition, they may be metals, semiconductors or semimetals, and additionally, most of them are ferromagnetic. The Heusler structure consists of four interpenetrating fcc sublattices with atoms at $X_1(0,0,0)$, $X_2(1/2,1/2,1/2)$, Y(1/4,1/4,1/4), and Z(3/4,3/4,3/4) what results in $L2_1$ crystal structure of the so-called full Heusler alloys (HA) in which X_1 and X_2 sublattices are fully occupied. A large number of different elements can be chosen for X (Ni, Co, Fe, Pd…), Y (Mn, Ni, Fe, Co, Ti…), and Z (Ga, Al, In, Si…) sublattices offering reach possibilities for tuning their magnetic, electrical and mechanical properties.

Recently, HA have attracted attention since they show great potential for spintronic [1] or for electromechanical [2] applications. The first aspect concerns half-metallic properties of some HA that offer 100% spin polarization at the Fermi level. The second aspect is related to shape memory effect of some HA – a reversible martensitic transformation resulting in a substantial mechanical strain. Since most of HA are ferromagnetic, both the spin dependent transport and the shape memory effect can be controlled by an external magnetic field.

Some new applications require preparation of HA in the form of thin films. The formation of a HA film is a challenging task from the point of view of a proper ordering of different elements into the four sublattices. Local disorder and antisite disorder effects are the most probable reasons of failure in achieving 100% polarization in nanostructures containing HA layers. We will review some examples of tunnel magnetoresistance (TMR) structures that include Co_2YZ HA layers (Y=Mn, Cr, Fe, Z=Al, Si, Ga). The influence of the structural ordering on the magnetic, magneto-optical and transport properties of our Co_2MnGa and Ni_2MnGe films will be also given with a special emphasis on crystallization process of the films with amorphous structure and a further improvement of structural ordering.

Equally difficult task concerns preparation of HA films exhibiting ferromagnetic shape memory effect. Single crystals of off-stoichiometric Ni-Mn-Ga alloy exhibits huge strains of 6% under application of moderate magnetic field of 1 T. Recent achievements in the thin film technology of these alloys will be reviewed. We will focus on our off-stoichiometric sputtered films. Their shape memory properties critically depend on composition and post-deposition annealing conditions. By a proper choice of these conditions, the ordered Ni-Mn-Ga films exhibit a well defined shape memory effect near room temperature. Their magnetic and electrical properties of the Ni-Mn-Ga films will be discussed in connection with their specific microstructure.

[1] I. Galanakis *et al.*, Phys. Rev. B **66** (2002) 174479.
[2] J. Enkovaara *et al.*, Mater. Sci. Eng. A **52** (2004) 52.

Name of the presenting author (plenary): Janusz Dubowik
e-mail address: dubowik@ifmpan.poznan.pl
url's: http://www.ifmpan.poznan.pl