

ESRF

Experiment title: DIRECT
OBSERVATION BY X-RAY TOPOGRA-
PHY OF GRAIN FORMATION IN
InGaAs/GaAs MISMATCHED
HETEROSTRUCTURES

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Local contact(s):

BARUCHEL JOSE

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Names and affiliations of applicants (*indicates experimentalists):

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

Report:

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

InGaAs/GaAs 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 final 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 buffer 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 distribution 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 topography. Such tilt variations do not appear to be continuous, but the buffer layer is divided in large crystal domains of constant tilts.

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

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

In which $a=565 \text{ \AA}$ is the GaAs lattice parameter. The sample of Fig. 1 shows a lattice tilt distribution of $\alpha=1^\circ$, meaning that the umbalance at the two edges changes by an amount of 6×10^5 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. Fernandez and H.H. Wieder. J. Vac. Scie. Technol. B10 (4) (1992) 1820
- 2) M. Mazzer, A. Camera, A. V. Drigo, C. Ferrari; J. Appl. Phys. 68 (1990)

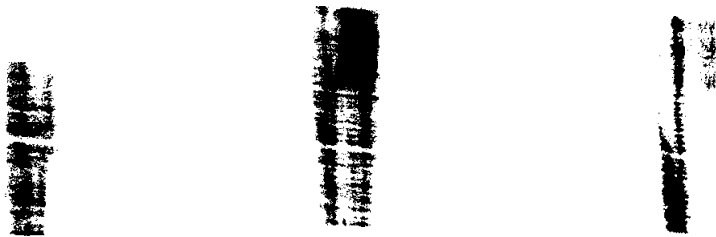


Fig. 1: x-ray topographs in the 004 symmetrical reflection geometry near the GaAs Bragg angle $\theta_B=10.9^\circ$ taken at different angular positions near the Bragg peak.