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MOVPE Growth at Sandia in the Taiyo Nippon Sanso SR4000 MOCVD System.

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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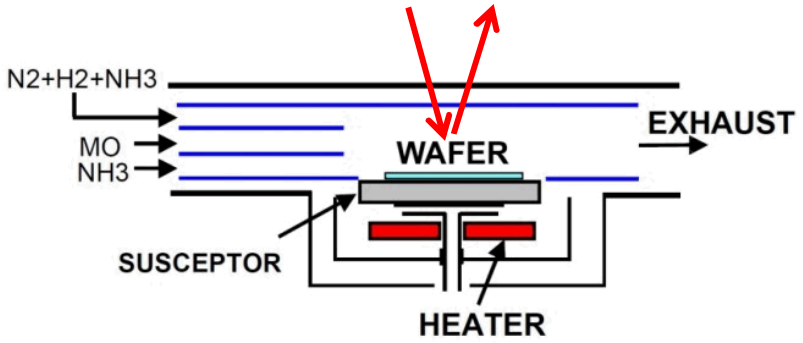
Delivery and Install at Sandia National Laboratories

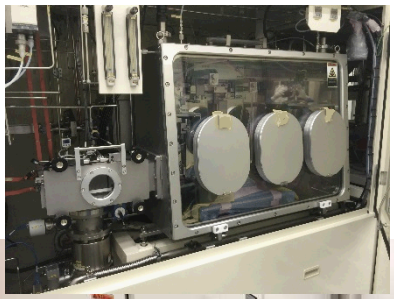
Accepted December 11, 2015

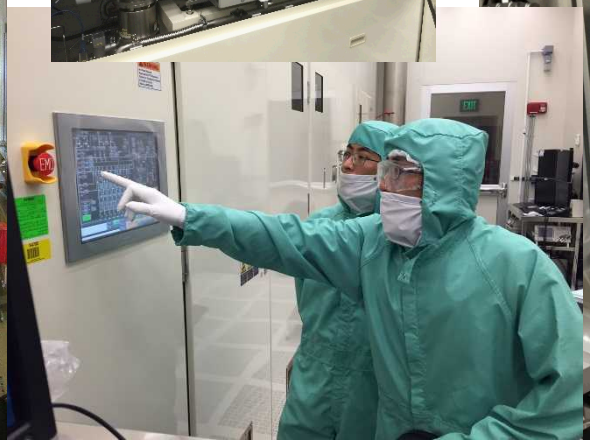
Atmospheric and reduced pressure growth
High Temperature, up to T = 1350 °C

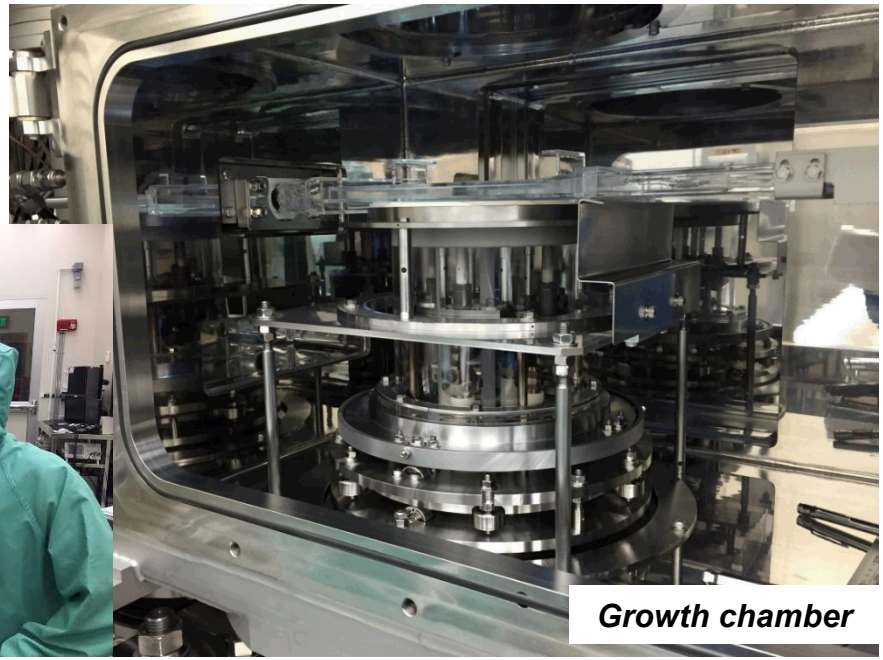
Acceptance Criteria included GaN, InGaN, ar
AlGaN thickness and composition uniformity
and doping both background and intentional.

Equipped with a Growth monitoring
LayTec epiTT and EpiCurve systems









Growth chamber

High Temperature AlN on sapphire

Testing the Reproducibility of AlN growth on sapphire

1320 °C AlN 2.7 µm
920 °C AlN 100 nm
Sapphire

7). Grow AlN,1 SLM NH_3 for 50 min ~ GR > 3 µm/hr.

6). Decrease pressure to 13 kPa.

5). Heat to 1320 ºC.

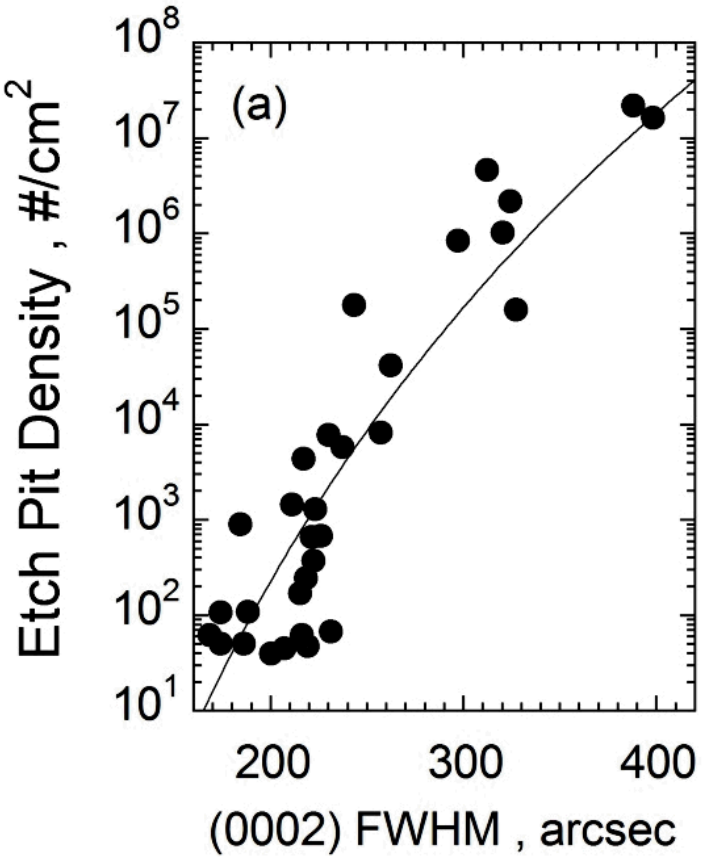
4). Grow AlN NL, 0.3 SLM NH_3.

3). Dose 1 SLM NH_3 for 7 min.

2). Increase pressure to 40 kPa.

1). Heat sapphire to 920 ºC.

Recipe developed by A. Mishima and K. Ikenaga during tool install.



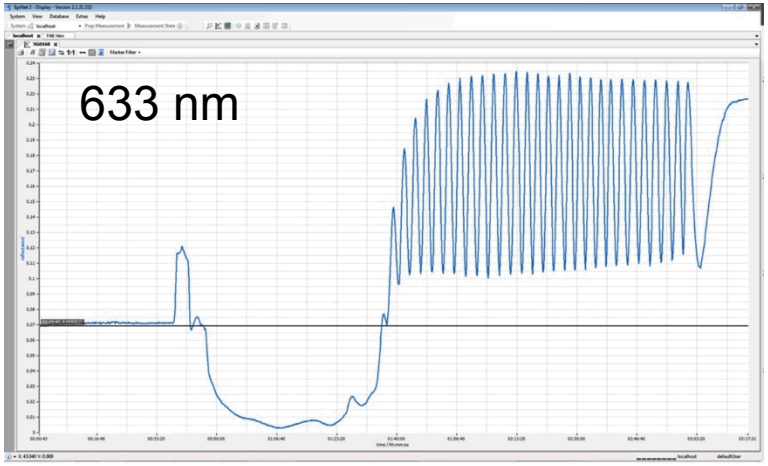
Lower (0002) FWHM – lower EPD

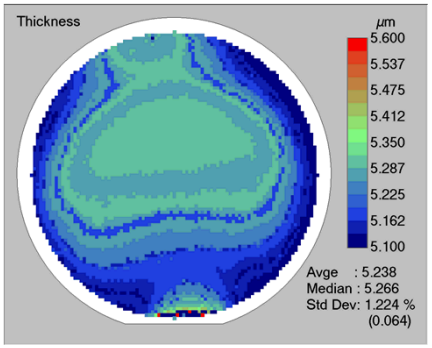
Achieved AlN on sapphire with EPD < 100 cm^{-2}

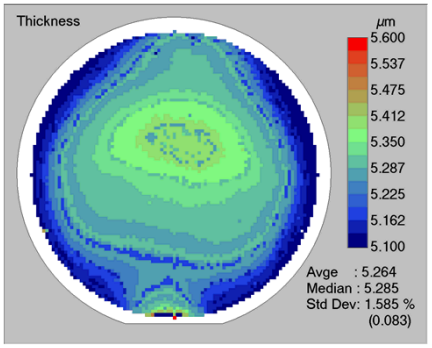
Delayed Recovery GaN on Sapphire

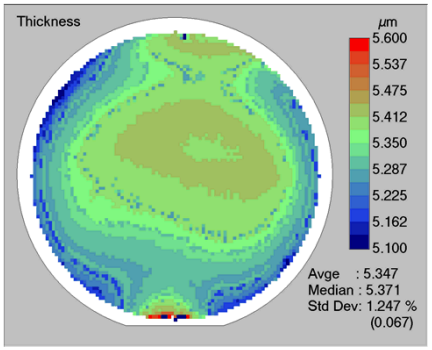
- Qualification GaN growth recipe, modified slightly.
- Thickness uniformity of 1.5 % for ~ 5 μm thick GaN at a growth rate of 2.7 μm/hour.
- XRD linewidths suggest dislocation densities
  - (0004) = 139 arcsec, Screw component ≤ $2x10^8$ cm^{-2}.
  - (10-11) = 247 arcsec, Edge component ≤ $4x10^8$ cm^{-2}.

  following Lee, *et al*. APL 86, 241904 (2005).
- Optical reflectance shows classic delayed recovery.









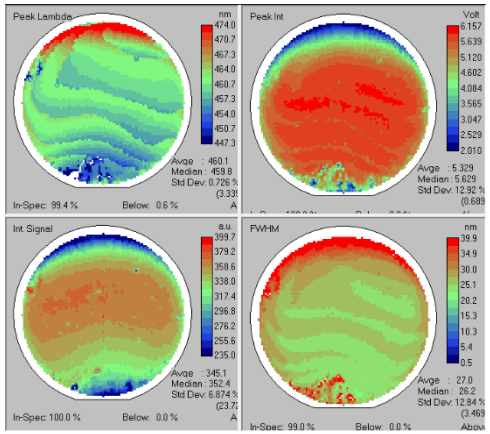
Blue wavelength MQWs on GaN on sapphire

- Changed MQW growth recipe based on qualification runs.
- Used 5 InGaN/GaN MQWs.
- Added InGaN underlayer, 190 nm thick with 4% indium.
- Varied GaN barrier and UL growth temperature.
- To achieve these results ~ 12 growth runs.

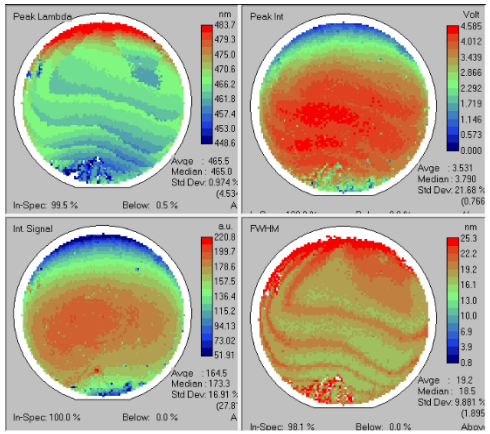
X_UL = 0.0442
h_UL = 190 nm

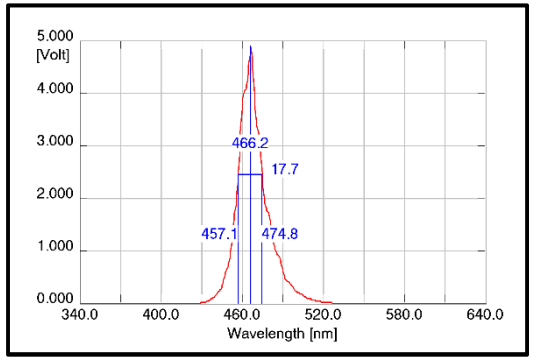
x_QW = 0.155
h_QW = 2.9 nm
h_B = 16.7 nm

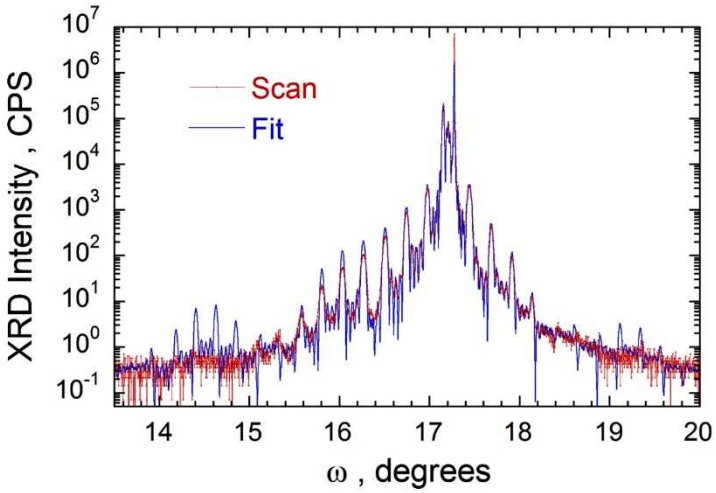
266 nm pulsed laser



325 nm cw HeCd laser







325 nm: λ = 465.5 ± 1.0 nm
266 nm: λ = 460.1 ± 0.7 nm

Estimate IQE ~ 70 %