ESRF	**Experiment title:** LOCAL MAGNETIC AND STRUCTURAL PROPERTIES OF Co IN IRRADIATED Pt/Co/Pt TRILAYERS	**Experiment number:** HE836
Beamline: BM29	**Date of experiment:** from: 29/2/2000 to: 4/3/2000	**Date of report:** 10/3/2000
Shifts: 12	**Local contact(s):** Michael BOROWSKI	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Stefania Pizzini* , Jan Vogel* - Laboratoire Louis Néel - CNRS - Grenoble

Thibaut Devolder*, Claude Chappert - IEF - Université Paris Sud - Orsay

Harry Bernas - CSNSM - Université Paris Sud - Orsay

In Pt/Co multilayers with small Co thickness, the strong contribution of Co/Pt interfaces to the magneto-crystalline anisotropy causes the easy magnetization to be perpendicular to the layers. When the proportion of interface atom decreases, or when the interface is less abrupt, the magnetization easy axis switches to in-plane orientation. We have shown that irradiation of Pt/Co/Pt sandwiches with light ions (He^+) leads to structural modifications of the interfaces which considerably affect their magnetic properties [1]. Magneto-Optical measurements reveal that irradiation induces a decrease of anisotropy and coercive field H_c, then a change of the easy axis of magnetization for heavy doses. A lowering of the Curie temperature (T_c) is also observed. The anisotropy decrease can be explained by irradiation-induced intermixing of the interfaces. The T_c decrease may be simply accounted for by the bulk properties of binary Co-Pt alloys, whose T_c decreases regularly when incorporating Pt. A really quantitative understanding of this phenomenon is still lacking.

In order to quantitatively understand the evolution of the magnetic properties, we want to study how irradiation affects the local structure at the Co/Pt interface. EXAFS measurements carried out in **June 1999** gave us some interesting qualitative information on two representative samples.

In a $[Co(5\ Å)/Pt(15\ Å)]_5$ multilayer epitaxially grown in $Al_2O_3(0001)$ single crystal, cobalt atoms are located at, or very near a Co/Pt interface. The multilayer has a perpendicular easy axis of magnetization with coercivity 0.6 kOe in the as-grown state. The coercivity first decreases upon irradiation. Then, a fluence of $3x10^{16}$ ions/cm² triggers a reorientation of the easy axis of magnetization towards the plane of the sample.
The EXAFS data show that cobalt is already partially mixed with Pt before irradiation. The nearest neighbor distance around cobalt is not far from that of $CoPt_3$ alloy. The as-grown sample exhibits a strong anisotropy of the local structure: a larger number of Pt-Co pairs is found out-of-plane with respect to in the plane of the layers. This strong structural anisotropy is consistent with the presence of a strong magnetic anisotropy. In the irradiated sample both the structural and magnetic anisotropies strongly decreases. The effect of irradiation is thus to 'homogenize' the distribution of Co and Pt , and the local environment of Co atoms tends to be isotropic.

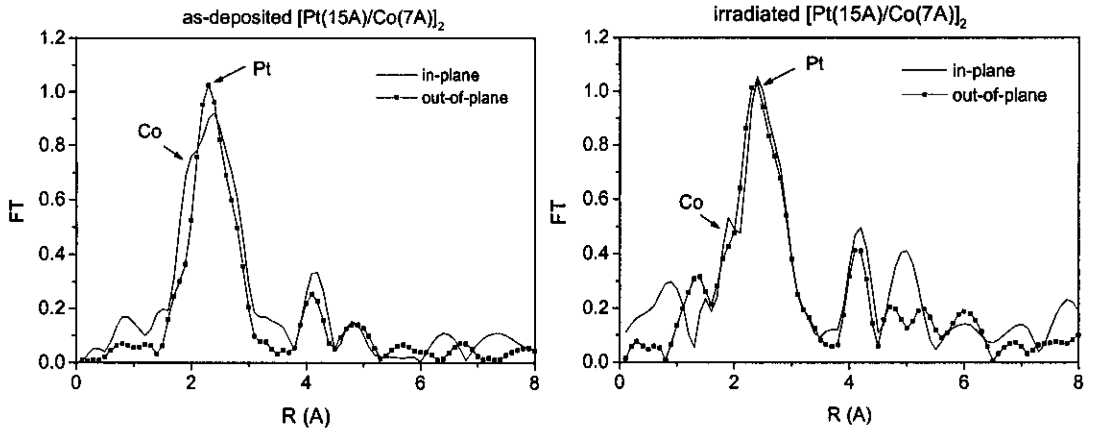
In the second sample, a Pt(22Å)/Co(14 Å)/Pt(65Å)/ Al_2O_3 simple sandwich, the majority of cobalt atoms are located in a pure cobalt environment. The sample exhibits a perpendicular magnetization in the as-grown state. Its magnetization easy axis progressively tilts towards the plane, but keeps a 30% perpendicular remanent ratio even at very high irradiation fluences. EXAFS of the sandwich sample reveals an additional effect for the Co atoms initially located in a Co-rich environment. In this case, the first stages of irradiation induce a decrease of the in-plane cobalt lattice parameter. The magneto-elastic contribution to anisotropy should thus diminishes abruptly.

Irradiation seems to help the cobalt atoms to relax in a perfect hexagonal compact lattice. Grazing X-Ray Reflectometry experiments confirm a low incorporation of Pt in the Co layer. Such processes – quick strain release followed by low Pt incorporation rate - could explain the first quick decrease of anisotropy and then the much lower anisotropy decrease rate in the sandwich.

In the experimental report for measurements just described, we concluded that "these first results would highly benefit from a more complete EXAFS study. An improved statistic would be necessary to investigate the intermediate range order around the cobalt atoms, which also plays a significant role in the magnetization reversal process. Measurements on already available sandwiches irradiated with other fluences, will allow to quantify the different rates of Co-Pt solid solution formation and quicker cobalt strain release".

This was the objective of the experimental run of **February/March 2000.** Measurements were carried out on BM29 with a single-element solid state fluorescence detector. The 13-element solid state fluorescence detector which we had required for this experiment was not available, due to the absence of the interface to SPEC. The S/N ratio of the data has obviously much suffered from this replacement. Note also that the first 5 runs were spent to deal with various problems with the beamline and the misfunctioning of the solid state detector.

A Pt(22 Å)/Co(7 Å)/Pt(15 Å)/Co(7 Å) bilayer was measured in the remaining time. The as-deposited sample has perpendicular easy magnetization axis and Hc=400Oe. The sample irradiated with 2 x $10^{16}He^+/cm^2$ has in-plane anisotropy. We have chosen to study this new bilayer sample, rather than perfectioning the data carried out in June on the Co(5 Å)/Pt multilayer, since the EXAFS data on the latter sample had shown an important interdiffusion of Pt and Co even before irradiation. We believe that this is due to the increasing interface roughness when the number of bilayers increases. The polarization-dependent spectra taken for this sample still suffer from a poor statistics (a very important noise above 9 $Å^{-1}$ even after 6-7 hours acquisition) . Nevertheless a preliminary analysis (the data were carried out last week) allows to show some interesting changes in the local structure (see Figure).



An important anisotropy in the local structure around cobalt is observed for the non-irradiated sample. A larger number of first neigbour Pt atoms is observed in the out-of-plane direction, consistent with the presence of perpendicular magnetic anisotropy. This anisotropy practically disappears from the main FT peak in the irradiated sample and explains the change of easy magnetisation direction from out-of-plane to in plane direction.