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Basic Ammonothermal Growth of GaN in Silver Lined Autoclave

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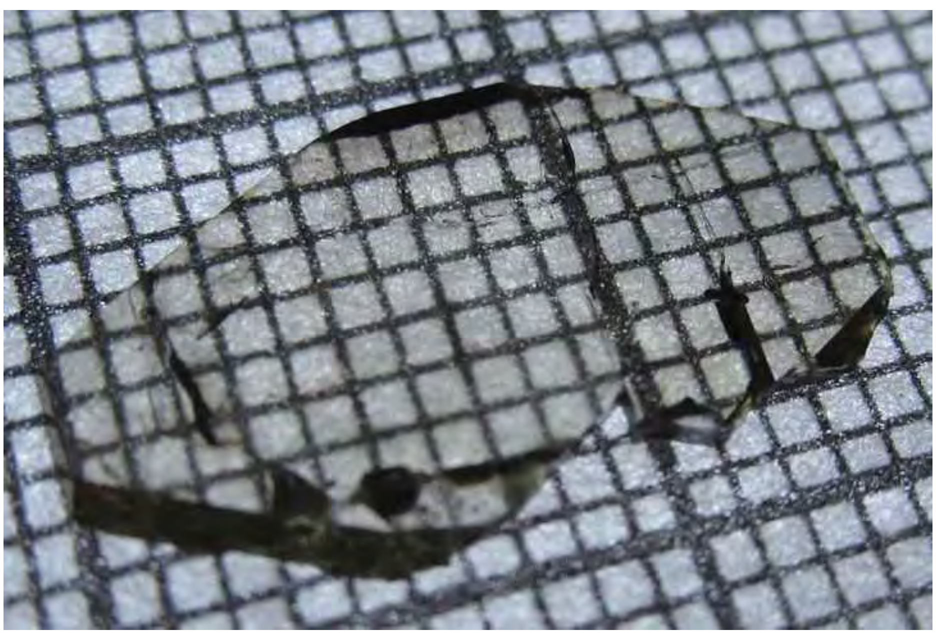
Gallium Nitride (GaN) and its alloys form a promising material system for optoelectronic and electronic devices. Heteroepitaxial growth of GaN on sapphire and SiC, while viable, introduces threading dislocations (between 1E8 – 1E11 cm^-2), mismatches in thermal expansion coefficients, and limitations on available growth orientations other than the polar, <0001> directions. With a push towards longer wavelengths, higher output powers at higher efficiencies with reduced droop for LEDs, non-polar and semi-polar oriented devices are becoming increasingly important, though need currently lacking, large area, bulk GaN substrates. A solution is the ammonothermal growth technique, which entails dissolving a GaN feedstock in a supercritical ammonia solution containing sodium (P < 270 MPa, T = 500—600 ºC) and re-crystallizing the material on a GaN seed. Improvements in growth rate are needed to reduce cost and increase throughput. To that end, an ultra high purity (UHP) growth environment was created within a typical Ni-Cr superalloy autoclave by introducing a silver capsule. 40 basic ammonothermal growth runs were performed on hydride vapor phase epitaxy (HVPE) GaN seed crystals. The capsule design significantly reduced concentrations of transition metals in the GaN crystals (<1x1E17 cm^-3) while improving the transparency to α(450 nm) = 2.2 cm^-1. Total growth rates improved from 200 to 344 ± 30 µm/day for c-plane and from 34 to 46 ± 2 µm/day for m-plane growth. Degradation in crystal quality based on the full width at half maximum of the ω-rocking curve using X-ray diffraction when compared to the seed crystal was only observed for Ga-face growth on c-plane oriented seeds, presumably due to poor nucleation. Cracking in thick growth layers was observed due to strain originating from the HVPE seed crystals. Differences in the total system pressure profiles were analyzed and the observed pressure drop due to outward diffusion of hydrogen during growth was modeled.



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