Title:
Structural and Magnetic Studies of the L10 FeNi Ordered Alloys with High Magnetic Anisotropy

Iron based thin films systems were studied: FeNi and FePt. Both systems are interesting in view of possible practical applications in perpendicular magnetic recording. FeNi thin films were grown by sputtering method in IMR on MgO(100) monocrystalline substrate and Fe/Pt multilayers were prepared by MBE on sapphire substrates in IPPAS in Warsaw. In both systems studied the aim is to obtain the ordered phase L10 with high perpendicular anisotropy.

The aim of the study within the scientific collaboration between IMR and IPPAS is to obtain metallic magnetic thin films with high perpendicular magnetic anisotropy for application in magnetic recording. Two iron based thin films systems were studied: FeNi and FePt. I was collaborating with prof. M. Mizuguchi on FeNi and with prof. T. Seki on Fe/Pt system in the prof. K. Takanashi Magnetic Materials Laboratory at IMR.

FeNi thin films were grown by sputtering method at IMR on MgO(100) monocrystalline substrate and Fe/Pt multilayers were prepared by MBE on sapphire (0001) substrates at IPPAS in Warsaw. Sputtered FeNi thin films were deposited directly on MgO substrate without any buffer layer to avoid any interdiffusion during post growth annealing at 300 C by RTA method and in order to have a simple, not costly as MBE and easy method of growing of L10 FeNi phase. The long-range chemical order parameter (S) was precisely estimated by grazing incidence X-ray diffraction (GI-XRD) using synchrotron radiation at SPring-8 in the Japan Synchrotron Radiation Research Institute. S parameter was estimated from the intensity ratio between a superlattice (110) peak and fundamental (220) peak seen on the diffraction pattern. However the highest value of S of about 0.3 was obtained what is significantly lower than for MBE grown films on a relevant buffer layers[1,2]. Another type of substrates such as spinel and SrTiO3 with smaller misfit values were tried but with no success – lower S values were found or no superlattice (110) peaks were observed. For now the reason for such behavior is not clear. In the next stage of the study based on theoretical predictions, the addition of 2-5 % of Ti and V replacing Ni in the multilayered structure was tried. Vanadium addition did not help at all the formation of L10 FePt alloy phase and Ti addition helped but only in a limited way. It seems there is a major drawback in obtaining pure ordered L10 phase of FeNi alloys. Also surfactants of O and Au were tried [3]- the largest Ku were 0.58 MJ/m3 for O-surfactant and 0.42 MJ/m3 for Au-surfactant. It has been concluded that the reason for the appearance of large Ku by using surfactants is attributed to the enhancement of the L10-ordering of FeNi. However it is still far from the value of 1.3 MJ/m3 reported for bulk FeNi single crystals. FMR measurements revealed peculiar in plane symmetry – two-fold, four-fold and even six- fold depending on the preparation method. However further detailed resonance field signal analysis including asymmetry of resonance lines and their widths revealed that peculiar six or eight fold

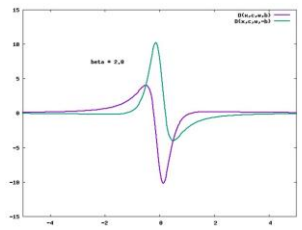

Fig.1 FMR resonance line shape for asymmetry parameter beta = 0 (green line) and 2 (violet line).

symmetry observed for MBE grown samples disappeared and was transformed into classic two-fold one typical for cubic structure. In Fig.1 one can see the exemplary shape of resonance line for asymmetry parameter beta equal 0 (symmetrical line) and 2 (asymmetrical line).

Taking into account the asymmetry of observed resonance lines we were able to explain peculiar shape of the angular in-plane dependence of the resonance field measured by ferromagnetic resonance (FMR). Below one can see how this angular dependence changes when the asymmetry is taken into account.

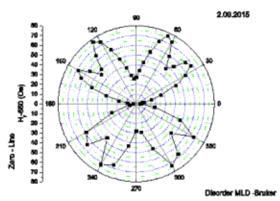

Fig. 2 Angular in-plane dependence of the FMR resonance field for asymmetry parameter beta= 0 – MBE grown sample, not annealed.

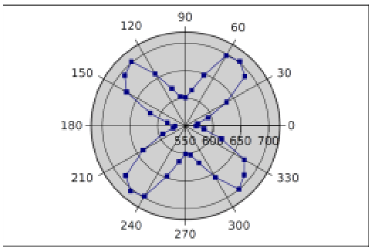

Fig.3 Angular in-plane dependence of the FMR resonance field for asymmetry parameter beta= 1 for the same MBE sample, not annealed.

Comparing Figs. 2 and 3 one can easily see that strange symmetry in Fig. 2 was changed into two-fold symmetry typical for cubic structure and expected for L10 structure of FeNi alloy.

Summarizing we have tried to grow FeNi alloys as thin films structure on different substrates and buffers, changing growth conditions and deposition methods but we have not succeeded to obtain high ordered samples in pure L10 structure. However the preparation of a publication of the obtained results is in progress.

Concerning the magnetic anisotropy modification by ion irradiation in Fe/Pt thin films the results were published in a common publication:

Structural and magnetic properties of MBE grown (Fe/Pt) (111) multilayers

A Marynowska, E Dynowska, S Lewińska, T Seki, K Takanashi, J Kanak, A Pietruczik, A Wawro, A Ślawska-Waniewska and L T Baczewski

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References

[1T. Kojima et al. Jpn J Applied Physics 51 (2012) 010204

[2] T. Kojima et al. J. Phys. Cond Matter.26 (2014)

[3] T. Kojima, M. Mizuguchi, T. Takanashi, Thin Solid Films, 603, (2016) 348

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