ESRF	**Experiment title:** In-situ high resolution diffraction and topography of the early stages of relaxation in III-V semiconductors (Feasibility study)	**Experiment number:** HS571
Beamline: BM5	**Date of experiment:** from: 18/9/98 to: 22/9/98	**Date of report:** 14/10/98
Shifts: 15	**Local contact(s):** A. Freund, A. Souvorov	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

B.K. Tanner*
Department of Physics, University of Durham, South Road, Durham, U.K.

C R Whitehouse, P Par-brook*
Department of Electrical Engineering, University of Sheffield, Sheffield, U.K.

A D Johnson, A M Keir*
Defence Evaluation and Research Agency, Great Malvern, U.K.*

Report: The aim of these experiments was to study

1. the image contrast from a multiple reflection monochromator;
2. the exposure time; and
3. the use of the FRELON camera

in double axis X-ray topographs of misfit dislocations at the interface of InGaAs layers grown by molecular beam epitaxy. The objective was to establish the feasibility of and justification for bringing the group's unique MBE chamber to perform *in-situ* X-ray topography studies in real time at station BM5.

Ex-situ double crystal topographs were taken in the grazing incidence 224 reflection from (001) oriented InGaAs films on GaAs. Previous studies at the Daresbury SRS [l] had shown that use of the 004 reflection from a silicon monochromator provided a suitable compromise between image quality and exposure time, reducing the latter by a factor of between 3 and 10 over that achieved previously at the SRS. Calculation of the enhanced flux at BM5 compared to station 9.4 of the SRS indicated another gain of up to 10. We aimed to use the existing water cooled 111 silicon monochromator as a means of handling the heat load prior to the main 004 channel-cut monochromator, which was specially cut to our design at the ESRF.

[1] B K Tanner *et al* SPIE Proc. 3448 (1998) in press;
B K Tanner *et al* submitted to J Phys D (Proc XTOP98)

Results: We have shown that the configuration provides a stable beam of sufficient parallelism to produce excellent double crystal X-ray topographs from the misfit dislocations With the standard 2/3 fill conditions and 180mA stored current, high resolution topographs have been recorded in 1 second on L4 Nuclear Emulsions (Fig 1). We have confirmed that use of Fuji plates reduces the exposure time by a further factor of 2 with no significant loss of image quality. The total reduction is over a factor of 200. With these sub-second exposures and stepping of the detector plate, we will be able to record genuine dislocation dynamics with micrometre resolution with no necessity for growth interupts. The small (0.18 mm) source size at the ESRF results in dramatically improved images compared with the Daresbury SRS and because we may now record only one 224 reflection, the associated reduction in alignment time will result in an effective gain of over 3 orders of magnitude. While high resolution images of misfit dislocations were recorded with the 1μm resolution FRELON camera, the integration times were too long for this configuration to be useful. A lower resolution arrangement is being investigated.

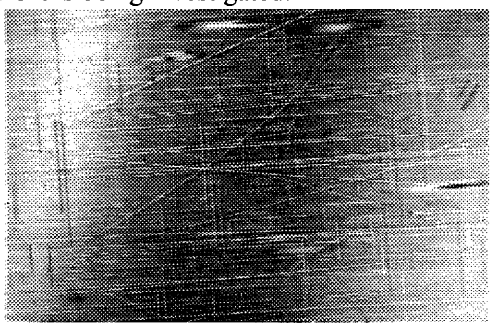

Fig 1. Misfit dislocations on Ilford L4 emulsion. 1 second exposure

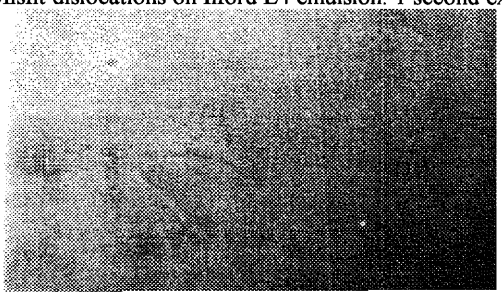

Fig 2. $In_{0.05}Ga_{0.95}As$ layer grown on an array of InAs quantum dots

During these experiments we have shown that growth of InGaAs on an array of InAs quantum dots alters substantially the relaxation mode. Figure 2 shows a synchrotron X-ray topograph taken at the ESRF of a 130nm $In_{0.05}Ga_{0.95}As$ layer grown on a 2.4 monolayer thick array of InAs quantum dots, with a 25 nm GaAs spacer above the quantum dot array.. Topographs of an equivalent InGaAs layer grown on a standard GaAs buffered wafer show a dislocation density comparable with Fig 1, that is below the second critical but above the first critical thickness. One of the objectives of *the in-situ* experiments will be to study the onset and mechanism of this relaxation process.