Microstructure & Texture

MS17.00.01 ELECTRON MICROSCOPY INVESTIGATION OF DEFECTS IN SiC. P. Pirouz, Department of Materials Science and Engineering, Case Western Reserve University, Cleveland, OH 44106-7204, U.S.A.

The applications of transmission electron microscopy (TEM) to investigate the structure of defects in various polytypes of SiC are discussed. The cubic 3C-SiC polytype is usually grown as an epitaxial film on (001) silicon or (0001) 6H-SiC substrates by chemical vapor deposition (CVD). In the SiC/Si system, a number of defects arise in the 3C-SiC film because of the large film/substrate lattice and thermal mismatches, as well because of demi-steps on the substrate surface. These include misfit and threading dislocations, a high density of stacking faults and twin bands, as well as inversion domain boundaries (IDBs). In the case of growth on the 6H-SiC substrate, depending on the vicinal angle of the substrate, ϕ, the film grows homoepitaxially when $\phi>0$, and heteroepitaxially, as the cubic 3C phase, when $\phi=0$. In addition, a large number of planar faults known as double positioning boundaries (DPBs) occur in the film. When a thin film is grown homoepitaxially on a 4H-SiC wafer, yet a new kind of defect occurs which has a triangular-shaped. Mechanism of formation of the various defects will be briefly discussed.

In bulk grown 6H-SiC and 4H-SiC, a variety of other defects occur which are mostly growth related. A predominant defect in these crystals are "micropipes" which run parallel to the [0001] growth direction of the boules. Deformation-induced defects in different SiC polytypes are mostly line defects which are dissociated into two partial dislocations bounding a wide ribbon of stacking fault. Geometrically, the core of a partial dislocation in these materials consists of either all carbon or all silicon atoms. Using the technique of large-angle convergent beam electron diffraction (LACBED), we have recently distinguished the core nature of partial dislocations produced by deformation. It turns out that the partial which has a core of silicon atoms (the Si(g) dislocation), has a higher mobility than the partial that has a core of carbon atoms (the C(g) dislocation). It is thought that polytypic transformations in SiC occur because of the large difference in the mobility of these two types of partial dislocations. This mechanism is briefly discussed and some experiments in support of it are presented.

MS17.00.02 THE DETERMINATION AND IMAGING OF CRYSTALLOGRAPHIC TEXTURE USING ELECTRON BACKSCATTER DIFFRACTION. D.J. Dingley, TexSEM Laboratories, Provo, Utah and The University of Bristol, UK

A system has been developed whereby Backscatter Kikuchi Diffraction patterns obtained from bulk samples in the scanning electron microscope can be automatically indexed enabling different crystallographic phases to be distinguished and crystal orientation measured. Such data collected at points spaced over a regular grid on a specimen surface permit the spatial distribution of these crystallographic features to be mapped on micrographical form. The technique is known as Orientation Imaging Microscopic and the maps as Orientation Image Micrographs. Interrogation of the maps allows both macroscopic and microscopic texture to be determined with intercorrelations of grain size, phase and texture component. Mesotexture, i.e. The distribution of disorientations across grain boundaries can also be determined together with a measure of internal strain and the residual energy stored in dislocations clusters.

Results obtained from partially recrystallized steel illustrate the procedure and a typical analysis. The macroscopic texture was determined for the combined cold worked and recovered parts of the microstructure and compared with that pertaining to each fraction. The cold worked material was distinguished by it's characteristic deformation cell structure, whilst recovered material was taken to be that where the cell size was greater than that of the deformed material and had cell walls of less than five degrees disorientation across them. Recrystallized grains were taken as grains containing little substructure and surrounded by high angle boundaries.

MS17.00.03 QUANTUM WIRE ARRAYS INVESTIGATED BY MEANS OF HIGH-RESOLUTION X-RAY DIFFRACTION. L. Tapfer, L. De Caro, C. Giannini, and Y. Zhuang, Centro Nazionale Ricerca e Sviluppo Materiali (PA.S.T.I.S.-C.N.R.S.M.), S.S.7 Appia Km. 712,1-72100 Brindisi, Italy

The geometrical and structural properties of periodic surface structures such as surface gratings, quantum wire and quantum dot arrays are investigated by high-resolution double-crystal and triple-crystal x-ray diffraction, reciprocal space mapping and x-ray reflectivity. The periodic surface structures are fabricated on (100)GaAs surfaces and MBE-grown AlGaAs/GaAs and InAs/GaAs multiple quantum well heterostructures by holographic lithography and subsequent dry-etching.

The analyses of the experimental x-ray diffraction patterns are performed by using a semi-kinematical scattering model. Simulations of the diffraction patterns and the reciprocal space maps allow us to determine the shape of the corrugation and geometrical parameters of the wires and dots. The x-ray data are compared with the results obtained by electron microscopy.

Diffraction patterns recorded in symmetrical and asymmetrical scattering geometries reveal a partial elastic lattice relaxation of the heterostructures which is caused by the finite lateral size of the quantum wires. It is shown that the tetragonal unit cells of the multiple quantum well wire structures are orthorhombically distorted due to the partial relaxation. An elasticity model which takes into account the lattice coherence at the wire/substrate interface along the wire direction explains and describes the data obtained from the x-ray diffraction experiments quantitatively.

MS17.00.04 SYNCHROTRON CHARACTERIZATION OF Zn-ALLOYED CdTe COMPOUND SEMICONDUCTORS PROCESSED IN MICROGRAVITY ON STS 50 AND 73. D.J. Larson, Jr., M. Dudley, H. Chung, and B. Raghothamachar, Materials Science & Engineering Department, State University of New York at Stony Brook, Stony Brook, NY 11794-2275 USA

Four CdZnTe crystals grown in microgravity (μ-g) were analysed with respect to hydrostatic and buoyant gravitational influences. Characterization was conducted utilizing optical and infrared microscopy, differential chemical etching, FTIR spectroscopy, x-ray rocking curve and precision lattice parameter mapping, and x-ray synchrotron topography. It was found that in the absence of hydrostatic pressure the liquid separated from the ampoule walls, depending on influences including: volumetric fill-factor, level of constraint, residual g-vector, ampoule geometry and growth conditions. Regions solidified without wall contact were found to virtually eliminate twinning, which is pervasive terrestrially. This suggests that many of the twinning defects are surface nucleated, and nucleation and/or multiplication is furthered by stiction at the ampoule/crystal wall. Further, the regions solidified without wall contact showed dramatic reductions in (111)[110] dislocation density, from 800,000 $\pm$ 400,000 (1-g) to 800 $\pm$ 400 (μ-g) epd. This was largely attributed to reduction in hoop stresses within the flight samples during growth and post-solidification cooling. Regions of partial wall contact showed defect gradients, with high densities on the wall side and low densities on the free surface side. These results are consistent with our original experiment hypotheses and are in excellent agreement with predictions from our high-fidelity thermal and thermo-mechanical stress models. Synchrotron reflection topographs of the sample surfaces, synchrotron transmission and reflection topographs of selected chemo-mechanically polished wafers, and Bragg contour maps of the residual strains within the one-g and μ-g crystals will be presented and explained on the basis of output of the thermo-mechanical process model.