ESRF	**Experiment title:** Magnetic x-ray resonant scattering of Sm in epitaxial Sm films and Sm based superlattices (Sm/Y, Sm/La)	**Experiment number:** HE - 477
Beamline: BM28	**Date of experiment:** from: 10/12/98 to: 17/12/98	**Date of report:** 02.99
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Report:

Epitaxial single crystalline films of samarium and samarium based superlattices with high crystal quality have been grown for the first time in Nancy by Molecular Beam Epitaxy, on sapphire substrates first covered with a niobium buffer.

We chose to investigate first the samarium magnetism in two samples where the samarium crystal structure is similar to the bulk one: a (0001) 5000Å thick samarium film and a (0001) Sm(120Å)/Y(145Å) superlattice. Up to now, only a few studies have been carried out on bulk samarium magnetism, because of its small magnetic moment and of its extremely large thermal neutron absorption cross-section. We performed magnetic resonant x-ray scattering measurements at the samarium L_{III} and L_{II} edges, both in the $\sigma-\pi$ and in the $\sigma-\sigma$ configurations.

5000 Å thick samarium film

Our interest was to investigate both the magnetic ordering and the magnetic resonance process in this film. The polarisation analysis, which permits to considerably reduce the charge contribution in the $\sigma-\pi$ channel, allowed us to obtain many complementary results after our preliminary neutron scattering investigation.

At 50K, we measured numerous magnetic satellites at the positions (0 0 7.5), (0 0 10.5), (0 0 16.5), (0 0 25.5), (1 0 15.5) and (1 0 24.5). All these peaks are localised at ±1.5 r.l.u. from a charge contribution peak due to the nine plane stacking sequence of close packed hexagonal layers. They reveal the magnetic ordering of the moments on the hexagonal atomic sites, with a magnetic modulated sequence similar to the bulk one: the moments order in ferromagnetic sheets parallel or antiparallel to the c-axis in the sequence 0++0--0++....

At lower temperature (around 8K), other magnetic satellites have been measured at the positions (0.25 0 9.25), (0.25 0 11.75), (0.25 0 15.25) and (0.25 0 18.25). These peaks correspond to the magnetic ordering of the moments on the cubic atomic sites, with a magnetic modulated sequence which is again similar to the bulk one: the magnetic unit cell is then four times the chemical one. The thermal dependence of these satellites (see figure 1) shows that the ordering temperature is close to 12K. These magnetic contributions at low temperature are very weak and they were only observed once before, by neutron scattering on an isotopically enriched bulk sample. We also investigated the influence of the cubic sites magnetic ordering on the magnetic ordering of the moments localised on the hexagonal sites ; we did not see any influence neither on the intensity nor on the satellite position or on the resonance profile.

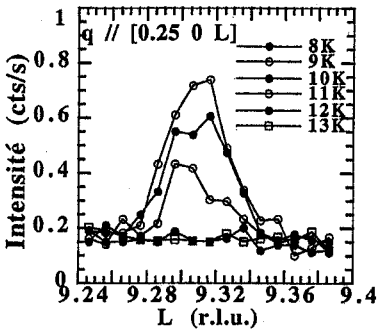

Fig. 1: Thermal evolution of a magnetic satellite (ordering of cubic sites moments) in a Sm film

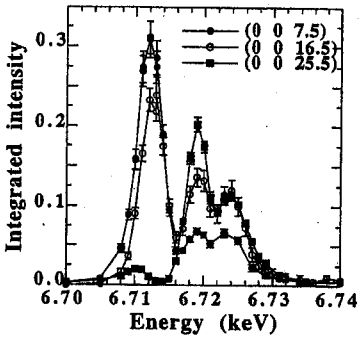

Fig.2: Integrated intensities versus the photon energy around the Sm L_{III} edge measured at 50K

The line shape of the resonance has been studied in $\sigma-\pi$ by measuring integrated intensities at different energies. At the L_{III} edge, we clearly observed three resonances (figure 2). The two higher energy resonances get stronger with increasing Q, which is typical of dipolar resonances ; they reflect the polarisation of the 5d band. The lower energy resonance is of quadrupolar type and related to the polarisation of the 4f electrons. The interpretation of the clearly split dipolar resonance will need to reconsider the cross-sections. The L_{II} edge only shows a double resonance.

Sm/Y Superlattice

In the superlattice, the room temperature spectra collected in the $\sigma-\sigma$ configuration confirmed that both samarium and yttrium keep their bulk crystal structure, that is a nine plane stacking sequence and a hcp stacking sequence of hexagonal close packed planes, respectively.

We succeeded in extracting a magnetic contribution from the samarium layers despite a very poor counting rate (8.10^{-5} cts/mon.). We measured the (0 0 16.5) magnetic satellite whose full width at half maximum appears to be much larger than for the previous samarium film. This reveals that the magnetic coherence length is limited to the individual Sm layer thickness. There is no long range coherent magnetic order, as it could have been expected with such thick yttrium spacer layers. The ordering temperature for the hexagonal sites moments is close to 100K and the energy scans look similar to the thick film.

Nevertheless, it was impossible to extract any magnetic contribution due to the ordering of the cubic sites moments below 10K in the superlattice, perhaps because of its extremely weak signal.