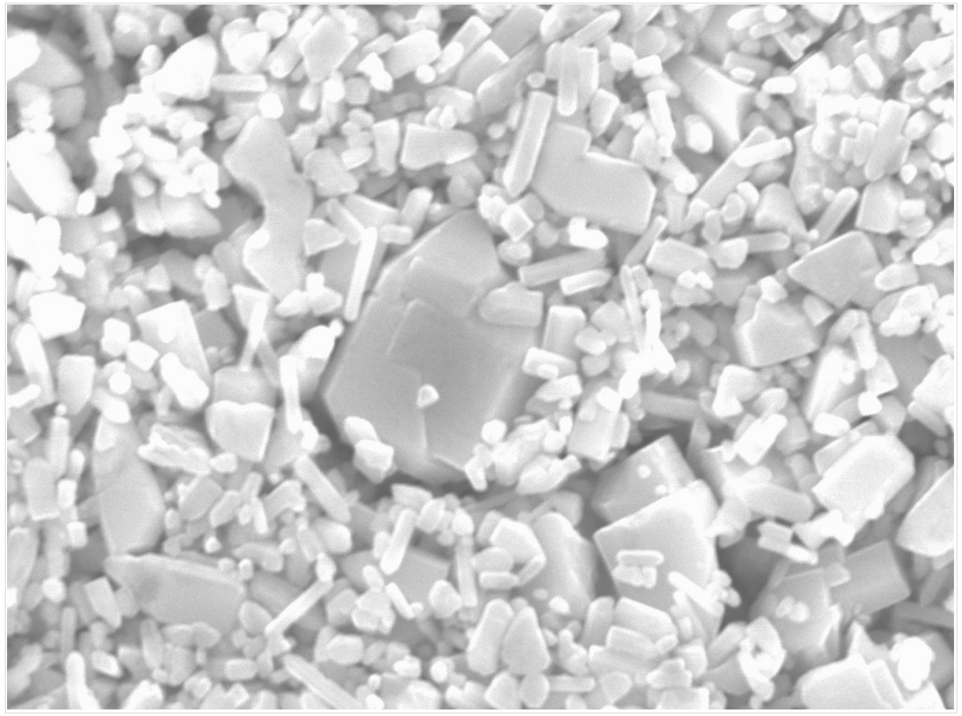
Ammonothermal method - history and state of the art

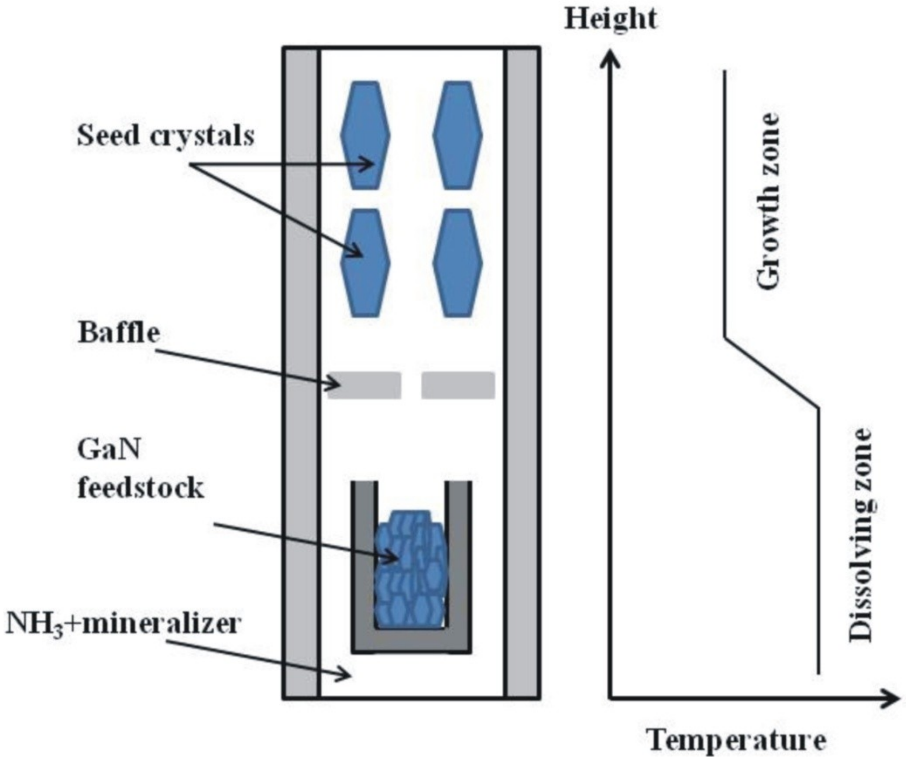
Ammonothermal method



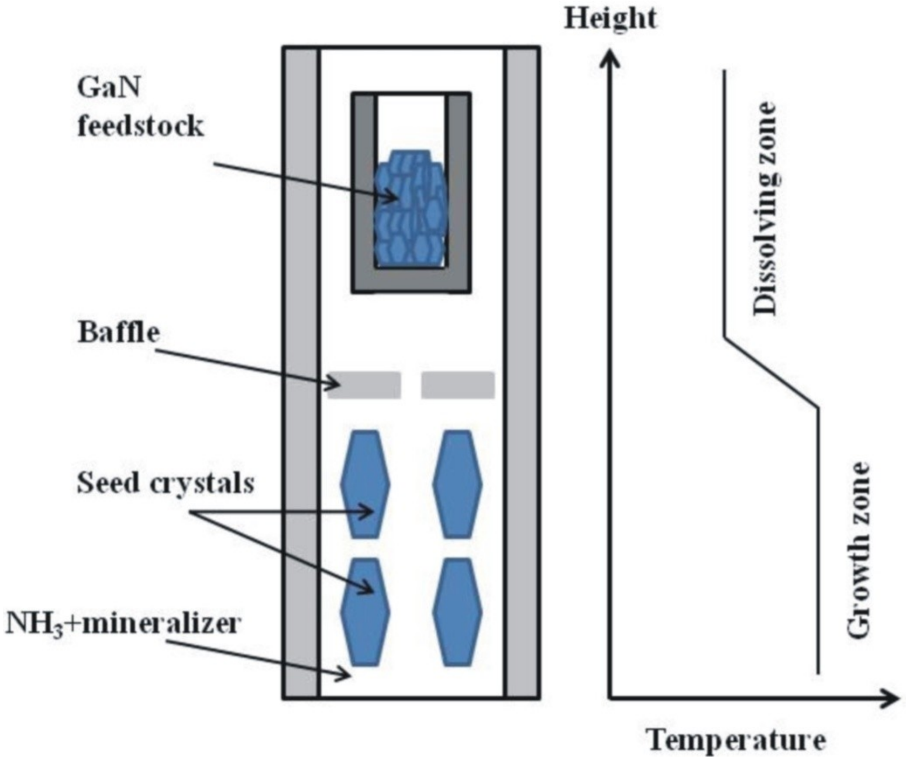
R. Dwiliński, et al., Acta Physica Polonica A 90, 763 (1996)

Ammonothermal method

- *analogous to hydrothermal crystallization of quartz*
- *ammonia used instead of water; ammonia in a supercritical state (enhanced reactivity)*
- *applied pressure and temperature: 1000-6000 atm. and 300–750^{o}C*
- *mineralizers are added to the solution in order to increase the solubility of GaN feedstok*

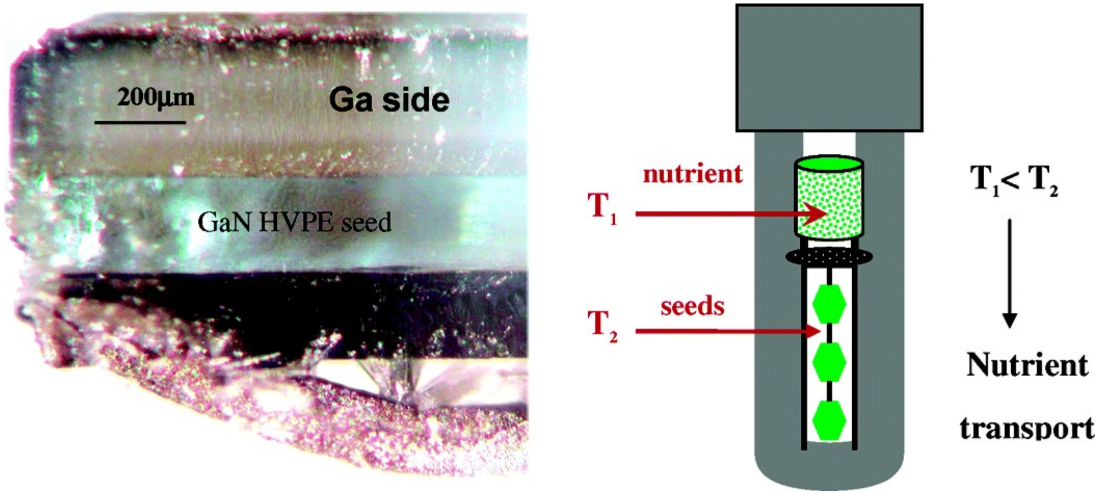


acidic



basic

Ammonothermal GaN grown on HVPE-GaN



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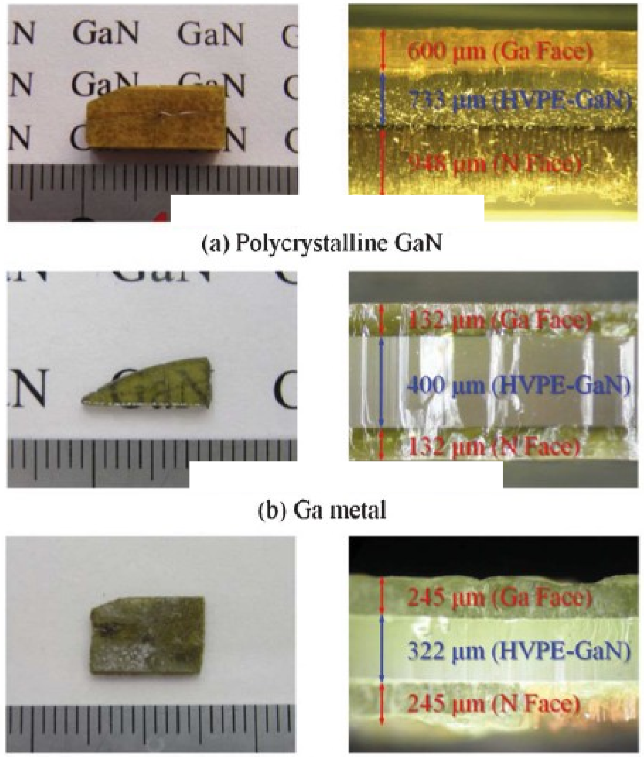

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High pressure growth of bulk GaN from solutions in gallium

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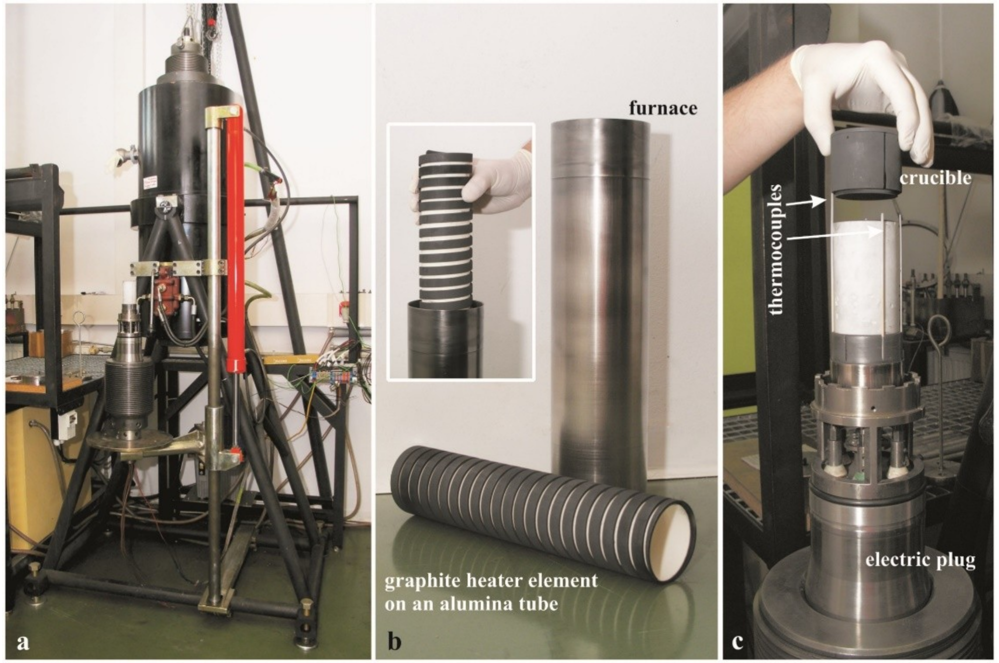


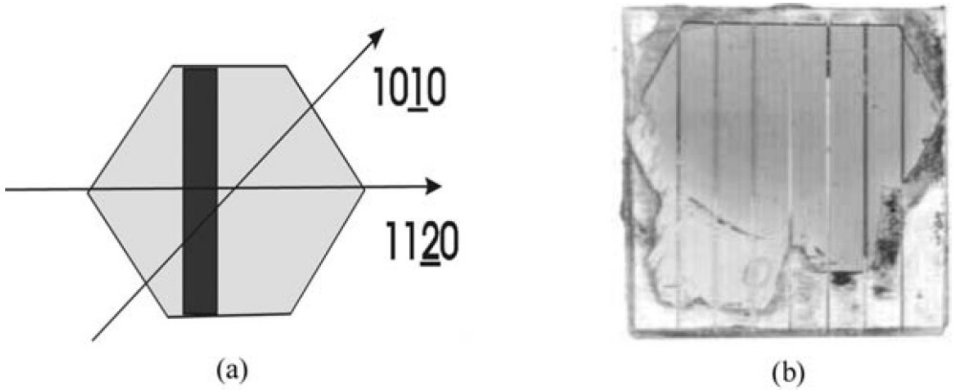


Figure 14. Preparation of the seed crystal for the growth in the fastest growth ⟨11 − 20⟩ directions: (a) schematic view, (b) GaN platelet after cutting by the wire saw—the width of each seed is 1 mm.

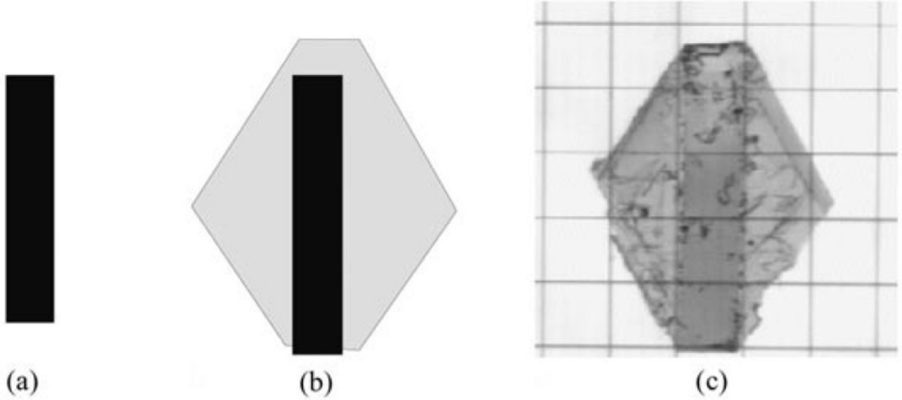
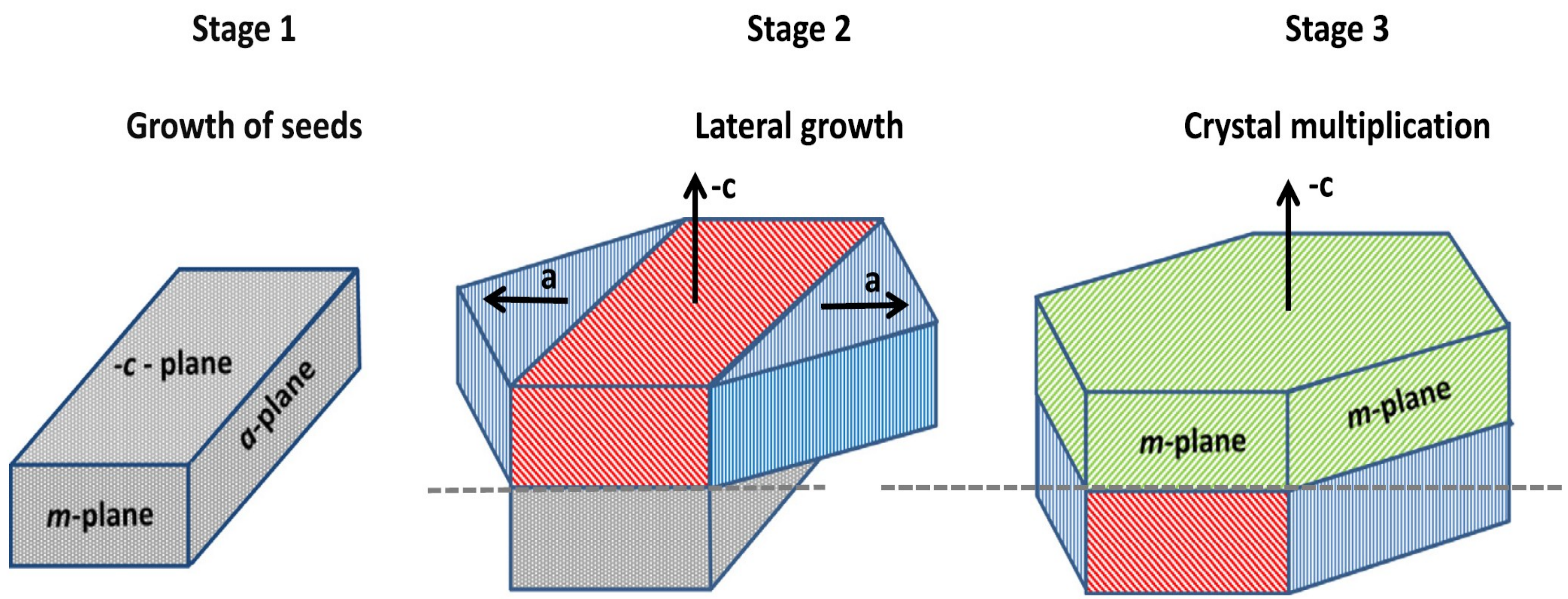


Figure 15. Seeded growth of GaN into ⟨11 − 20⟩ directions: (a) schematic view of the seed, (b) expected result of the growth, (c) result of the 40 h growth.

Ammonothermal method



M. Zajac et al., Progress in Crystal Growth and Characterization of Materials 64 (2018) 63–74

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Excellent crystallinity of truly bulk ammonothermal GaN

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ABSTRACT

In this paper we are presenting the excellent structural parameters of truly bulk gallium nitride crystals, which were grown by using the AMMONO-Bulk Method. In the crystals grown using this method a low dislocation density in the order of $5\times10^{3}\,cm^{-2}$ is readily attainable. At the same time the lattice of ammonothermally grown crystals is extremely uniform. Regardless of the crystal size, the radius of lattice curvature is higher than 100 m, whereas in the best crystals it is higher than 1000 m. Exceptional crystallinity is also evident in a very narrow X-ray (0 0 0 2) rocking curves, with FWHM values of about 17 arcsec as measured by a standard Panalytical X'pert high-resolution diffractometer.

Such excellent structural parameters of AMMONO-GaN crystals show clearly that truly bulk GaN can be grown by using a scalable method, which can be employed in mass production. The authors are convinced that crystals produced using their method will make a breakthrough in the manufacturing of high-power GaN-based devices.

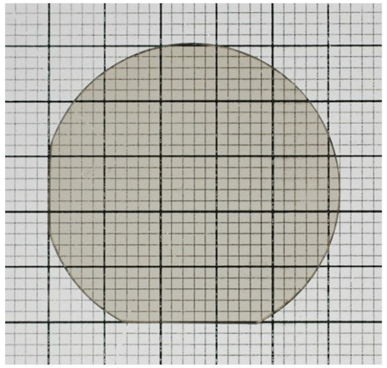


Fig. 3. 1-in AMMONO-GaN substrate.

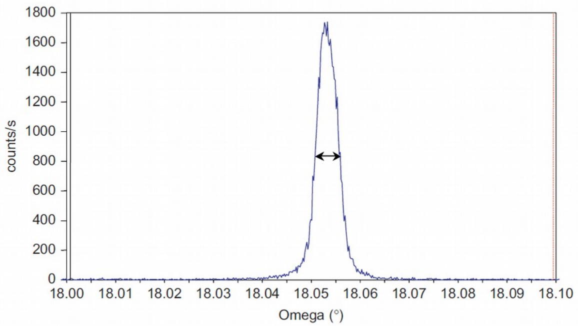
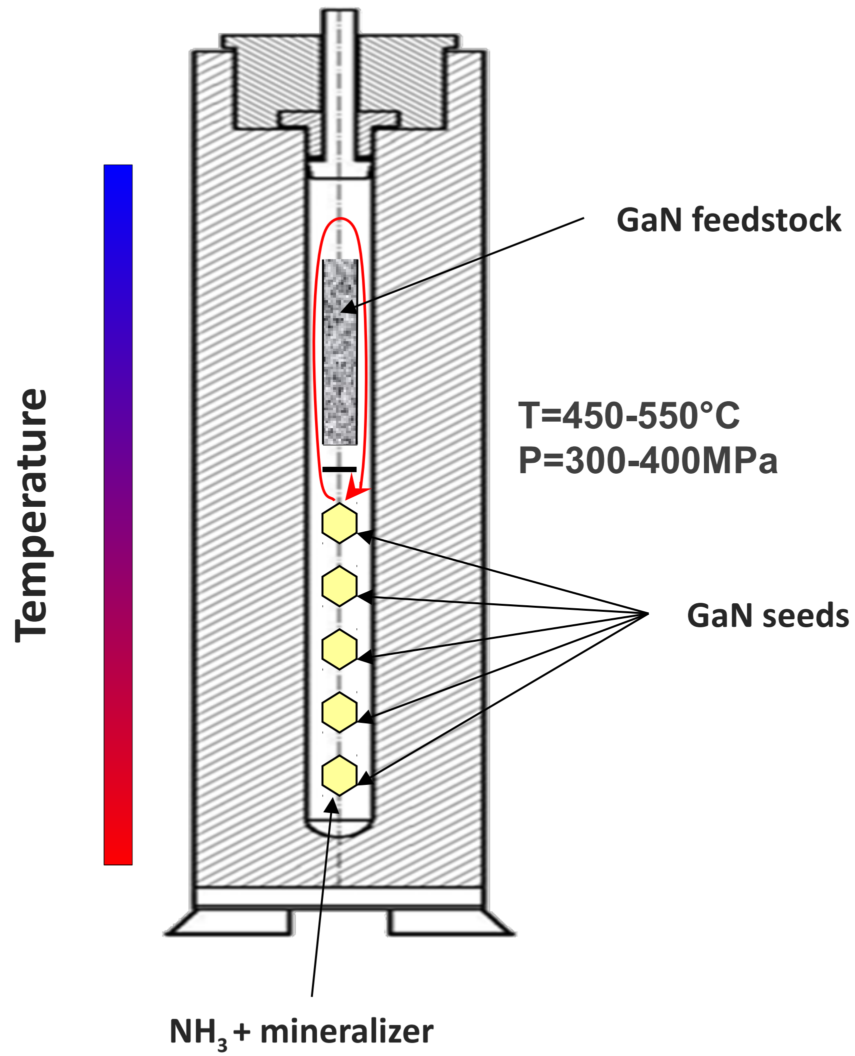
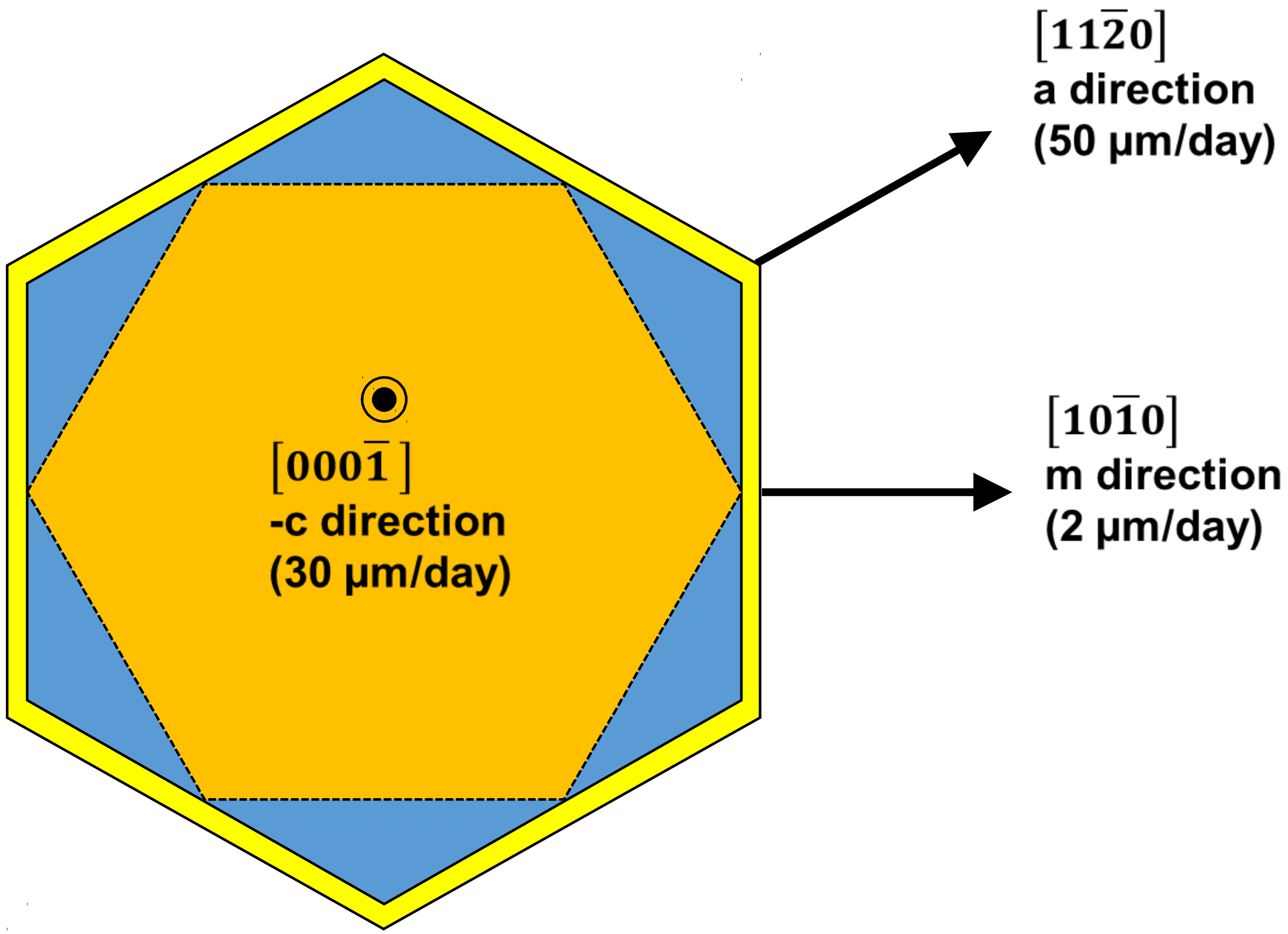


Fig. 5. (0 0 0 2) X-ray rocking curve of AMMONO-GaN.

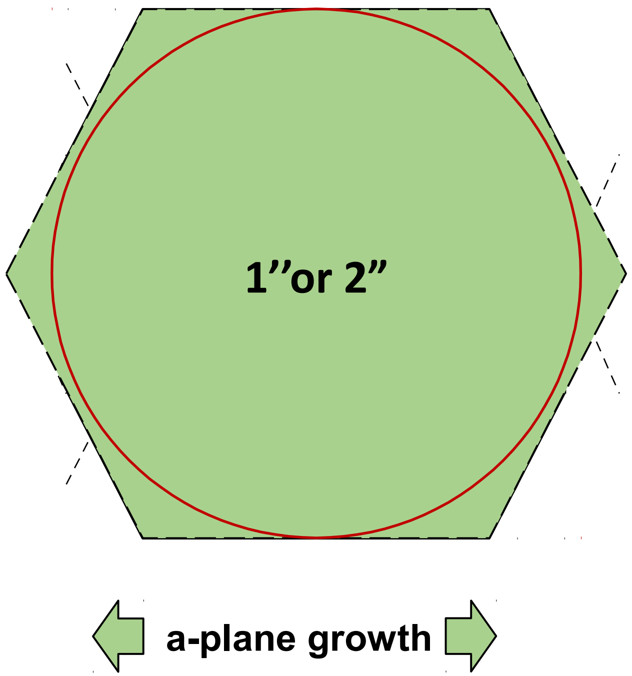
Ammonothermal method – growth rate

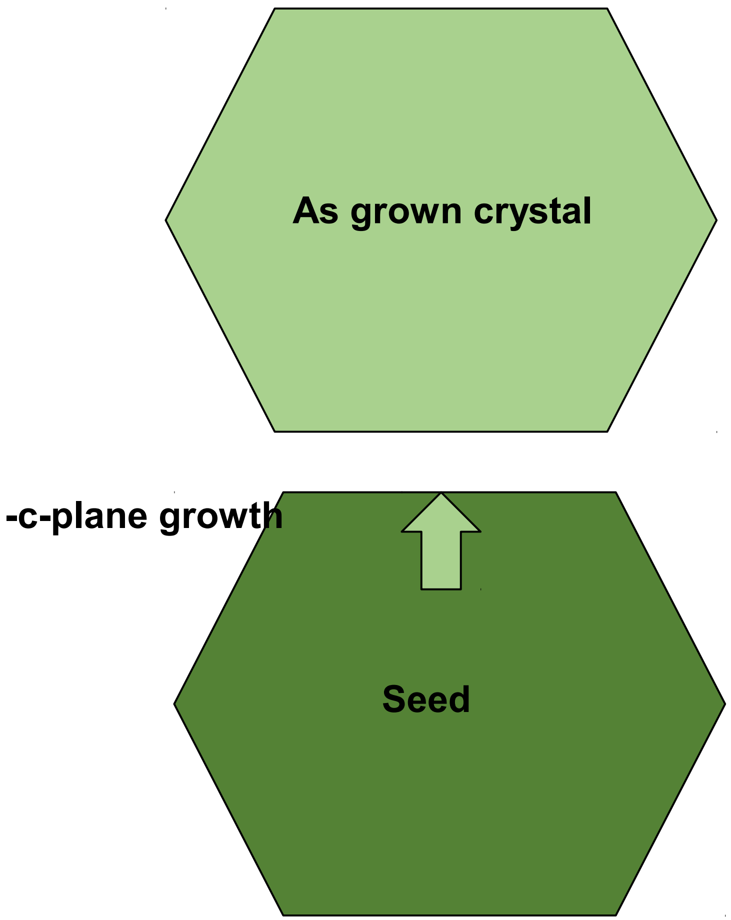




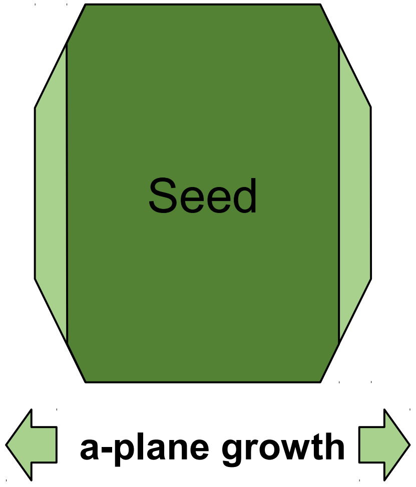
M. Zajac et al., Progress in Crystal Growth and Characterization of Materials 64 (2018) 63–74

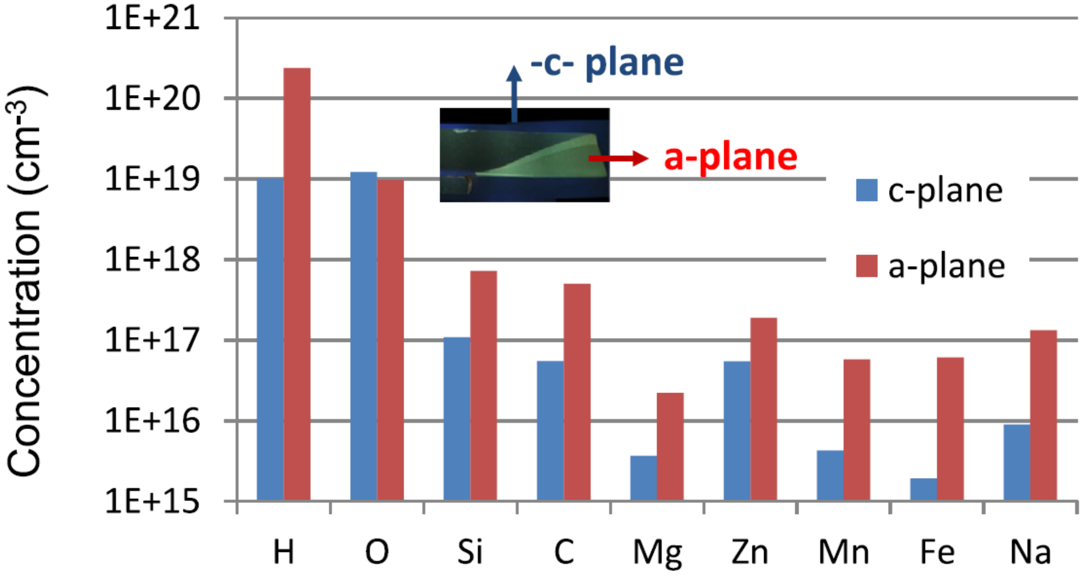
Ammonothermal method – two crystallization runs

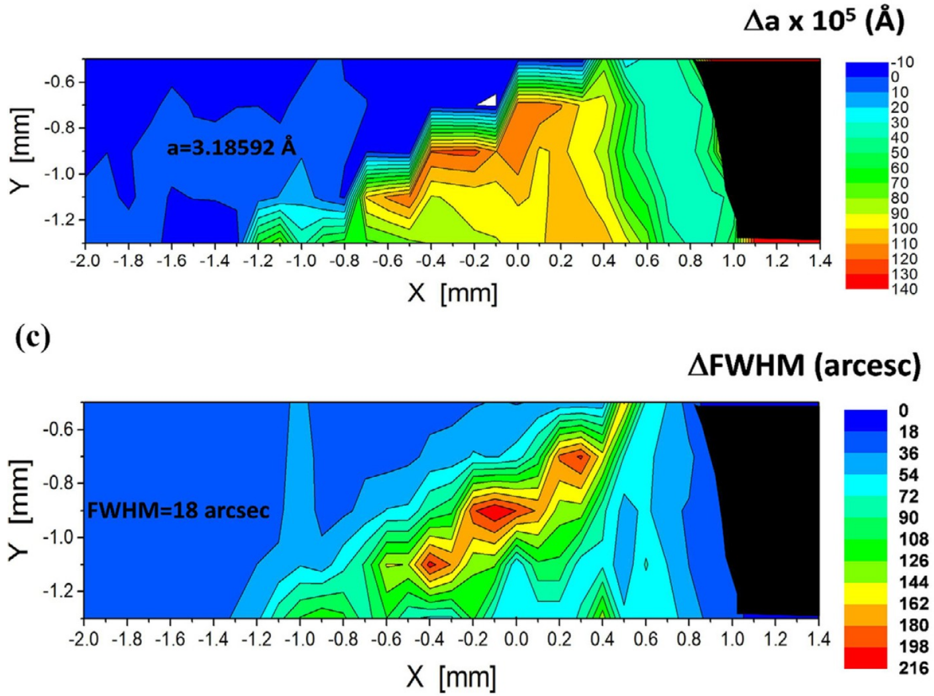




Ammonothermal GaN – limiting factor







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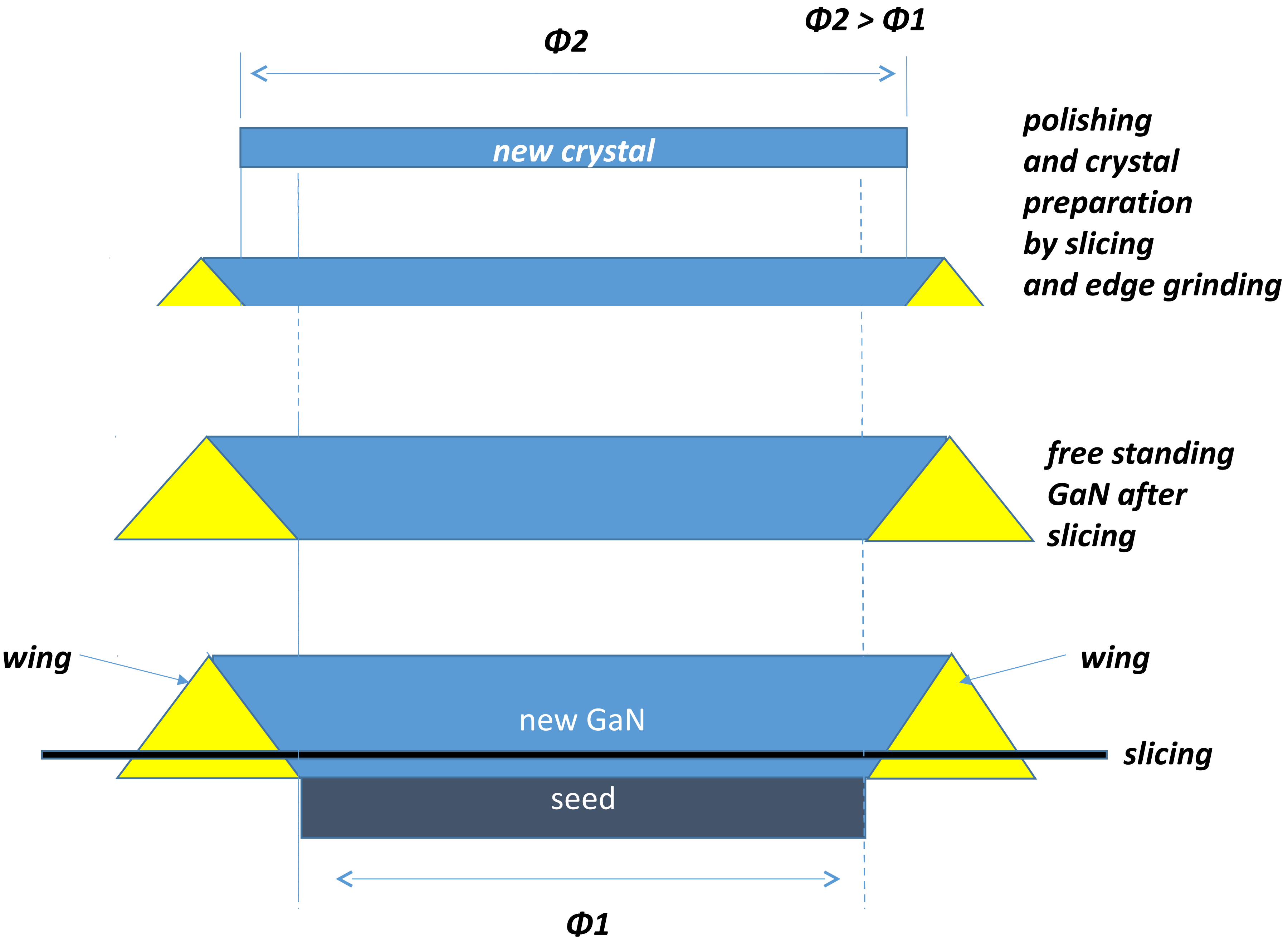

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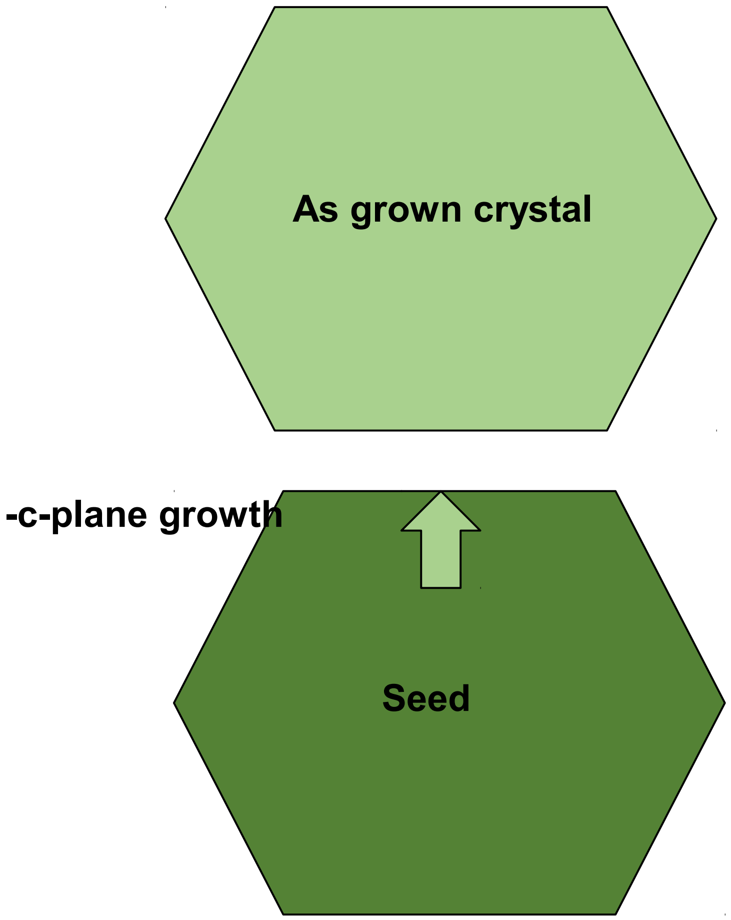
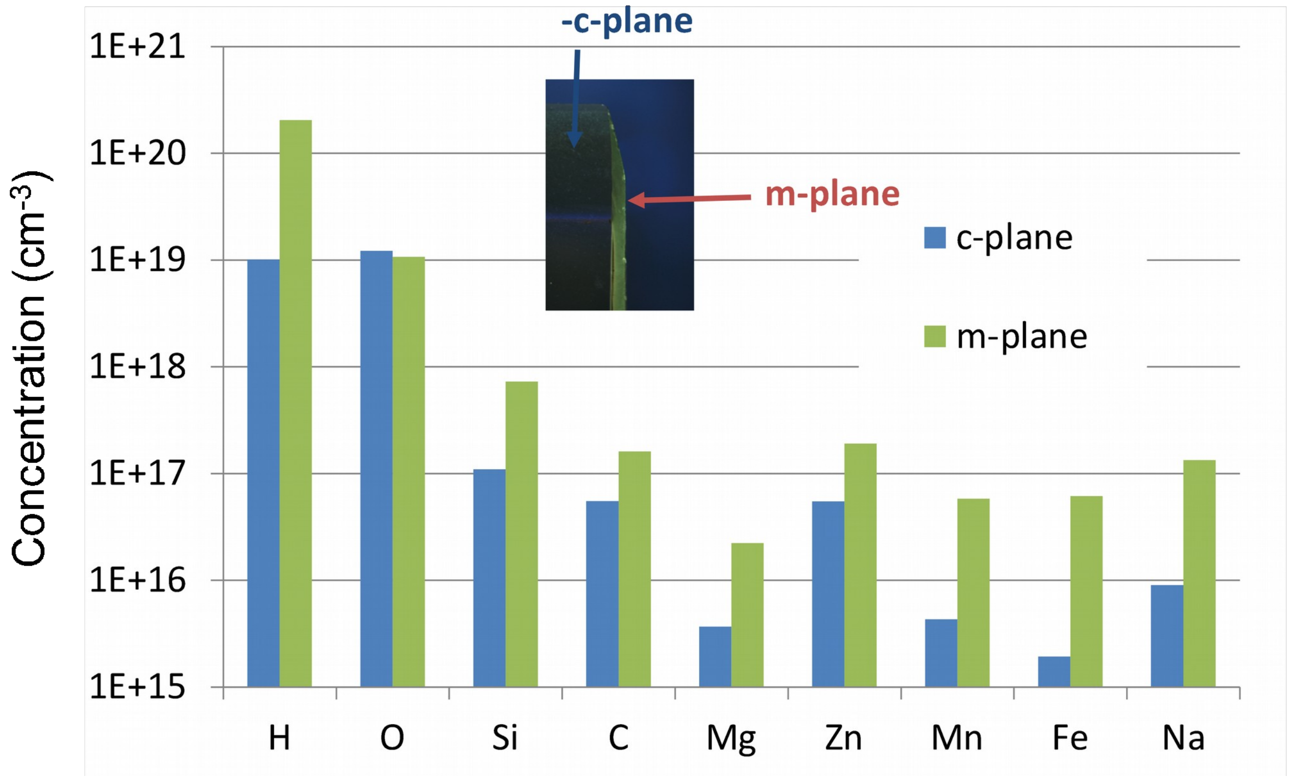
Ammonothermal GaN – limiting factor





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Ammonothermal GaN substrates

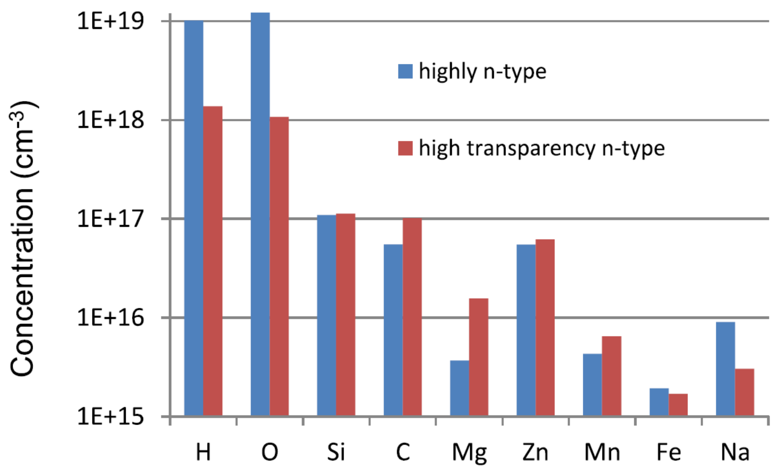
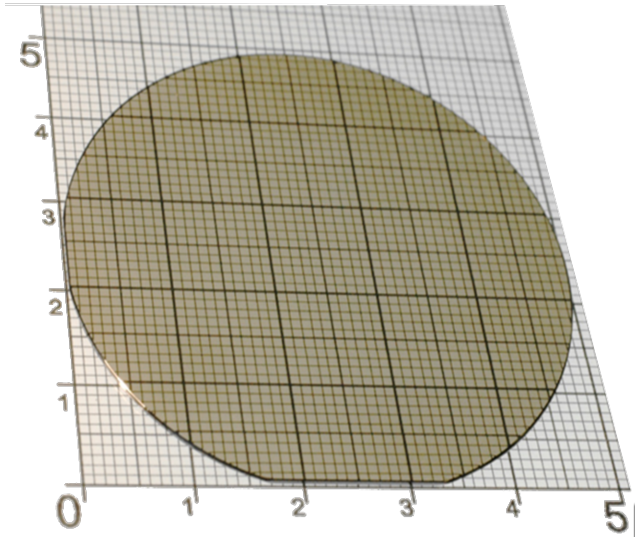
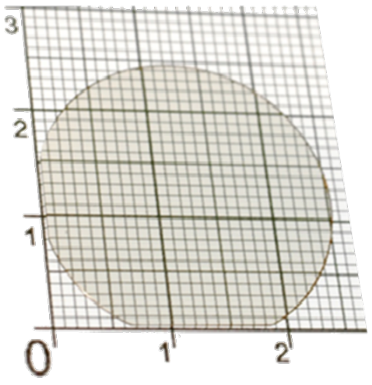
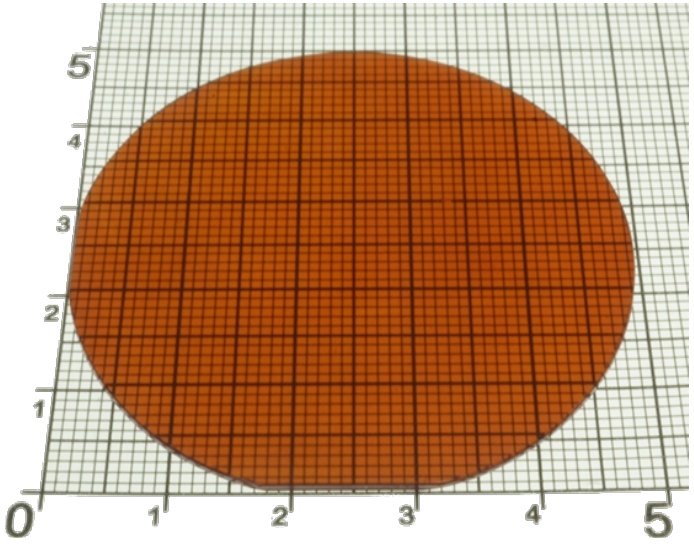


Fig. 13. Concentrations of elements measured by SIMS in n-type of a high carrier concentration and high transparency crystals.







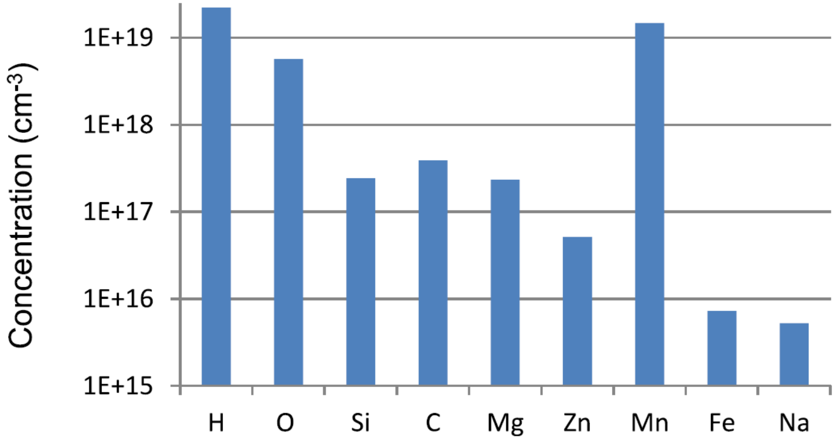
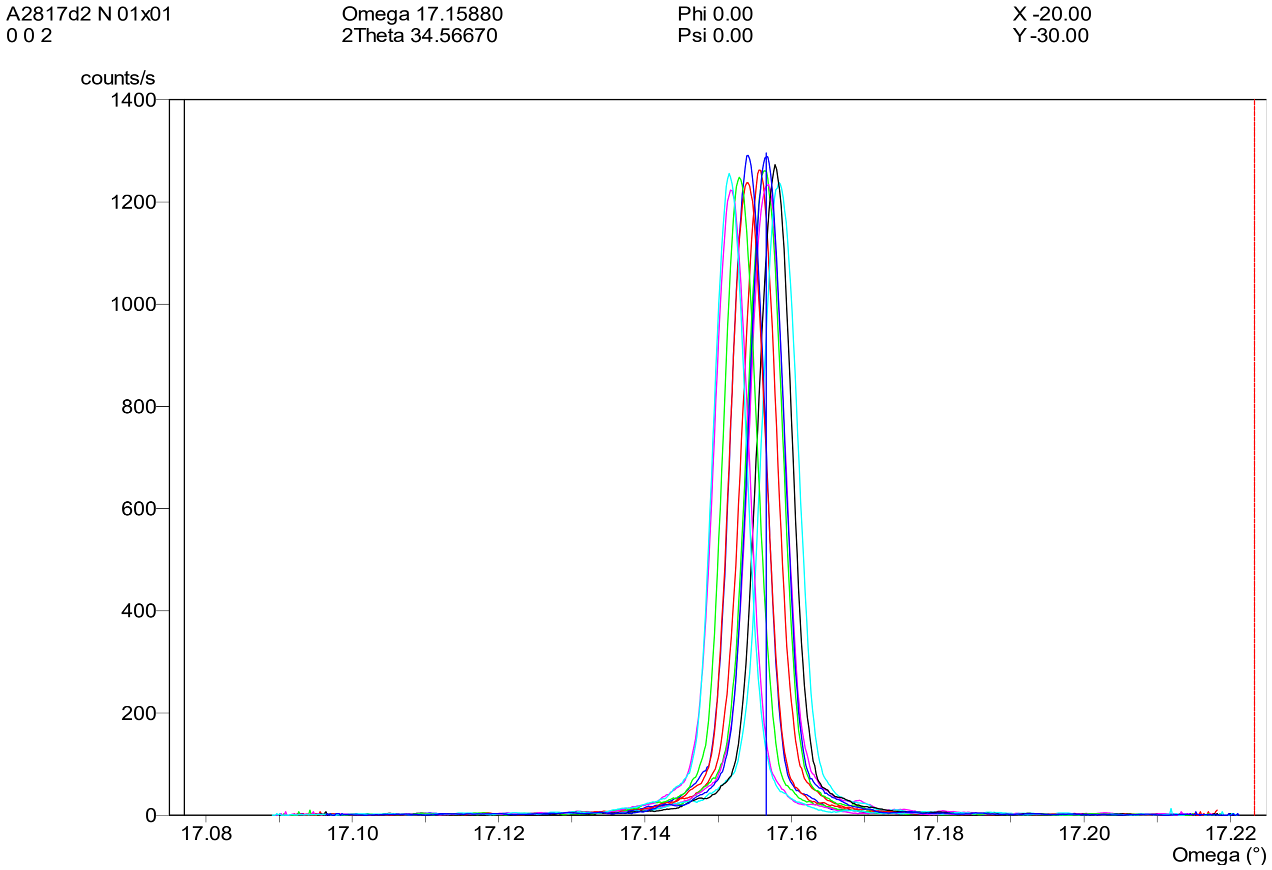
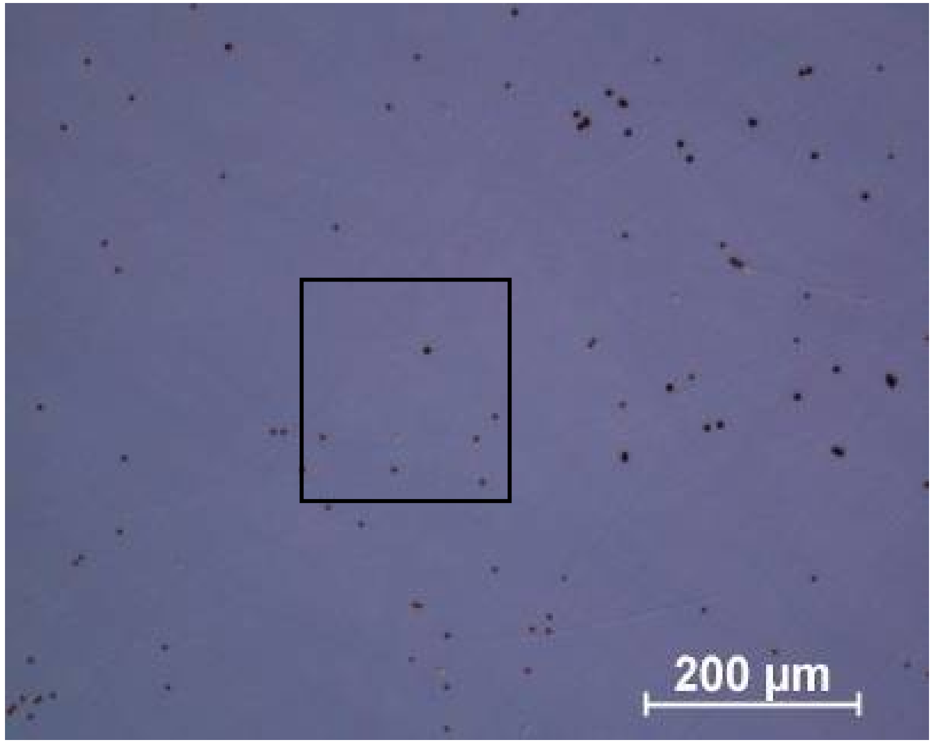


Fig. 22. Concentrations of chemical elements measured by SIMS in semi-insulating GaN doped with Mn.

Ammonothermal GaN substrates



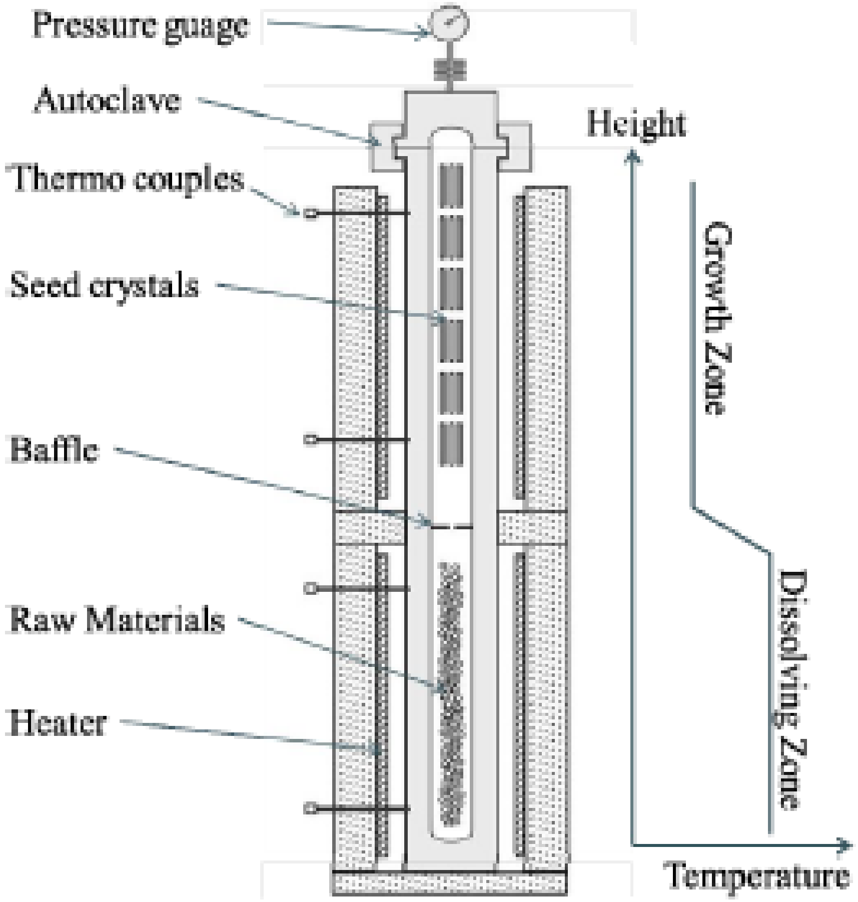


R_{curve}= 142-165 m, FWHM = 20 arcsec

Etch pit density – $5x10^4$ cm^{-2}

Ammonothermal method SCAAT™

SuperCritical Acidic Ammonia Technology



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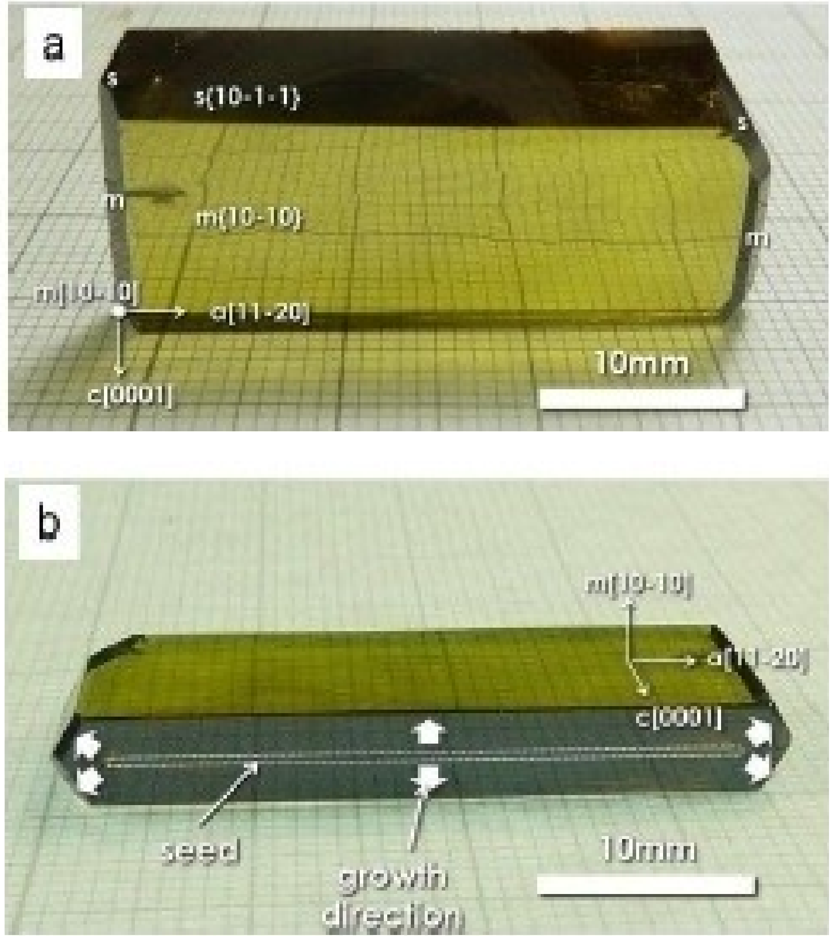

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