

EXPERIMENTAL REPORT

RAPPORT D'EXPERIENCE

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N° Projet Comité de Programme

32 03 601

PROJECT TITLE : *TITRE DU PROJET* :

Co/Pt(111) interface oxidation

LIGNE : BM32 (CRG-IF) – SUV

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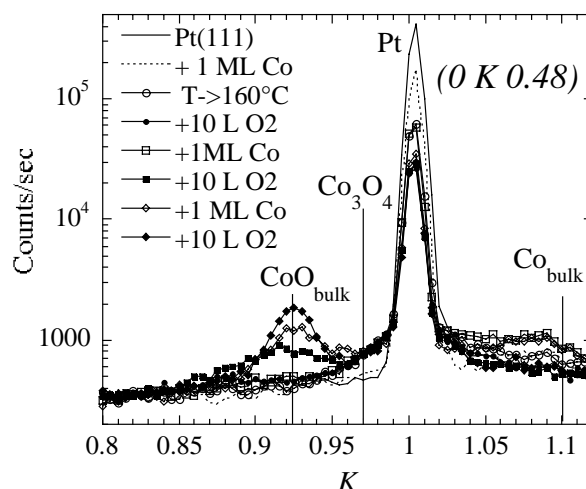
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A quantitative explanation of the exchange coupling between ferromagnetic (F) and antiferromagnetic (AF) layers require an adequate characterization of the structure and of the exchange interactions at the interface on an atomic level.¹ Recently a F-AF system with perpendicular magnetic anisotropy (PMA), namely a [Co(4 Å)/Pt(5 Å)]₅ multilayer covered by a partially oxidized polycrystalline Co film, was studied.² It showed a strong exchange anisotropy below 220 K. The aim of our project was to elaborate a closely related system with a better defined structure, growing the CoO layer directly in contact with the Pt and improving its structure to increase the strength of the coupling, the PMA and the blocking temperature.

The first step was the growth of a CoO layer directly on top of Pt(111). For this purpose, an iterative procedure was repeated n times: 1 ML Co was evaporated in UHV conditions, and then was oxidized by exposure to about 10 Langmuir of O₂. The first ML was deposited at room temperature (RT), and then the temperature was increased and kept at 160°C for the following steps. No significant Pt segregation was observed during the annealing. It is known that, after deposition of 1 ML at RT, Co takes preferably the Pt fcc lattice sites, with a small amount of atoms in disordered or hcp sites.³ The epitaxial relationship was

observed by surface x-ray diffraction (XRD). As usual, a unit cell was chosen with *a* and *b* defining a hexagonal surface mesh and *c* perpendicular to the surface. Fig.1 shows a scan in reciprocal space parallel to the surface, along the *K* direction, at different stages of growth. The first Co ML is mainly in register with the substrate (the Pt rod intensity decrease

Growth 3 ML CoO/Pt(111)



strongly). After 2 cycles of Co deposition followed by oxidation, a rod characteristic of a relaxed CoO(111) film appears, which is better defined for 3 CoO layers. The intensity distribution is flat in the regions of Co(0001) and of Co₃O₄(111) rods. The CoO(111) surface is polar and hence intrinsically unstable. For this reason, it was found that bulk CoO(111) is covered by a Co₃O₄(111) layer at the surface.⁴ XRD shows that this do not happens in our case. In NiO(111) the surface is stabilized by a p(2x2) reconstruction. Such a

¹ A.E. Berkowitz, K. Takano, J. Mag. Mat. 200, 552 (1999)

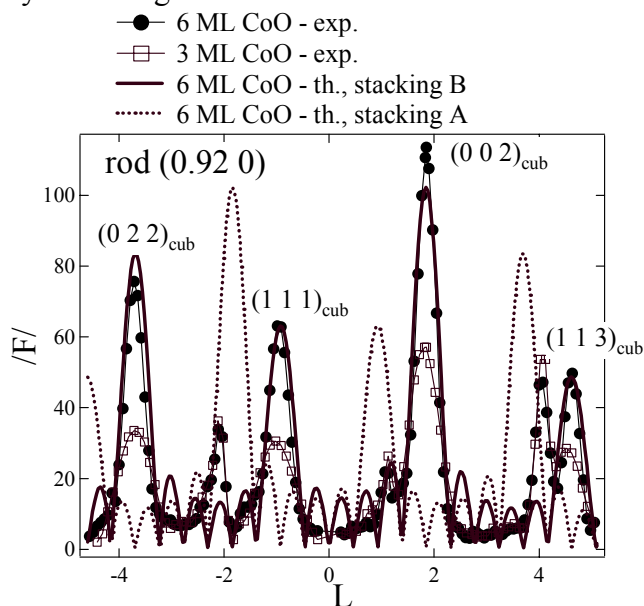
² S. Maat, K. Takano, S. S. P. Parkin, Eric E. Fullerton, Phys. Rev. Lett. 87, 087202 (2001).

³ E. Lundgren, B. Stanka, M. Schmid, P. Varga, Phys. Rev. B 62, 2843(2000).

⁴ C. Mocuta, A. Barbier, G. Renaud, Appl. Surf. Sci. 162-163, 56 (2000).

kind of surface reconstruction is not observed in the present case, however this could be due to the size of domains.

The stacking of the CoO layers was studied by measuring its rods. In an ideal CoO(111) film the Co sublattice can either follow the Pt fcc stacking (domain A) or be twinned (domain B). In fig.2 the (0.92 0) rod measured for sample thickness of 3 CoO layers and of 6 CoO layers is shown, and compared to the simulation for the two kind of stacking of a perfect 6 CoO layer. The fig.2



shows clearly that only the B type of stacking is present. The data reproduce quite well both the peak positions and the structure factor ratio expected for the NaCl structure type (the intensity measured at $L=-2, 1$ and 4 comes from the close Pt Bragg reflections). The absence of Kiessig fringes shows that the surface or/and the interface is quite rough, however this cannot be discussed in detail without taking into account the misfit structure. The growth of a single domain is closely linked to the interface structure.

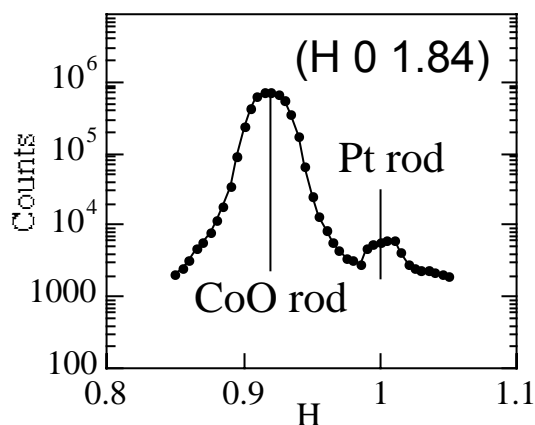
As next step, we tried to elaborate the CoO oxide directly by deposition of 6 ML Co/Pt(111) at room temperature, followed by O_2 exposure. Both the oxidation at room temperature and at 160°C result in the growth of the two kind of domains. This is due to the presence of stacking fault in the as deposited Co film, which are not recovered during the oxygen intercalation.

Finally, a F-AF interface was studied. We have already shown that a two-layer thick surface alloy is grown by deposition of ~ 1 ML Co onto a Pt(111) crystal held at 300°C . The top layer is very rich in Pt, and the second one very rich in

Co.⁵ This bilayer is ferromagnetic at room temperature, with a strong PMA.⁶

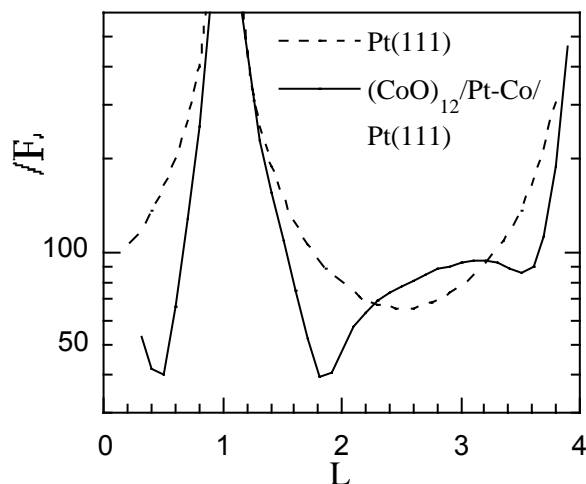
In the present experience, this surface alloy on Pt(111) was elaborated at first, and then a 12 layer thick CoO oxide was grown on top as described above. XRD allows studying both the ferromagnetic bilayer, which is in coherent epitaxy, and the relaxed CoO film. Two sets of rods need to be analyzed (see fig. 3).

12 ML CoO/Pt-Co/Pt(111)



The shape of the measured Pt rod is characteristic of an interface with a Co rich layer underneath a Pt rich one (see fig. 4 and ref. 5).

(1 0) rod



The analysis of the CoO rod shows that the presence of the alloy bilayer at the interface do not modify the stacking within the oxide layer. A more quantitative analysis is still in progress. The magnetic measurements on this sample will be performed *ex-situ* as soon as possible.

⁵ M. De Santis, R. Baudoing-Savois, P. Dolle, M. C. Saint-Lager, Phys. Rev. **B 66**, 085412 (2002).

⁶ L. Giovanelli, M. De Santis, G. Panaccione, F. Sirotti, I. Vobornik, S. Eggert, G. Rossi, to be published.