Properties of Al-Polar PVT Grown Single-Crystalline Aluminum Nitride

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Aluminum nitride (AlN) bulk crystals, to be used for substrates for III-nitride epitaxy, are grown by physical vapor transport (PVT) using directional sublimation/recondensation of an AlN source. One of the key issues is the preferential growth direction for optimized substrate quality. In principle, the PVT technique sets no restriction on growth orientation. On the other hand, it was shown earlier that growth morphology and crystalline quality strongly depend on the crystallographic orientation of the facet where growth occurs. In this study, we investigate structural and optical properties of AlN bulk crystals grown in the Al-polar c-direction; results are compared with crystals grown in other directions. Structural quality of Al-polar grown AlN crystals was evaluated by X-ray diffraction, X-ray topography, and wet chemical etching. Although we find etch pits in the order of 10^4 cm^-2 as well as inclusions in some crystals, rocking curve FWHM values of .025° emphasize good crystalline quality and absence of mosaicity. Also, Al-polar grown AlN crystals exhibit excellent optical properties. In near band-edge photoluminescence at 4.2K, free excitons are clearly observed at 6.033 eV. Bound excitons at 6.006 eV and 6.011 eV exhibit FWHM values as low as 3 meV. We also show that below band-gap luminescence and absorption is lowest on Al-polar grown crystals as compared to crystals grown in other directions, and is homogeneously distributed across the growth area.