ESRF	**Experiment title:** XRMS study of patterned (Co/Pt)n layers : nanodot arrays	**Experiment number**: HE-1090
Beamline: ID08	**Date of experiment**: from: 21 November 2001 to: 27 November 2001	**Date of report**: 26/02/02
Shifts: 15	**Local contact(s)**: Dr. Sarnjeet DHESI (e-mail: dhesi@esrf.fr)	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

K. CHESNEL*
M. BELAKHOVSKY*
S.P. COLLINS*
S. DHESI*
E. DUDZIK
S. LANDIS
B. RODMACQ
G. Van der LAAN*

Report:

We have used soft x-ray resonant magnetic scattering (S-XRMS) to study magnetic nanostructures at the Fe L_3 edge (708 eV) and Co L_3 edge (780 eV). We have followed the evolution of the magnetic configuration under an applied magnetic field. In addition, we have obtained, with coherent light, magnetic speckle patterns in the reflection geometry. The perspective is to access to the static / dynamic magnetic topology.
Two types of samples were measured:
- Thin wedge film (40 nm) of FePd alloy, obtained with a layer by layer epitaxial growth at ambient temperature. This sample exhibits well aligned magnetic stripes. The film was etched by lithography and ion bombardment, resulting in thin Co/Pt lines of 8 µm. Identical such micrometric structure were present at various locations along the wedge, in order to study thickness dependent magnetism. This unique sample is shown on Fig.1.
- Co/Pt multilayer deposited on patterned silicon substrates from LETI/PLATO. The magnetic $[Co(5Å)/Pt(18Å)]_{13}$ layer presents a perpendicular magnetization. Different patterns were studied: lines grating (100nm/100nm), and dots gratings (squared dots 100x100nm, and rectangular dots 100x400 nm, with a separation of 100 nm).
The instrument used is the θ/2θ Daresbury vacuum diffractometer, transported to ESRF for the purpose of this experiment. A CCD camera was mounted on a flange at 45°, in order to record the 2D speckle patterns.

Results

a) <u>Measurement with a point detector</u>
Using first a point Si photodiode, we have measured the reflectivity and magnetic rods for the Co/Pt multilayer, showing the superlattice Bragg peaks and the Kiessig fringes. Then going on the patterned part

(Co/Pt lines), we systematically measured the asymmetry ratio between the two x-ray helicities on the structural "grating" peaks by describing the whole hysteresis loop with a perpendicular magnetic field, as shown on Fig. 2. This will allow through modeling to retrieve the shape of the magnetic deposit, and to quantify the magnetic part of the scattering factor.

b) Coherent measurements using an in-vacuum CCD camera

Since the camera was placed at 440 mm from the sample, the far field condition are nearly fulfilled. A special mount was in addition designed at Daresbury to align a pinhole inside the vacuum diffractometer, at 50 mm in front of the sample. For the 20 µm pinhole used, this is well into the near field, the transverse spot size being 20.7 µm at the sample location.

1. *FePd film of micrometric size*

The first measurement was performed on FePd over a continuous area. The diffraction speckle pattern shows the specular spot and the two magnetic satellites due to the magnetic periodicity. The image is not shown here since it is submitted for publication,. These satellites present a dichroic effect for opposite light helicities, as expected [1]. The intensity fluctuations present a coherence degree of about 78 %.

We have then been able to illuminate an FePd etched line of 8 µm. This was demonstrated by the presence of intensity modulations (interference effect from the line edges), with a period exactly corresponding to 8 µm. A unique speckle structure with a very high contrast of the magnetic satellites (over 90% at least) was obtained. We believe this is a major step forward to have been able to use a *coherent* beam of enough intensity on such a *micrometric* structure, the measuring time being about 30 minutes (the corresponding figures are not attached here for publication reason). The reconstruction procedure is under work .

2. *CoPt nanolines and dots*

We have also used the coherent beam to study Co/Pt lines grating under an in situ magnetic field. In the saturated state, the CCD image shows only the specular and the structural superlattice peaks (Fig. 3a). When the X-ray energy is tuned to resonance, magnetic satellites progressively appear in between as the field is swept along the whole hysteresis loop towards the coercive points, where the magnetic antiferromagnetic signal become prominent (Fig. 3b); a "movie" have been recorded.

A preliminary measurement have been made on Co/Pt dot arrays. However, the magnetic signal is weak and we need to increase the magnetic ordering by an improved demagnetization process or narrowing the dot separation to get a larger dipolar interaction.

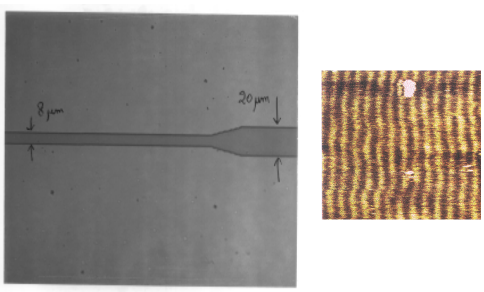

Fig. 1 The nano-object studied : a 8 µm FePd line on the MgO substrate. The MFM image shows the stripe orientation.

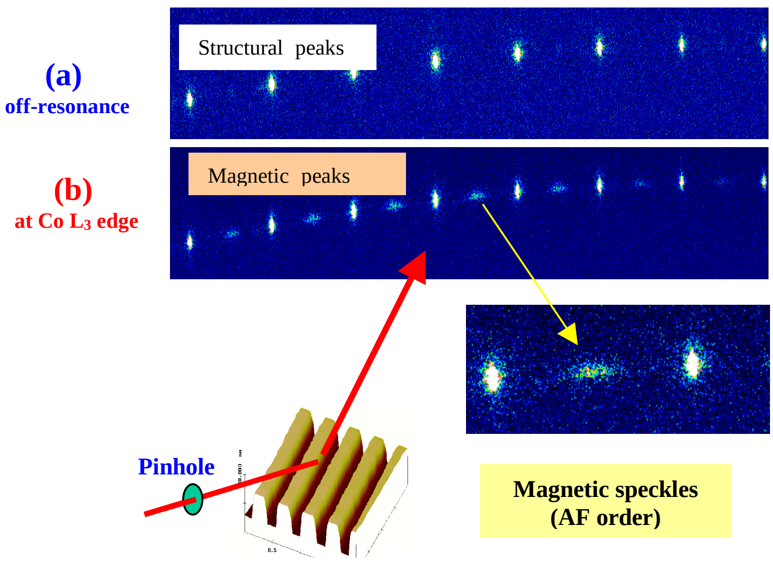

Fig. 3 Magnetic scattering on CoPt lines grating

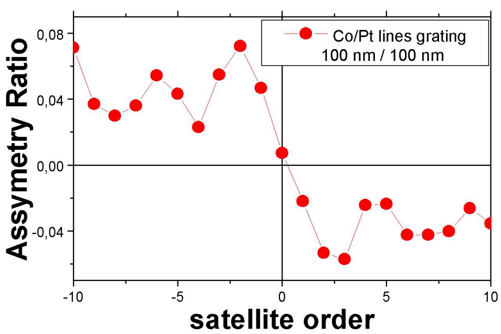

Fig.2 Asymmetry ratio of the magnetic contribution to the "grating" peaks

[1] H.A. Dürr et al, Science 284 (1999) 2166