ESRF	**Experiment title:** Surface Magnetic X-Ray Scattering From NiO(111) Single Crystal Surfaces and Co/NiO(111) Magnetically Exchange Coupled Interfaces.	**Experiment number:** HE-813
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Report (preliminary) :

The present experiment belongs to a larger research program started several years ago, aiming at the understanding of magnetically coupled ferromagnetic (F) metals / antiferromagnetic (AF) oxides interfaces. They are a major constituent of magnetic sensors based on the so-called spin-valve geometry which are studies in the SP2M (CEA/Grenoble) laboratory. Because of the high stability of NiO, sensors operating in harsh environments can be expected. The magnetic exchange coupling is used in the sensors but is still not well understood. From our previous experiments and recent literature it appears that the origin of the effect probably lies in the antiferromagnet (NiO) . It is thus mandatory to investigate the antiferromagnetic structure of NiO(111) near the surface and of the interface region of Co/NiO(111) interfaces. A method of choice is X-ray magnetic scattering. Since NiO(111) has no magnetic peak in the surface plane it was necessary to work in an asymmetric diffraction geometry keeping the incidence angle constant (and small) in order to obtain the necessary surface sensitivity. This corresponds to a standard surface diffraction geometry. However the diffraction plane is then no longer only vertical or only horizontal and the polarization analysis become complex. To overcome this difficulty we have introduced the rotation angle η of the detector in the geometry in order to discriminate between the charge and the magnetic signal. The geometry that was successfully used is reported in figure 1.

In order to have the best polarization analysis we have worked in-non resonant conditions at a wavelength of λ=1.58Å with a graphite analyzer. A rejection ratio of 99.98% has been measured. The NiO(111) single crystal was of the expected quality (mosaic spread of 0.028°) and exhibited the p(2x2) surface reconstruction that cancels the polarity of the surface [1, 2]. All the diffraction features of the sample had widths in the range 0.02-0.06°. Although only one undulator could be used on ID20 (i.e. a loss of a factor 3 in flux), measurable signal has been observed down to very grazing incidence (α=0.1°). At the critical angle for total external reflection a counting rate of about 100 counts per seconds has been measured on the magnetic peak for an estimated penetration depth of less than 100 Å. Measurements on the 1,1,1.5 (h and k expressed in a triangular surface mesh and L perpendicular to the surface) (figure 2) along the direction perpendicular to the surface showed that the signal becomes broader in L at small angles. The signal in off Bragg conditions arises from the NiO(111) surface since the same critical angle for total external reflection has been measured. This signal indicates that the magnetic surface exists and that the sample is magnetically ordered up to the very last surface planes.
The other accessible magnetic peaks were also investigated and measured quantitatively. A characterization of the magnetic S domain structure of the NiO(111) surface is expected (only one K domain exists) near the surface. However the original proposal, which included studying the magnetically coupled Co/NiO(111) interface could not be completed because of lack of time.
The present experiment proved that magnetic surface diffraction could be observed in grazing incidence on NiO(111), without being in resonant magnetic conditions. Importantly, the incidence angle allows us to tune the probed depth from volume-like to surface-like (down to 20-30Å) opening the possibility to study the magnetic surface structure of NiO(111) and interfaces which can be built on this single crystal.

References :

[1] A. Barbier, C. Mocuta, H. Kuhlenbeck, K. F. Peters, B. Richter, and G. Renaud, Phys. Rev. Lett. *In press*
[2] A.Barbier and G.Renaud, Surf. Sci. Lett. 392 (1997) L15

Figure 1 : Surface geometry that has been implemented on ID20 in order to keep the incidence angle of the vertical sample constant.	Figure 2 : L scans (perpendicular to the surface plane) in symmetric and asymmetric diffraction conditions. The incidence angle when fixed varied from 3° down to 0.1°.