11.2-3 THE COMPARISON OF X-RAY AND RAMAN MEASUREMENTS OF STRAINS IN HYDROGEN-IMPLANTED GALLIUM ARSENIDE.

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Crystal lattice deformation of gallium arsenide single crystals implanted with high energy protons (1.6 MeV) or deuterons (2MeV) have been studied using cw Nd-YAG infrared laser Raman scattering and X-ray double crystal reflection method. The sample orientation was (100) and implanted doses were about 6.5 x 10^{17} cm^{-2}. IR Raman scattering enabled us to probe the damaged layers as they are approached laterally, showing gradual decrease in the scattering intensity of the LO and TO phonons and a downward shift of their frequencies. These effects are attributed to defect-induced absorption and lattice strains. It is well known that the LO and TO frequencies of GaAs can be shifted upwards by an external compressive stress. Thus, the downward shifts observed in this work can be associated with tensile strains introduced during implantation (some 2 at % of foreign atoms are added). For a rough estimate, we assume that these strains η are primarily along the [100] axis. From the measured phonon shifts we obtain $\eta = 0.3 \pm 0.1$ %. For the X-ray study (deuteron-implanted sample only) a (100) Si single crystal was used as a monochromator. The 400 reflection was used with Cu radiation. The topographs taken showed not only the increase of lattice spacing but also strong spherical lattice curvature. The sign of the curvature was determined from the sequence of "zebrastripes" appearing successively. Crystal bending was spread out over the whole sample. The radius of curvature was estimated to be about 4 m. In order to compare the magnitude of lattice interplanar spacing, the rocking curves for implanted and nonimplanted parts of the sample were simultaneously taken. The obtained value of the interplanar distance change in the direction perpendicular to the crystal surface is $\Delta d/d = 0.0027$, which compares well with optically determinated lattice strain η.

11.2-4 AN X-RAY DIFFRACTION STUDY OF LATTICE IMPERFECTIONS IN COLD-WORKED FACE-CENTERED-CUBIC ALLOYS. VII. COPPER-SILICON (α-PHASE). By S.K. Pradhan, M. De and S.P. Sen Gupta, Department of Materials Science, Indian Association for the Cultivation of Science, Jadavpur, Calcutta - 700 032, India.

Following earlier approaches in this series of work (Ghosh, De and Sen Gupta, J. Appl. Phys., 1984, 56, 2201-6) detailed X-ray peak-shift, peak-asymmetry and peak-broadening analyses have been performed on the X-ray diffraction line profile obtained from cold-worked filings of five compositions of Cu-Si alloys in the f.c.c. phase namely, Cu-2.2, 4.3, 6.4, 8.7 and 9.6 at % Si. The cold-worked states of the materials have been characterized from a quantitative estimate of several microstructural parameters namely, propensity of stacking faults (intrinsic, extrinsic and twin-faults), coherent domain sizes, r.m.s. microstrains, long-range residual stresses, lattice parameter changes, dislocation density and stacking fault energy. The analysis reveals increased presence of stacking faults of intrinsic nature primarily responsible for the observed peak-shift and domain size peak-broadening. The very small amount of extrinsic stacking faults accounts for the observed asymmetry in the profiles and the twin faults are nearly absent. The effective particle sizes decrease and microstrains increase with increasing solute concentration and these are anisotropic in nature. An estimation of dislocation density, ρ and stacking fault energy, γ for the alloys has also been made and compared with the results obtained earlier from electron microscopy.

11.2-5 A γ-RAY DIFFRACTION STUDY OF EXTINCTION IN ANNEALED SILICON SINGLE CRYSTALS. by J.R.Schneider, O. Gonçalves and H.A. Graf, Hahn-Meitner-Institut, Berlin, FRG and W. Zulehner, Wacker-Chemitronic, Burghausen, FRG.

Homogeneous distributions of defects have been created by annealing Czochralski grown silicon crystals of different oxygen content at temperatures of 750, 1050 and 1200°C. Using 0.0392Å γ-radiation, absolute values of the integrated reflecting power, as well as double crystal rocking curves with 1.4" resolution, have been measured in Laue geometry on disk-shaped samples of 10 cm diameter and 1 cm thickness, the cylinder axis being parallel to the <001> growth direction.

The integrated reflecting power measured in a perfect crystal as a function of sample thickness exhibits Pendellösung oscillations. This has been found with 0.0392Å γ-radiation at the 220 reflection of a silicon crystal containing $0.8 \cdot 10^{17} cm^{-3}$ oxygen atoms after annealing it at ~750°C for 70 hours. For samples with $8 \cdot 10^{17} cm^{-3}$ or more oxygen atoms the intensities are shifted to higher values, and the Pendellösung oscillations are located on a slope. This extra scattering is interpreted as Huang diffuse scattering and it is determined on an absolute scale. The experimental data can also be described by means of Kato's statistical dynamical theory.

Darwin's extinction theory is applied to interpret the thickness dependence of the integrated reflecting power measured in samples annealed at temperatures above 1000°C. It is shown that the assumption of a Lorentzian mosaic distribution simulates the effect of primary extinction in a theory conceived for secondary extinction only.

For 0.0392Å γ-radiation, the full width at half maximum (FWHM) of the diffraction pattern of a perfect silicon crystal is of the order of only 0.1". After annealing at 1200°C the integrated reflecting power measured at reflection 220 from the 1 cm thick sample is approximately 30 times the average dynamical value. The increase in intensity is uniform over the whole crystal. The FWHM of the intrinsic diffraction pattern of the annealed crystals (mosaic distribution) as determined from double crystal γ-ray rocking curves does not exceed 3" even for path lengths in the crystal up to 10 cm. The material allows efficient monochromatisation of high energy synchrotron radiation and presents new possibilities for achieving a better compromise between resolution and intensity in X-ray spectroscopy.