ESRF	**Experiment title:** Magnetic X-Ray scattering from Dy/Er superlattices	**Experiment number:** HC 336
Beamline: ID 20	**Date of experiment:** from: 14/05/96 to: 21/05/96	**Date of report:** 09 / 96
Shifts:	**Local contact(s):** Christian Vettier	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimelitalists):

*K. Dumesnil - **Laboratoire de Physique des Matériaux, Université H. Poincaré-Nancy I, BP 239,** 54506 Vandoeuvre les Nancy dédex
*Ph. Mangin - Laboratoire de Physique des Matériaux
C. Dufour - Laboratoire de Physique des Matériaux
*C. Vettier - ESRF
*A. Stunault - ESRF

Report:

Epitaxial thin films of dysprosium and dysprosium/erbium superlattices have **been grown** along the [0001] direction of their hcp structure by molecular beam epitaxy on sapphire plates. Niobium and yttrium buffers were deposited prior the rare earth. We have studied the magnetism of dysprosium by magnetic resonant X-ray scattering at the dysprosium L_{III} edge, both in the $\sigma-\pi$ and in the $\sigma-\sigma$ configurations.

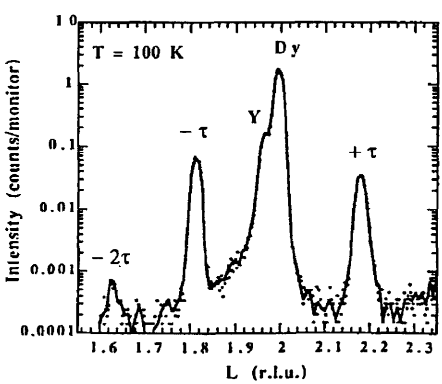

Fig. 1 : σ–π scan performed at 100 K for a 2500 Å thick dysprosium layer

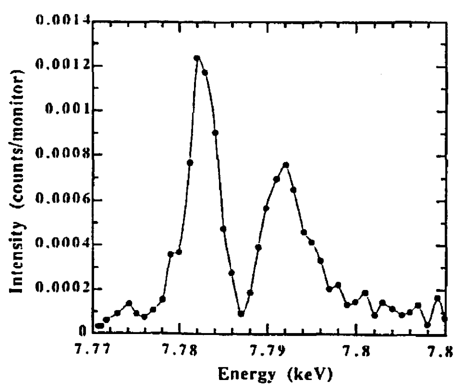

Fig. 2 : σ–π Energy scan around the $[0002]^{-2\tau}$ performed at 100 K for a 2500 Å thick dysprosium layer

Figure I shows a L scan in the Q-K channel performed at 100 K for a 2500 Å thick dysprosium layer. It exhibits the [0002] charge density peak of dysprosium surrounded by two intense magnetic satellites ($[0002]^{-\tau}$ and $[0002]^{+\tau}$) due to the helical magnetic order of this element. The extra peak is due to the yttrium buffer. We have followed the thermal evolution of the magnetic satellites and also observed the $[0002]^{-2\tau}$ and $[0002]^{+2\tau}$ magnetic satellites, as well as the first and second harmonics around the [0004] charge density peak. The energy scans revealed that for the first harmonics, as in holmium, the intensity of the σ to π scattering is the strongest. Moreover, and contrary to what has been observed for holmium, the scan in the $\sigma-\pi$ channel exhibits two splitted peaks, as it is presented in figure 2.

In the Dy/Er superlattice at the Dy L_{III} edge, we observed the [0002] charge density peak surrounded on each side by 8 charge density satellites due to the chemical periodicity of the superlattice. In addition, in the temperature range where the magnetic helical phase develops, two sets of magnetic peaks separated themselves by $2\pi/\Lambda$ appear on each side of the [0002] charge density peak. Each set of magnetic peaks replaces in fact the unique $[0002]^{-\tau}$ and $[0002]^{+\tau}$ magnetic satellites of the single layer. The occurrence of several thin magnetic peaks is due of the coherence of the magnetic helix which develops in the dysprosium layers and propagates through paramagnetic erbium. We also observed the two sets of $[0004]^{-\tau}$ and $[0004]^{+\tau}$ magnetic peaks. In an ultimate measurement, we followed the evolution of the set of "$[0002]^{-\tau}$ magnetic peaks" half a Kelvin by half a Kelvin in the vicinity of the Néel temperature. In the q-range of figure 3 are present the "-2" and "-3" charge density satellites.

The temperature-dependant peaks are the magnetic peaks. The magnetic contribution exhibits thin peaks separated by $2\pi/\Lambda$ just below the Néel temperature of the superlattice. It means that the helix is long range coherent as soon as it develops in dysprosium and there is no significant temperature range in which it is incoherent.

The neutron diffraction experiments performed at low temperature have shown that a ferromagnetic transition occurs inside the dysprosium layers and that the long range coherent helical order is then replaced by an antiparallel arrangement between the ferromagnetic dysprosium layers.

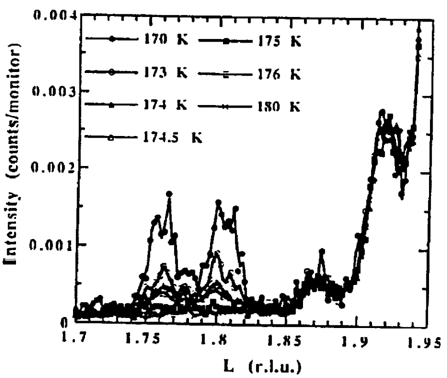

Fig. 3 : σ–π scans performed at various temperatures for a Dy/Er superlattice.

The $[0002]^{-2\tau}$ magnetic peak due to this antiferromagnetic phase has also been observed at 10 K by magnetic resonant X-ray scattering at the dysprosium L_{III} edge in the $\sigma-\pi$ configuration.

Finally, as a preliminary test to further experiments, a7000 Å thick epitaxial terbium film has been studied at the terbium L_{III} edge, with exactly the same experimental set-up as for the dysprosium case. Despite the narrow temperature range where the helical order is stable for this element, the magnetic satellites and their thermal evolution have been very nicely observed between 228 K and 220 K.

In conclusion, this set of experiments has shown that this technique offers the possibility to study the modulated magnetic phases of epitaxial thin films and superlattices in extreme situations : for very thin layers (an optimisation of the beam should permit to measure 100 Å thick film) and in the vicinity of a magnetic transition.