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Report:

Bulk samarium crystallographic structure is constituted of a nine–layers stacking sequence of close-packed planes, ABABCBCAC…, called "Sm structure". Recently, dhcp samarium single crystal films and superlattices have been elaborated for the first time by molecular beam epitaxy in Nancy. They present a four-layer stacking sequence ABAC…. The atoms located on planes A present a cubic symmetry (*c*), whereas the ones located on layers B and C exhibit an hexagonal one (*h*). The stacking sequence is thus *c h c h c*…

Because of the samarium extremely large thermal neutron absorption cross-section, magnetic resonant X-ray diffraction is an unique tool to study the magnetic structure of this new samarium crystallographic phase.

Measurements have been performed on a 5000Å thick dhcp Sm film between 8K and 300K at the Sm L_{III} edge. Magnetic scattering was measured using polarization analysis, to benefit from the extremely reduced charge background in the rotated $\sigma-\pi$ polarization channel. A Cu(220) crystal was used as analyzer. Two sets of magnetic satellites have been observed in two different temperature ranges:

- the first set of magnetic reflections, observed below 80K, corresponds to propagation vector τ_1=(0 0 1). As an example, the thermal evolution of the (007) magnetic reflection is given in figure 1. By analogy with the magnetic structure of bulk samarium, a possible magnetic structure associated with this propagation vector is an antiferromagnetic coupling between ferromagnetic planes of hexagonal symmetry, with moments pointing along c. We measured the integrated intensities of several reflections. Their Q-dependence is consistent with the proposed magnetic structure.
- the second set of magnetic reflections is observed below 24K, and corresponds to a propagation vector τ_2=(0.25 0 1). By analogy with bulk samarium, this can be associated with long range magnetic order developing between the cubic planes, with moments pointing

along c. The cubic planes are antiferromagnetically coupled along c, with ferromagnetic rows parallel to the a_2 axis and a + + - - + + - - + +… sequence along the a_1 axis (the magnetic wave vector is in the basal plane). The observed integrated intensities are consistent with this model.

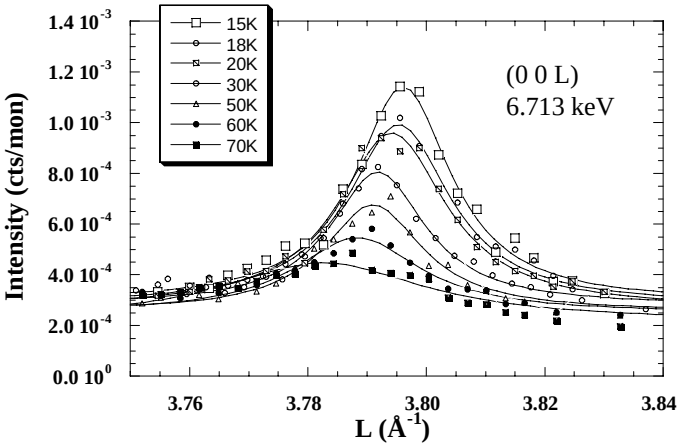

Figure 1: Thermal evolution of the (007) magnetic satellite in a dhcp (001)Sm film.

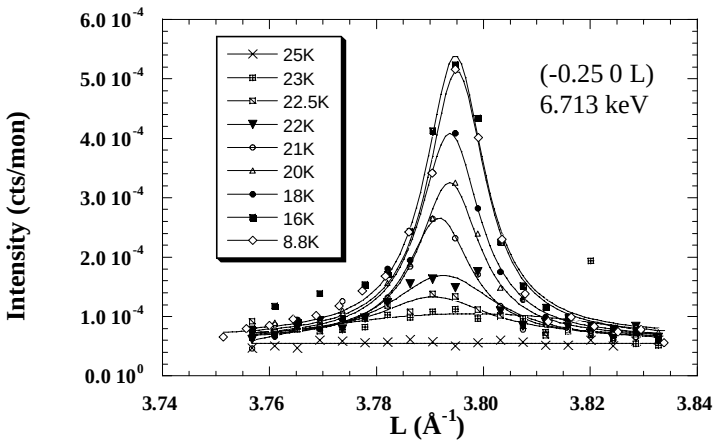

Figure 2: Thermal evolution of the (-0.25 0 7) magnetic satellite in a dhcp (001)Sm film.

The energy dependence of the magnetic reflections from both sets shows a resonance at 6.712keV (below the edge). All the above mentioned reflections were measured at this energy. The study of the Q dependance demonstrates that this resonance is quadrupolar in origin and related to the polarization of 4f electrons.

Finally, the thermal evolution of the interlayer spacing along the c-direction (measured in the $\sigma-\sigma$ configuration from the position of the (008) charge peak) confirms the occurrence of a magnetic transition at 24K correlated to huge magnetoelastic effects. To illustrate the difference between "Sm structure" Sm and dhcp Sm, the thermal evolution of the d-spacing in bulk Sm is also presented on figure 3: in this "Sm structure" sample, the low temperature transition occurs around 14K. Finally, one can note that the d-spacing in the film is slightly larger than in the bulk compound. This could be correlated to the different stacking or to epitaxial strains.

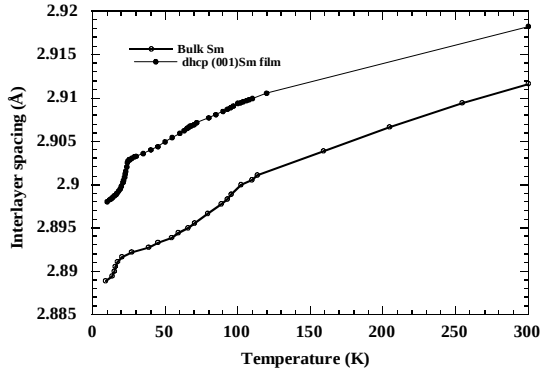

Figure 3: Thermal evolution of the d-spacing along the c direction in a dhcp (001)Sm film and in bulk samarium