ESRF	**Experiment title:** DIRECT OBSERATION BY X-RAY TOPOGRA_ PHY OF GRAIN FORMATION IN InGaAs/GaAs MISMATCHED HETEROSTRUCTURES	**Experiment number:** HC 531
Beamline: ID 19	**Date of Experiment:** from: 31/7/96 to: 2/8/96	**Date of Report:** 22/1/97
Shifts: 6	**Local contact(s):** BARUCHEL JOSE	*Received at ESRF :* 29 JAN. 1997

Names and affiliations of applicants (*indicates experimentalists):

CLAUDIO FERRARI
CNR MASPEC INSTITUTE VIA CHIAVARI 18/A
LAURA FRANCESIO
"
"
SARA GENNARI
"
"
FILIPPO ROMANATO
DIPARTIMENTO DI FISICA UNIVERSITA' DI PADOVA VIA MARZOLO 8 PADOVA

Report:

Direct observation by x-ray topography of grain formation in InGaAs/GaAs compositionally graded beterostructures

InGaA.4GaA.s layers of graded composition and mismatch can be used as buffer layers for the growth of mismatched heterostructures with the possibility of achieving a desired fmal lattice parameter and with the confinement of dislocations in the buffer layer. In such structures, large lattice tilts between buffer and substrate crystal have been observed in partially relaxed heterostructures (1) due to the preferential alignment of the Burgers vector component perpendicular to the interface of the misfit dislocations.

InGaAs buffers layers have been grown by the Molecular Beam Epitaxy (MBE) technique at the growth temperature of 500 °C and different composition profiles from 0 to 35% of In.

A Si 111 monochromator was used to select a wavelength of 0.53 Å for topography and x-ray diffraction measurements. X-ray diffraction rocking curves were taken in the 004 symmetrical reflection geometry corresponding to a Bragg angle of 11.5 degrees. Several topographs in the same geometry were taken at different points of the rocking curves to evidence the change of the lattice tilts.

The analysis of the topographic images evidenced that the distibution of misfit dislocations in the structures is largely non uniform, at the microscopic scale. In all the samples investigated lattice tilt variations in the buffer layers up to 1 degree between the two edges of the samples have been detected by topograhy. Such tilt variations do not appear to be continous, but the buffer layer is divided in large crystal domains of constant tilts.

According to Mazzer et al (2) a lattice tilt a is given by the umbalance of the dislocation density $\rho+$ and ρ^- with opposite component of the Burgers vector, assuming perfect a/2(110) dislocations:

$$\alpha = \frac{(\rho^+ - \rho^-) \cdot a}{2} \qquad 1)$$

In which a=565 Å is the GaAs lattice parameter. The sample of Fig. 1 shows a lattice tilt distribution of α=1°, meaning that the umbalance at the two edges changes by an amount of 6x105 dislocation/cm, in comparison with the total misfit dislocation density of nearly 6.5×10^5 dislocation/cm. This means that nearly all the dislocations at the sample edges have opposite Burgers vector component perpendicular to the interface.

Thus during the buffer layer growth in addition to the strain due to the lattice mismatch, a driving force dependent on the distance from the sample edges is responsible for the selective multiplication of dislocation with definite Burgers vector component.

1) K. L. Kavanagh, J.C.P. Chen, J.M. Femandez and H.H. Wieder. J. Vac. Scie. Technol. Bl0 (4) (1992) 1820

2) M. Mazzer, A. Camera, A. V. Drigo, C. Ferrari; J. Appl. Phys. 68 (1990)

Fig. 1: x-ray topographs in the 004 symmetrical reflection geometry near the GaAs Bragg angle θ_B=10.9° taken at different angular positions near the Bragg peak.