X-Ray Characterization Of Bulk InP:S Crystals Grown By LEC in a Low Thermal Gradient

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Introduction: Single crystals of S-doped InP grown with very low dislocation density under conditions of low axial and radial thermal gradients, are typified by a flat solid-liquid interface. The consequence of a reduced thermal gradient [1-3], together with the dislocation pinning effect of sulfur doping, produces single crystal InP crystals with EPD < $500/cm^2$. Dislocations generated at the periphery of the growing crystal are blocked by the high S-concentration, especially at striations where high doping concentrations increase the critical resolved shear stress on a local scale.

Methods and Materials: Sulfur-doped InP crystals are typically grown with dislocation density less than $500/cm^2$ and with an extremely flat solid-melt interface in a low thermal gradient environment. These crystals, grown at Crystacomm, were studied using synchrotron white beam x-ray topography (SWBXT). A slice was cut vertically through the cone on the (110) plane and polished for x-ray topography. This slice bisected the two $(111)_{In}$ facets.

Results: For the sulfur-doped InP crystals, synchrotron x-ray topography reveals two conspicuous features. First, very few dislocations are present in the bulk crystal, and these do not appear to emanate from the seed [4]. This fact is illustrated in Fig. 1, an x-ray topograph of the axial (110) slice cut from the cone section. Second, the S-doped crystals show a much higher striation contrast than do crystals with equivalent levels of other dopants.

It appears that low dislocation density and high x-ray contrast of striations, are related crystallographically. If this hypothesis is correct, one would expect to find dislocations terminating at striation features as seen in x-ray topography. Figure 1 shows the striations delineating the solid-melt interface, with a curvature that is only slightly convex toward the melt. On the right side (111) edge facets are clearly visible, and a stripe running parallel to the slope marks the facet/off-facet boundary. On the left, the facets do not appear because this region was previously removed with the $(111)_{In}$ slice. Other than these features, and some scratches, one cannot resolve any dislocations at this magnification. This is consistent with etch pit density analysis on (100) wafers from this crystal, showing a dislocation density less than 500 cm^{-2}.

The high contrast of S-doping striations is seen in Fig.1. Here the diffraction vector, $\boldsymbol{g}$ = 004, is perpendicular to the striae for maximum contrast [5].

Conclusions: Low-dislocation density InP:S crystals are produced in a modified thermal gradient. The generation and propagation of dislocations has been studied using synchrotron white beam x-ray topography. A model has been presented to explain the mechanism of dislocation-pinning in the growing crystal, which is consistent with the appearance of high striation contrast in x-ray topographic images.

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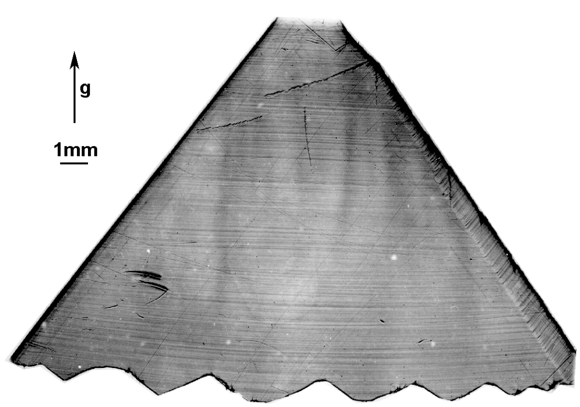

Figure 1. X-Ray topograph of (110) InP slice: $\boldsymbol{g}$ = 004