AlN substrates for optoelectronic devices

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This talk reviews the current status of bulk AlN growth activities, with emphasis on (i) the implications on substrate properties that are demanded for in AlGaN epitaxy and UV-C device preparation, and (ii) what was achieved during the WideBaSe collaboration at the Leibniz Institute of Crystal Growth.

Single-crystalline aluminum nitride (AlN) is the most promising substrate material for deep-UV optoelectronics based on AlGaN epitaxial layers with high Al content. In recent years, AlN bulk growth by sublimation-recondensation (PVT method) at temperatures exceeding 2000°C greatly advanced to yield AlN single crystals and substrates of sufficient structural quality and size, which have already been employed in first device demonstrators within the WideBaSe consortium. Bulk growth is now typically performed on AlN substrates (homoepitaxial seeding), enabling perpetuation in quality and steady improvement in diameter by subsequent seeding on substrates cut from these boules, see Fig. 1.

However, sublimation growth of bulk AlN still faces important challenges on its way to a technology feasible for production. In particular, the technological route employed in initial seeding critically influences structural quality of subsequently grown boules and thus governs properties of available AlN substrates. We show that the excellent structural quality of spontaneously nucleated free-standing AlN crystals can be perpetuated during homoepitaxial seeding. However, main issues remain to be solved and will be discussed in detail: (i) very slow diameter increase, (ii) still high deep-UV absorption in the substrate, and (iii) crack formation caused by seed fixation issues and improper thermal field during growth. In contrast, AlN material which stems from AlN-on-SiC template seeds is available in 2-inch diameter size. It shows quite low deep-UV absorption, but contains areas with high density of structural defects. Here, significant quality improvement remains a veritable challenge. Finally, first results of epi-ready polishing and epitaxy on AlN substrates as preformed by the partners in the WideBaSe consortium will be presented.

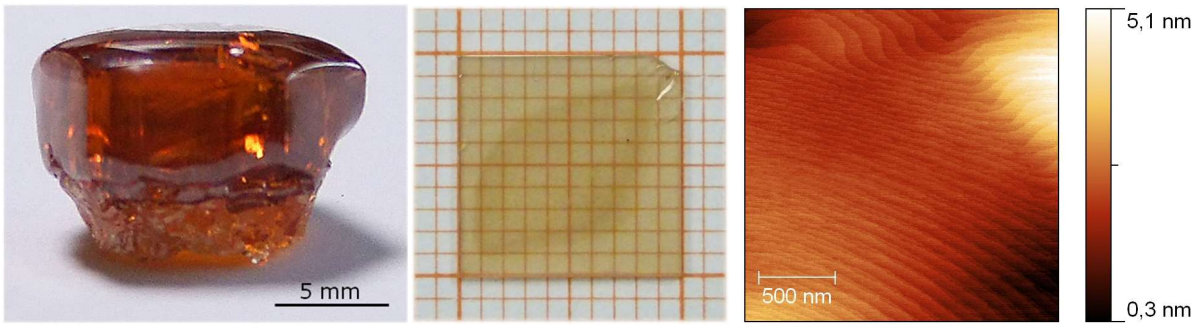

Fig. 1: Bulk AlN crystal grown on an AlN seed (left); polished single-crystalline AlN wafer on mm-sized grid (middle); atomic force microscope image of an 2.5 µm thick AlN epilayer on an AlN wafer showing monolayer step-flow on the surface, courtesy FBH and TU Berlin (right).