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Structural properties of Fe/Pt multilayers before and after ion beam irradiation

E. Dynowska[1]*, A. Marynowska[1], L. T. Baczewski[1], J. Fassbender[2], R. Böttger[2]

[1]Institute of Physics Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warsaw, Poland
[2] Helmholtz Zentrum Dresden-Rossendorf, Bautzner Landstrasse 400, 01328 Dresden, Germany

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*e-mail: dynow@ifpan.edu.pl

FePt alloys are extremely promising candidates for future high density recording media due to its high magnetic anisotropy up to 7×10^7 ergs/cm^2 [1]. The reason for such high magnetic anisotropy is attributed to the transformation of the disordered face-centered cubic (fcc) FePt alloy to the ordered face-centered tetragonal (fct) one. Typical method of obtaining fct FePt alloy is post annealing of Fe/Pt multilayers. However, the high temperatures (up to 700 °C), used in this method are not compatible with magnetic media manufacturing techniques. The better method for intermixing of the Fe/Pt system is ion beam irradiation which does not require such high temperatures [2]. The intermixing of the Fe/Pt system may result in the formation of several different phases: disordered fcc FePt, ordered fct FePt, iron-rich Fe_3Pt and platinum-rich $FePt_3$.

In this paper we report the results of structural characterization of several Fe/Pt multilayer samples Al_2O_3(0001)/Pt10nm/(Fe1nm/Pt1nm)×15/Pt10nm before and after Ne^+ ion beam irradiation. All samples of 5×3,3 mm size were grown simultaneously in molecular beam epitaxy system at room temperature in 10^{-10} Torr vacuum. All pieces were irradiated with Ne^+ ions of the energy 25 keV but each with different dose (2×10^{15} – 1×10^{16} ions/cm^2), respectively.

The crystal structure of all samples has been examined by X-ray diffraction methods. The PANalitycal Empyrean X-ray diffractometer with Cu $K\alpha_1$ radiation, equipped with the Johansson monochromator Ge(111) in the incident beam and a linear semiconductor strip detector has been used. The symmetrical and asymmetrical X-ray diffraction patterns were performed.

The examples of X-ray symmetrical patterns from the as grown and irradiated multilayer are shown in Figures 1 and 2. On the basis of the first diffraction pattern (Fig.1) it can be concluded that the Pt layers as well as the superlattice Fe/Pt grow in the [111] direction. The peaks marked by -1, -2 and +1 are the satellite lines from the superlattice – from their positions the thickness of the Fe/Pt bilayer (superlattice period *C*) can be calculated. The X-ray pattern of the as grown sample in the vicinity of 111 Pt reflection (not shown here) shows also the presence of thickness fringes originating from the individual layers, as well as from the whole structure thickness. This is the evidence of very sharp interfaces inside the multilayer.

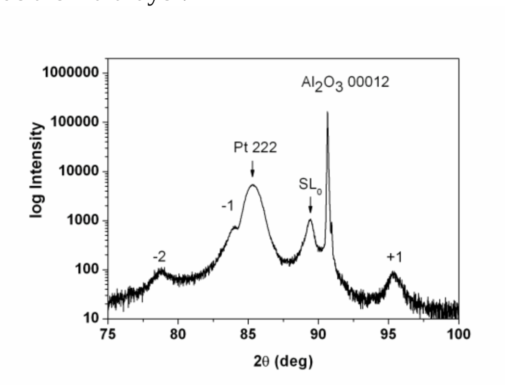

Figure 1. X-ray diffraction pattern in the vicinity of 222 Pt reflection performed for the as grown sample.

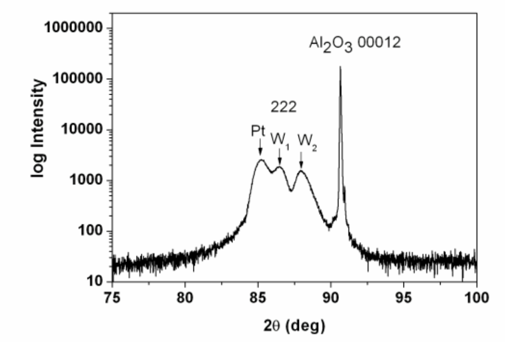

Figure 2. X-ray diffraction pattern in the vicinity of 222 Pt reflection – sample irradiated with 25 keV Ne^+ ions of 2×10^{15} ions/cm^2 dose.

As it is seen in Figure 2 even the smallest of the applied doses of irradiation completely changed the crystal structure of the multilayer – as a result two kinds of disordered fcc FePt alloys (W_1 and W_2) with different composition have been formed. The intermixing of the Fe/Pt superlattice caused the creation of the alloy with composition of about $Pt_{0.50}Fe_{0.50}$. The composition of this alloy practically does not change with increasing dose. The reason of the W_1 alloy formation is the diffusion of the Fe atoms to the platinum cover layer – the Fe content in this alloy increases with the increasing dose from $Fe_{0.14}Pt_{0.86}$ to $Fe_{0.26}Pt_{0.74}$. Peak marked as Pt is related to Pt buffer layer and it's position is the same as that for the as grown sample. The quality of the thickness fringes from this layer deteriorates with the increasing dose what evidences substantial damaging of respective interfaces.

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