ROBL-CRG	**Experiment title:** In-situ structural investigations of the $L1_0$ ordering in FePt layers during magnetron sputtering	**Experiment number:** 20-02-665
Beamline: BM 20	**Date of experiment:** from: 30.04.2008 to: 01.05.2008	**Date of report:** 28.01.2009
Shifts: 9	**Local contact(s):** Dr. Nicole Jeutter	*Received at ROBL:*

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REPORT

FePt is widely investigated because of its peculiar high magneto anisotropy density K_U = 3.7 – 6.2 ×10^{19} eV/cm^3 [1] that allows to strongly reduce the volume of a single switching magnetic domain still satisfying the thermal stored data stability condition K_UV/k_BT = 50 – 70 [1]. To ensure an acceptable noise reduction, FePt domains have to be magnetically decoupled, for example, by a diamagnetic matrix like Ag having a lower surface energy (~ 7.11×10^{14} eV / cm^2 [2]) than FePt (~ 1.31×10^{15} eV / cm^2 [3]) and therefore to not segregate into the FePt particles. RT deposited FePt layers exhibit a metastable soft - ferromagnetic A1 fcc phase. Subsequent annealing at temperatures above 500°C gives the tetragonal distortion to the strong ferromagnetic $L1_0$ phase [4].

In previous studies [5], we reported of low transition temperatures (T ~ 350°C) achieved using the ROBL dual magnetron deposition chamber [6]. In this study, we investigated FePt nanostructures evolution during deposition at 400°C as function of the Ag thickness (sample *A*: 7.3 nm thick $Fe_{54}Pt_{46}$ layer separated by 0.2 nm Ag and sample *B*: 7.5 nm thick $Fe_{57}Pt_{43}$ layer separated by 6.0 nm Ag) by in-situ grazing incident small-angle X-ray scattering (GISAXS) at an energy of E = 10 keV. To detect the formation of the $L1_0$ FePt phase, a scintillation detector (BEDE) was positioned to analyse the (110) FePt superstructure peak at 2θ = 26°.

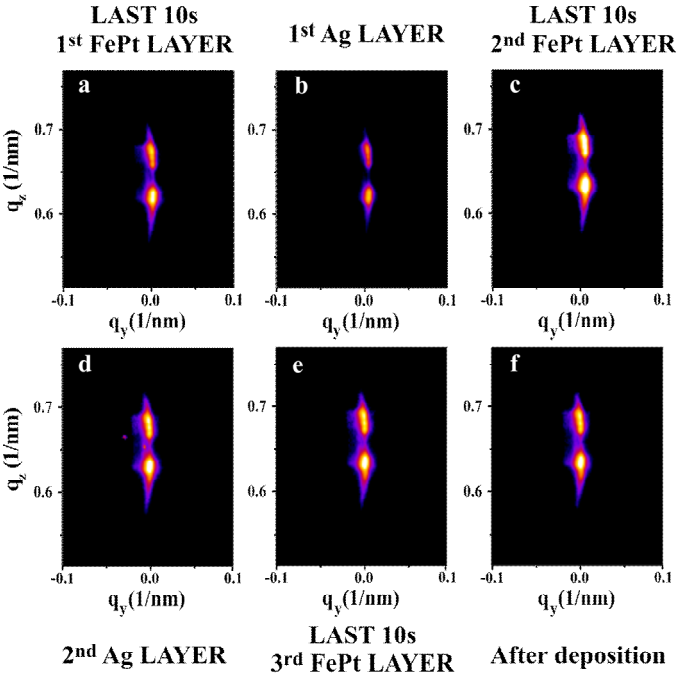

Figure 1: GISAXS evolution patterns collected for 10s during deposition at an incident angle α_i = 0.35° for sample *A* (intensity in logarithmic scale); figure (f) is collected just after deposition at 400°C.

Figure 1 shows the GISAXS patterns of sample *A* recorded during deposition at α_i = 0.35°, close to the Ag critical angle for total external reflection. During film growth,

there is no significant change in the GISAXS patterns: specular and transmitted signals broadening points out only a roughness increasing. Ag amount is too low to separate FePt islands.

The FePt phase evolution, detected by the point detector, is reported in figure 2 as function of the deposition time. The $L1_0$ phase formation began around 300 s. Therefore, we obtained the $L1_0$ phase at 400°C with a minimum FePt thickness of about 12 nm.

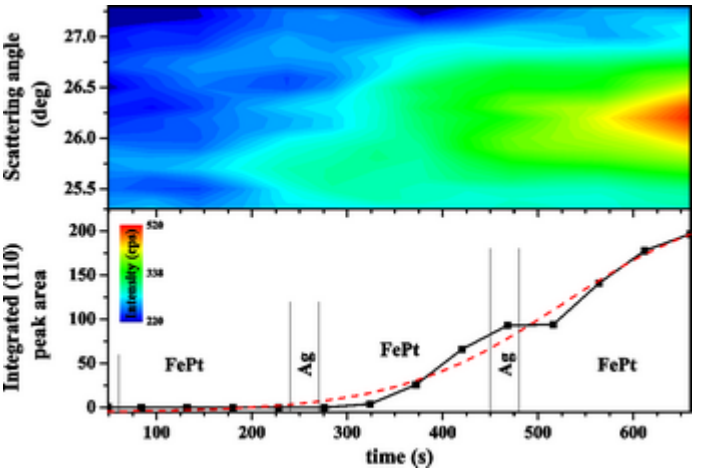

Figure 2: GIXRD (αi = 0.5°) results on the (110) FePt peak during deposition of sample *A*. Lower graph: peak integrated area vs. deposition time (experimental data: black line with dots corresponding to the middle of each scan; simulation: red dashed line. Upper graph: (110) peak evolution vs. time.

In figure 3, the GISAXS evolution is shown for sample *B*: during growth figure 3a to figure 3e and after cooling down at RT, figure 3f. 6 nm of Ag directly on the a-SiO_2 at 400°C forms islands [7]. The subsequent FePt layer is, therefore, replicating the low frequency roughness created by Ag enhancing the GISAXS signal (figure 3c). Ag is forcing FePt agglomeration into clusters. From the GISAXS patterns collected at the end of deposition (fig. 3e, 3f) FePt clusters have side facets tilted by almost 25° from sample surface normal and characteristic length size that shrinks at RT (fig. 3f) to 150 nm from 180 nm at the end of the first FePt deposition (fig. 3c).

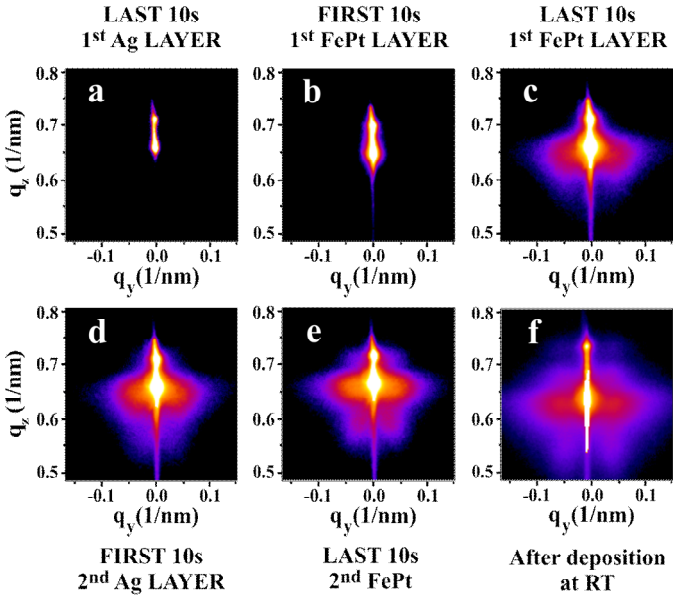

Figure 3: GISAXS evolution patterns collected for 10s during deposition at an incident angle α_i = 0.35° for sample *B* (intensity in logarithmic scale): (a) is the profile at the end of the first Ag layer deposition, (b) is the beginning of the FePt deposition concluded in (c), (d) is the last Ag deposition and (e) the last FePt layer at 400°C; (f) is taken at RT directly after deposition.

The simultaneous detection of cluster growth and evolution by GISAXS and phase transition in XRD geometry was successful applied to investigate, in-situ, the deposition of the FePt/Ag system on amorphous SiO_2 at a deposition temperature of 400°C. Using a certain amount Ag it is possible to trigger islands growth of the hard ferromagnetic $L1_0$-FePt phase.

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