13-Defects, Microstructures and Textures

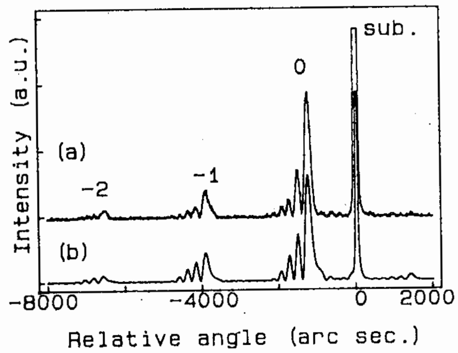

Fig.1 X-ray diffraction rocking curves $Si_{1-x}Ge_x/Si$ superlattice: (a) experimental; (b) simulated.

crystal diffraction rocking curves, combined with computer simulation. Its perfection was characterized by x-ray plane wave topographic technique using both synchrotron radiation and laboratory x-ray sources. X-ray topographs were taken at different positions of 224 asymmetric reflection rocking curve. The experimental results show that there exist a kind of novel regular dislocation network on the interface between the substrate and the epilayer. They were determined to be pure edge dislocations with the Burger's vectors $\frac{a}{2}[110]$ and $\frac{a}{2}[\bar{1}10]$, respectively. By analysing the x-ray diffraction rocking curves, the following perfection information of our sample was obtained: the mean strain relaxation $R = 31.7\%$; the mean mismatch $f = 0.55\%$; the dislocation density $\rho \sim 2.71 \times 10^7 cm^{-2}$.

PS-13.02.13 CHARACTERIZATION OF InAs AND InGaAs ON (1$\bar{1}$0) GaAs BY X-RAY DIFFRACTION AND TOPOGRAPHY. By L. Hart*, P. F. Fewster[1], X. Zhang and D. W. Pashley[2], Interdisciplinary Research Centre for Semiconductor Materials, Imperial College, London, UK, [1]Philips Reasearch Laboratories, Redhill, UK, [2]Department of Materials, Imperial College, London, UK.

There has recently been interest in semiconductor growth on (110) orientated surfaces. Strain relief in heteroepitaxial layers grown on (110) substrates is affected by the surface geometry since, in the [001] direction the {111} slip planes are inclined to the surface, while in the [1-10] direction, the {111} planes are perpendicular to the surface. Transmission electron microscopy has shown that strain relief of InAs on (110) GaAs is asymmetric, with 60° misfit dislocations in the [1-10] direction, giving rise to large tilts, and Lomer type dislocations in the [001] direction.

X-ray diffraction and topography have been used to determine relaxation and tilt in a range of samples of varying thicknesses of InAs and InGaAs, grown by molecular beam epitaxy on (110) GaAs. Reciprocal space mapping around the 220, 620 and 331 reflections enabled separation of components of strain and tilt in the [110], [1-10] and [001] directions respectively. From the reciprocal space maps, it was possible to determine both the macroscopic, "average" tilt and the spread of microscopic, "local" tilts. The relaxation and tilt in the [001] direction were found to increase with sample thickness: a 400Å InAs layer was almost fully relaxed and the average tilt was 1.0°, with a spread of 1.8°. In the [1-10] direction, however, relaxation was high even for the thinnest samples studied (30Å) but there was negligible tilting. Topographs taken from the same areas studied by diffractometry gave additional information on the size of the tilted regions.

PS-13.02.14 MINUTE STRAIN FIELDS IN AN AS-GROWN FZ Si CRYSTAL CONTAINING D-DEFECTS. By S. Kimura*, T. Ishikawa and J. Matsui, Microelectronics Research Laboratories, NEC Corporation, Japan.

The nature of D-defects in FZ Si crystals is still unclear since non-destructive characterization techniques have not been effective in observing D-defects in "as-grown" crystals, due to their small size and minute strain. In a previous work (Kimura, Ishikawa, Mizuki & Matsui, *J. Cryst. Growth*, 1992, **116**, 22-26), we had shown that minute tensile strain fields around A-defects in an as-grown FZ Si crystal can be quantitatively detected using plane-wave X-ray topography with extremely collimated X-rays, combined with the oscillatory profile of the diffraction curves in the Laue geometry. In the present work, therefore, this technique was applied to an as-grown FZ Si crystal containing D-defects. We examined a (111) wafer prepared from an undoped FZ Si crystal containing D-defects. The X-ray topographic measurements were performed at BL-15C of the Photon Factory at the National Laboratory for High Energy Physics. In this experimental arrangement, successive asymmetric 220 and $\bar{2}\bar{2}0$ diffractions from the first and second collimator crystals produced incident X-rays with an angular divergence of about 0.01 arc sec for λ = 0.735 Å (Ishikawa, *Acta Crystallogr.*, 1988, **A44**, 496-499). Contrast analysis of the topographs gives following results: The D-defects region in an as-grown FZ Si wafer was thereby non-destructively imaged for the first time; D-defects had only been observed previously using X-ray topography following copper decoration or a preferential etching technique using Secco's etchant (Yamagishi, Fusegawa, Fujimaki & Katayama, *Semicond. Sci. Technol.*, 1992, **7**, A135-A140). Furthermore, in the D-defect region, tensile strain with $\Delta d/d$ less than 1.5×10^{-5} exists. Finally, the spatial distribution of this strain is not uniform, while copper decorated D-defects show a uniform distribution.

PS-13.02.15 CHARACTERIZATION OF THE CELLULAR GROWTH STRUCTURE OF GaAs - 0.2 at % In BY X-RAY TOPOGRAPHY. By F. Minari* and B. Billia, Laboratoire Matériaux Organisation et Propriétés, ass. CNRS, Univ. Aix-Marseille 3, France.

In order to obtain large GaAs single crystals by the Czochralski technique, Indium is usually added into the melt to reduce the density of grown-in dislocations. Under optimal growing conditions, the moving liquid-solid interface remains plane, but due to morphological instabilities it can turn to a cellular structure. The case of GaAs/In is particularly interesting because the cells are partially faceted,i.e.they are made of portions of {111} planes connected by rough regions, in opposition with entirely faceted or entirely rough cells occuring in other materials. Moreover, in Czochralski growth, the well-known phenomenon of striation takes place due to periodic fluctuations of In content at the interface. These striations, which are revealed as sharp fringes by X-Ray Topography on a plane section of the ingot, act as a natural marker of the interface (plane as well as faceted) at constant intervals of time. Using the X-Ray images of these striations,we studied the birth, the evolution and the geometrical characteristics of the cellular structure on sections parallel and perpendicular to the [001] growing axis. Our observations show that:
- a unique local perturbation near the center of the initially flat interface initiated the whole cellular structure,
- no individual dislocation is visible within the cells, but such defects may be present at the junctions between cells,
- the fourfold symmetry of the cells expected on (001) sections is strongly altered by convection in the melt,
- dynamical roughening is evidenced at the edges of a cell undergoing overgrowth by neighbouring cells, which increase in size,
- whatever the extension of the facets (i.e. the cell-size) the width of the rough grooves between cells is remarkably constant while solidification proceeds,

