ESRF	**Experiment title:** **The structure of exchange coupled Co/Fe2O3 thin films.**	**Experiment number**: SI-1317
Beamline: ID 01	**Date of experiment**: from: 26 April 2006 to: 02 May 2006	**Date of report**: 08/08/2006
Shifts: 15	**Local contact(s)**: C.Mocuta	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

(*) **Dr. MOCUTA Cristian** / ESRF

(*) **Dr. BARBIER Antoine** / CEA/Saclay, DRECAM/SPCSI, 91191 Gif-Sur-Yvette

(*) BEZENCENET Odile / CEA/Saclay, DRECAM/SPCSI, 91191 Gif-Sur-Yvette

Experimental Report:

Much work is devoted nowadays to provide a detailed knowledge of the structural, chemical, spin and magnetic behaviour of magnetic exchange coupled ferromagnetic (FM) / antiferromagnetic (AF) interfaces in order to better understand and to optimize the exchange bias, both on the FM and on the AF side. AFM oxides like hematite (α-Fe_2O_3) belong to the most promising candidates to play the role of the AFM pinning layer in spin-valves and tunnel-junction devices. It has a high Néel temperature (T_N=955 K) and good corrosion resistance. Its growth conditions using atomic oxygen assisted molecular beam epitaxy growth are now well established. Cobalt has a high Curie temperature (T_C=1388 K) and the resulting Co/α-Fe_2O_3 interface is expected to have high magnetic stability. In the present experiment we have investigated the crystalline structure of Co layers during their in-situ growth in order to complete previous magnetic and X-ray absorption spectroscopy data (recorded at SLS-SIM, BESSY-UE46 and ESRF-ID08).

An epitaxial 20 nm thick α-Fe_2O_3/Pt(111) layer was prepared in a dedicated setup at the CEA-Saclay laboratory and was mounted in a portable UHV chamber on the ID01 diffractometer, using horizontal surface scattering geometry. The surface was successfully cleaned by annealing under a partial pressure of oxygen prior Co deposition. The α-Fe_2O_3 layer was found of good crystalline quality (surface mosaic spread about 0.5°) and the interface between α-Fe_2O_3 and Pt(111) revealed a very well ordrered dislocation network (figure 1). These features were quantitatively addressed through extensive in-plane rocking scan measurements at the location of the dislocation satellites and through the quantitative measurement (rocking scans) of the [10L] and [11L] crystal truncation rods of α-Fe_2O_3.

We have investigated the stucture of Co layers of 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4, 12.8 and 25.6 nm thickness using an incident photon energy of 18 keV. Reflectivity scans were used to cross check the deposited thicknesses.

For all layers, in-surface-plane scans (at critical and sub-critical incidence conditions) along the high symmetry directions ([h00] and [hh0]) were recorded, as well as rocking scans on the location of each peak originating from hcp-Co and α-Fe_2O_3 (figure 2a). Out-of-the-surface-plane scans were performed along the Co diffraction rods and along the α-Fe_2O_3 crystal truncation rods (qualitatively and quantitatively). Grazing incidence small angle x-ray scattering (GISAXS) scans were also performed (figure 2b) and confirmed the 3D growth of Co clusters (below 3 nm) as well as anisotropic features present in the α-Fe_2O_3 film. Structural relaxation occurs for very large Co thicknesses (i.e. above 6.4 nm). The dislocation network propagates through the Co film after coalescence.

The epitaxial relationship could be determined as [0001]Co//[0001] α-Fe_2O_3 and an in-surface plane mixture of [100]Co//[100] α-Fe_2O_3 and [110]Co//[100] α-Fe_2O_3 (i.e. the in-plane lattices of Co and α-Fe_2O_3 are rotated by 30°). The growth of hcp-Co was found epitaxial but of rather poor crystalline quality (about 10° mosaic spead) but could be fully characterized thanks to the high photon flux available at ID01.

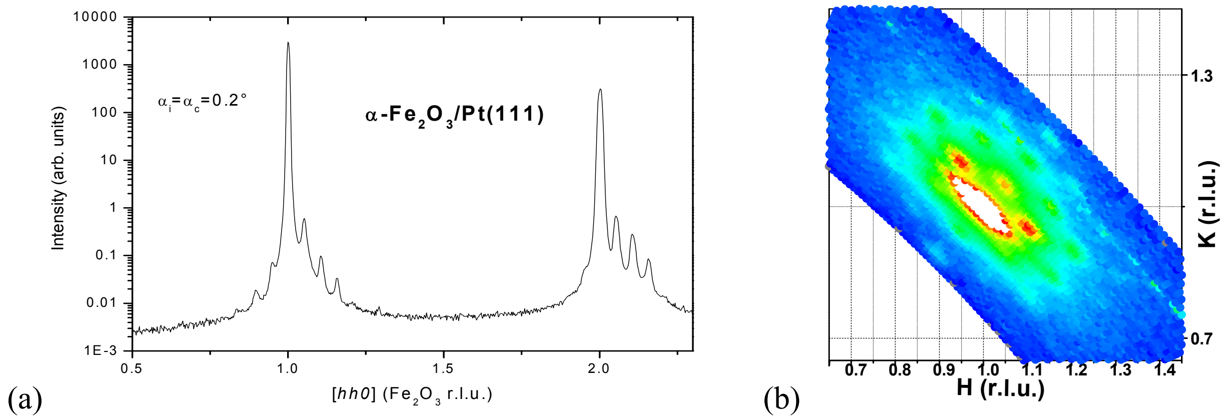

Figure 1 : *Evidence of a dislocation network at the α-Fe_2O_3/Pt(111) interface. (a) In-plane scan along [hh0] direction showing the (110) and (220) Bragg peaks surounded by well defined satellites. (b) In-plane map around the (110) Bragg peak (bright central feature).*

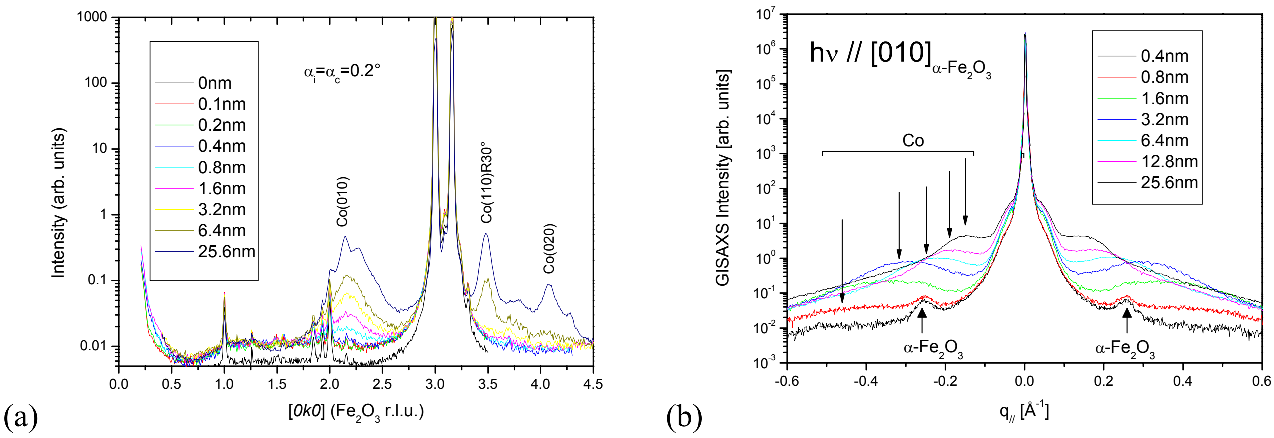

Figure 2*: Growth of Co on α-Fe_2O_3. (a) In plane scans along the [0k0]direction evidencing the rotated and non rotated Co networks. (b) Grazing incidence small angle in-plane measurements showing the nucleation, growth and coalescence process that occurs upon growth.*

In summary the proposed experiment has been fully carried out and the expected structural data could be recorded in good experimental conditions. The quantitative interpretation of the data is in progress.