XMaS the UK-CRG	**Experiment title:** The Critical Thickness of a Holmium Thin Film	**Experiment number:** 28-01-~~63~~82
Beamline: **BM 28**	**Date of experiment:** from: 12 July to: 18 July 2000	**Date of report:** 16/10/2000
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Report:

A series of high quality single crystal thin films of holmium staircase structures grown on thick yttrium seeds have been prepared using molecular beam epitaxy techniques in Oxford. The structure of these thin films have been studied by high-resolution x-ray diffraction, using synchrotron radiation at beamline 28 of the European synchrotron radiation facility, and by using in-house facilities in Oxford.

Due to the lattice mismatch between the thin film and the seed, theory suggests that the holmium layer is lattice matched to the yttrium substrate for thicknesses less than a critical thickness, h_c. For thicker films it is energetically favourable for the spontaneous creation of dislocations to relieve the misfit strain in the basal plane. Further increases in the thickness lead to increasing numbers of dislocations and to the holmium film in-plane lattice parameter tending towards the corresponding lattice parameter of bulk holmium.

X-ray scattering Measurements of the (-1015) Bragg reflection allowed the in-plane strain to be obtained as a function of holmium thickness.

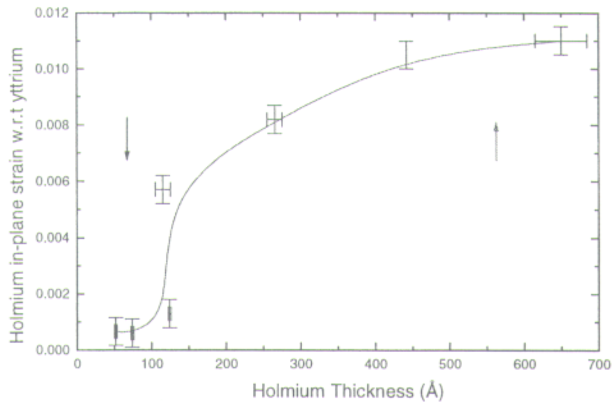

Figure 1: In-plane strain calculated from off-axis peaks with respect to the yttrium substrate. When the holmium layer is highly strained, the in-plane strain with respect to the yttrium layer is small. However, when the holmium layer is totally relaxed and takes its bulk lattice parameters, the strain with respect to the yttrium layer is larger, and is 0.019.

The in-plane strain of the holmium layer with respect to the yttrium substrate is shown above in figure 1. Below ~125 Å the holmium layer is highly strained because it is lattice matched to the yttrium substrate. Above ~125 Å, some of the strain is relieved by the introduction of misfit dislocations into the holmium layer. For thicknesses greater than 700 Å, the strain tends asymptotically towards the value one would expect to find using the bulk lattice parameters of holmium and yttrium.

X-ray scattering measurements around (0002), (0004) and (0006) Bragg reflections allowed the out-of-plane strain to be determined, as well as transverse peak shapes.

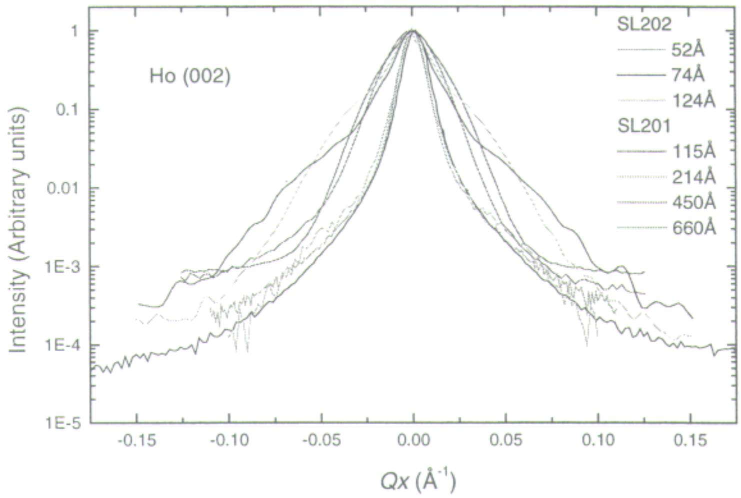

Figure 2: Transverse scans through (0002) holmium. The change in lineshape of the holmium peak shows the transition from Transverse scans for the (0002) holmium reflection are shown above in figure 2. For holmium films thicker than ~125Å, the two component line shapes show that the holmium layer is above the critical thickness. Misfit dislocations have partially relaxed the strain. This corresponds to the region of large in-plane strain with respect to yttrium, highlighted by the red arrow in figure 1.

Below ~125 Å the holmium peak shape closely resembles the yttrium peak shape, showing that the holmium layer grows pseudomorphically, being lattice matched to the yttrium substrate. This shows that the holmium layer is below the critical thickness. In this regime, the holmium film is highly strained, and so its in-plane strain with respect to the yttrium layer is small. The black arrow on figure 1 marks this regime.

These results show that the critical thickness at which misfit dislocations begin to set in is (125±20) Å for holmium grown on thick yttrium. It is the transition point between pseduomorphic film growth and dislocated film growth. This result is in contrast to the basic theory that suggests a critical thickness of 40 Å.

The results of modelling the scattering will be reported.