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Names and affiliations of applicants (* indicates experimentalists):

Maciej Oskar Liedke[1*], Alexandra Mougin[2*], Jarosław Kanak[3*], Iosif Sveklo[4*]

[1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany

[2]Laboratoire de Physique des Solides, Univ. Paris-Sud, CNRS, UMR 8502, F-91405 Orsay Cedex, France

[3]Department of Electronics, AGH University of Science and Technology, 30-059 Kraków, Poland

[4]Faculty of Physics, University of Bialystok, Lipowa 41, 15-424 Bialystok, Poland

Report:

The main aim of this experiment was to study the structural and chemical arrangement, e.g. changes in the lateral stress and order, for a Co film in the Al_2O_3(0001)/Pt(t_{Pt})/Co(3.3nm)/Pt(5nm) trilayers under 30 keV Ga^+ by means of the Co K-edge X-ray Absorption Fine Structure (EXAFS) and Anomalous X-Ray Scattering measurements (AXRS). Two series of samples with different Pt buffer thickness, i.e. t_{Pt}=5 nm (S1139) and t_{Pt}=20nm (S1151), irradiated each with fluences D=0, $2.80\text{x}10^{14}$, and $5.70\text{x}10^{15}$ $Ga^+\cdot cm^{-2}$ were studied. As a reference MgO/CoPt sample in the L10 phase was investigated.

In the case of EXAFS studies the Co-Co and Co-Pt bonds were calculated with the IFEFFIT software. First, the reference MgO/CoPt sample in the L10 phase were measured and accordingly analyzed. The CoPt L10 ordered alloy has the P4mmm (group 123) crystallographic structure with parameters a=b=3.803Å and c=3.701Å (for bulk). A small difference of 0.11 and 0.01 between the bulk and our measured film for the Co-Co and Co-Pt bonds, respectively was found. In addition, we have found a difference of the Co-Co bond length for the non-irradiated samples (2.49Å for both the MBE grown 1139 and 1151 samples) and the literature value of 2.57Å for the Pt/Co7Å/Pt/Co7Å/Pt sputtered system, studied by Devolder et al. [1]. The Co-Co bond length changes only with the irradiation fluence D. The Co-Co bond length increases concomitantly with D. The Co-Co bond length scales as a function of the irradiation

fluence as follows: (i) 2.49Å for the non-irradiated sample, (ii) 2.52Å for D=2.80·10^{14} Ga^{+}·cm^{-2}, and finally (iii) 2.62Å for D=5.70·10^{15} Ga^{+}·cm^{-2}. The similar tendency, namely the increase from 2.57Å to 2.60Å, was observed for He^{+} irradiation by Devolder et al. [1].

The main idea behind AXRS is to compare the intensity ratios for x-ray energies below (or above) and close to the K edge of Co at various Bragg reflections [2]. In Fig. 1(a) an example of two such measurements is shown for the non-irradiated S1139 sample. The energy E_1=7718eV corresponds to the K edge of Co, whereas E_2=7778eV is the energy above the K edge. Once both spectra are subtracted from each other we obtain the Co profile only [Fig. 1(b)]. Since the Co profile is not noise free the 35Hz low pass filtering was applied. From the peak position the lattice parameter c=4.03584Å was obtained.

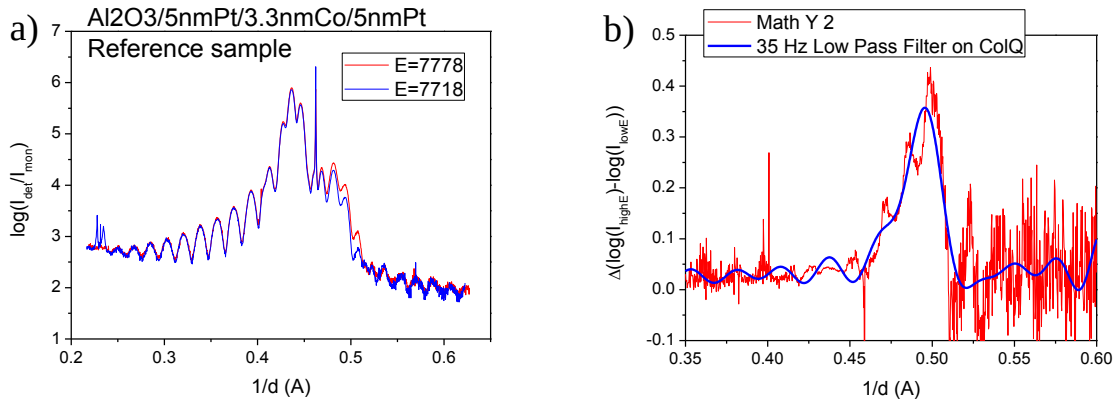

Fig. 1 AXRS spectra measured at two distinct energies above and close to the K edge of Co for the non-irradiated S1139 sample (a). The Co profile after subtraction of the spectra from each other (b).

In the case of the irradiated S1139 sample with a fluence D=2.80·10^{14} Ga^{+}·cm^{-2} the c parameter increases to 4.1245Å, due to Co+Ga+Pt intermixing and/or structural defects. For the irradiated S1139 sample with a fluence D=5.7·10^{15} Ga^{+}·cm^{-2} the difference between scans was too small in order to obtain a clear Co profile, however no evidence of the CoPt ordered alloy was found. For the sample with the thicker Pt buffer layer a similar results compare to the thin case were found. The c parameter was 4.0128Å and 4.1347Å for the non-irradiated and irradiated sample with a fluence of 2.80·10^{14} Ga^{+}·cm^{-2}, respectively. The lattice of the Co layer expanded due to Pt, Ga, and Co intermixture. Again for the sample with the highest fluence no evidence of the Co peak was found that suggests a complete dissolve of Co into the Pt layer.

In summary we found a partial relaxation of the Co layer, and a strong distortion of the Co/Pt mixed layers due to irradiation. Moreover, the D-W factor increases by nearly a factor of 2, and a suppresion of the diffraction fringes suggests the rough or absence of clear interfaces due to irradiation. In general, both EXAFS and AXRS investigations are consistent, e.g. due to irradiation the increase of Co lattice parameter, followed by the decrease of Pt lattice parameter was found.

[1] T. Devolder et al., *Eur. Phys. J. B* **22**, 193 (2001)

[2] T.U. Schülli et al., *Phys. Rev. Lett.* **90**, 066105 (2003)