X-ray Topographic Characterization of Zinc Oxide Crystals

G. Dhanaraj, M. Dudley (SUNY, Stony Brook) and D. Bliss, M. Callahan, M. Harris (Air Force Research Lab.)

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Introduction: Zinc Oxide (ZnO) is a wide band-gap semiconductor with an energy gap of 3.37 eV [1-4]. It has a potential for applications as emitter devices in the blue to ultraviolet region and as a substrate material for GaN based devices. This effort uses synchrotron x-ray topography of hydrothermally grown ZnO crystals to characterize defects and reveal the suitability as substrate for epitaxy.

Methods and Materials: Hydrothermal autoclaves made of high strength steel were used for crystal growth, with a sealed platinum liner to isolate the crystal growth environment from walls of authoclaves. The mineralizer solution was a mixture of Li_2CO_3, KOH, and NaOH, with 99.99% ZnO powder. During growth, the nutrient zone was at 355°C with the temperature gradient of 10°C. Growth rates on (0001) basal plane seed plates averaged to 10 mils per day. Crystal plates of (10-10) ZnO cut perpendicular to the seed were polished for topographic characterization. The crystal plate contained the seed crystal and bulk grown on the seed was used to show the growth history of the crystal. X-ray topographs were recorded on Laue configuration using white beam synchrotron radiation.

Results: The topographs revealed that the dislocation density is very high near the seed/crystal interface, showing strain near the initiation of growth. Interestingly, most of these of these dislocations do not originate from seed and propagate into the bulk. Instead, these dislocations seem to nucleate as misfit dislocations at the micro-capped region. These large numbers of dislocations are, however, stopped by a growth band which could have resulted from fluctuation in growth condition. This was verified with growth data and found to be correct. Some fresh dislocations get nucleated from the growth band in some regions. In general the subsequent growth after the growth band leaves bulk with considerably lower dislocations. In some cases it is also possible to observe micro-cavities originating from seed/crystal interface, these cavities heal during the growth nucleating dislocations.

Conclusions: ZnO crystals have been grown by hydrothermal method. The growth history and defect structures were studied. Dislocations seem to originate from strained region near seed. Many of these dislocations were stopped by a growth band leaving the subsequent region with lower dislocation density.

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Fig.1 Topograph of (10$\bar{1}$0) ZnO plate (g = 0001). Large number of dislocations originating from micro-capping is observed

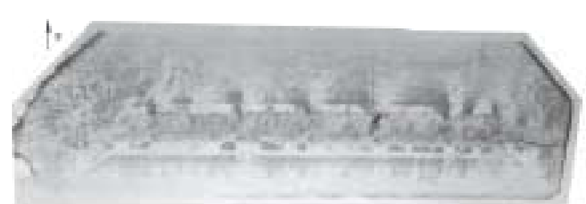

Fig.2 Topograph (g = 0001) shows the dislocations originating from micro-cavities