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SWBXT Study of Dislocations in Bulk AlN Single Crystals Grown by the Sublimation Technique

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Beamline(s): X19C

Introduction: Large area, low defect density, single crystal AlN substrates are currently being sought for the development of electronic and opto-electronic devices in the areas of short wavelength emission and detection, and high power, high-frequency microwave devices. Currently, the sublimation-recondensation technique [1] is the most promising method to produce large, bulk AlN single crystals. During crystal growth, defects such as dislocations, inclusions, etc. can be routinely introduced and these are potentially detrimental to device performance. Characterizing defect types and their distributions is necessary for understanding their origins and to minimize or eliminate them. SWBXT [2] is a non-destructive technique that can be used to rapidly characterize such structural defects in large, low defect density crystals. Using SWBXT, defect distributions in AlN substrate wafers cut from boules grown by the sublimation-recondensation technique have been carried out.

Methods and Materials: AlN substrate wafers were first mechanically polished followed by chemical mechanical polishing. SWBXT expts. were carried out at Stony Brook Synchrotron Topography Station, Beamline X19C.

Results: An x-ray topograph recorded from an AlN wafer (Fig.1(a)) shows dislocation lines, both straight and curved, running along different line directions, mostly close to the periphery. Dark contrast spots are inclusions. On the right edge, cracks and slip bands emanating from the right edge as well from crack tips are observed. Dislocation lines are also revealed under an optical microscope (Fig.1(b)), indicating they are decorated by impurity, probably the same type that form the inclusions. Dislocations inclined to the basal plane are decorated with a high impurity concentration. They lie close to the growth axis and are likely growth dislocations. Basal plane dislocations, belonging to $(0001)<11\bar{2}0>$ slip systems, are less decorated because they were formed after growth at lower temperatures under stresses generated due to differential thermal expansion between crucible and boule. Undecorated slip bands emanating from the right edge of the wafer and from crack tips belong to the prismatic set $\{1\bar{1}00\}<11\bar{2}0>$. Crack formation and slip band nucleation occurred at lower temperatures when higher stresses are generated due to differential thermal expansion between boule and crucible. Impurity material responsible for inclusion formation and dislocation decoration is most likely to be oxygen since AlN has a high affinity for oxygen [1].

Conclusions: Using the sublimation-recondensation growth technique, high quality AlN single crystals with low dislocation densities (800-1000 /cm^2) have been grown. Impurities (most likely oxygen) decorate dislocations near growth temperatures and also form inclusions. Stresses due to differential thermal expansion of crystal and crucible cause significant deformation chiefly in the peripheral regions and also cracking.

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References:

[1] G.A. Slack and T.F. McNelly, J. Crystal Growth, **34**, *263* (1976).

[2] M. Dudley, in Encyclopedia of Advanced Materials (David Bloor, Richard Brook, Merton Flemings, Subhash Mahajan and Robert Cahn, eds.), 4, Pergamon Press, New York, 1994, p. *2950*.

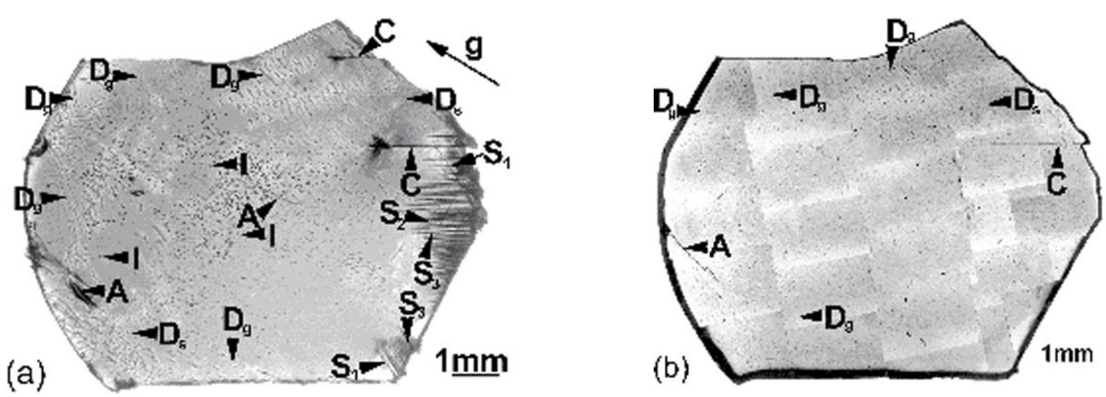

Fig.1. (a) Transmission topograph (g = $10\bar{1}0$, λ = 0.78Å) showing the different defects observed (D_g – growth dislocation, D_s – slip dislocation, S – slip band, C – crack, A – surface artifact/scratch, I – inclusion), (b) Optical micrograph showing surface artifacts (A), cracks (C) and decorated dislocations (D_g – growth dislocation, D_s – slip dislocation).