

# AlN – From amorphous to preferentially oriented hexagonal thin films

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# Outline

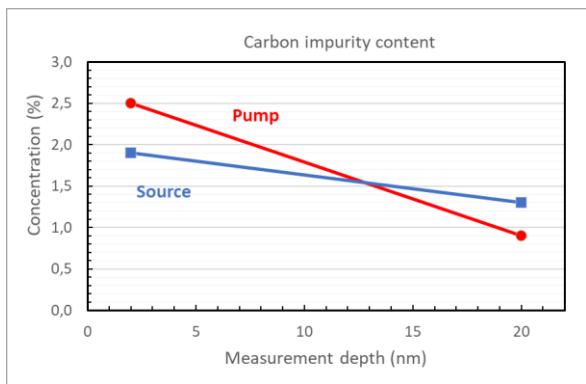
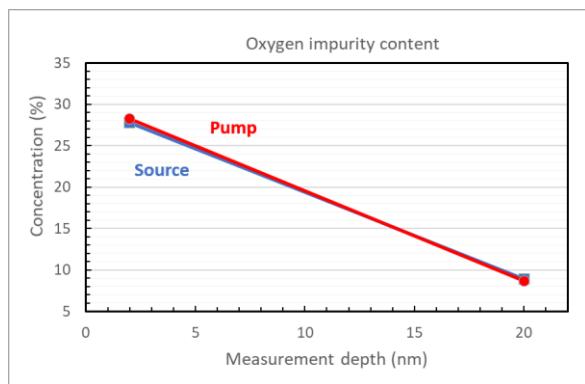
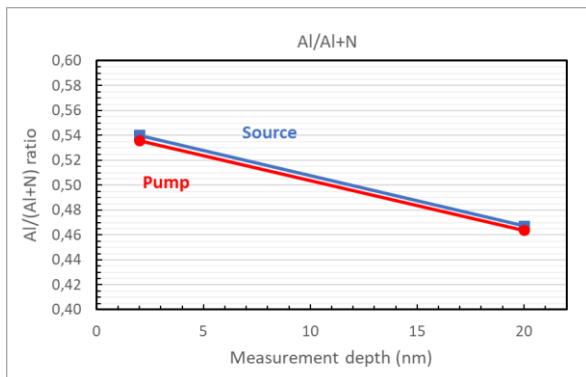
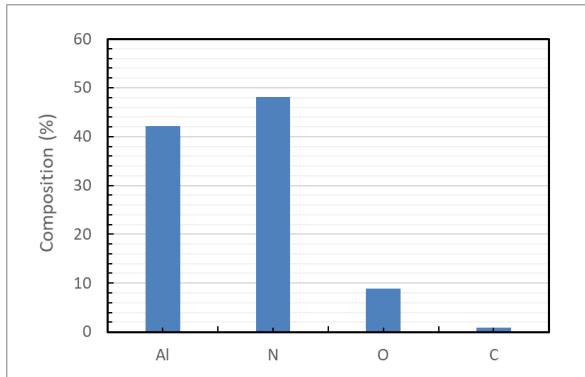
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- ALD AlN with three different processes
  - Plasma enhanced ALD
    - TMA – NH<sub>3</sub> plasma
  - Thermal ALD
    - TMA – NH<sub>3</sub>
    - AlCl<sub>3</sub> – NH<sub>3</sub>
- Conclusions

- Single wafer processing with TFS-200
  - TMA – NH<sub>3</sub> plasma
  - 220 °C
  - 200mm/8" wafer
    - Thickness uniformity 3.3%  
$$\left( = \frac{\max - \min}{2 \times \text{average}} \times 100\% \right)$$
    - Refractive index 1.875
  - Amorphous structure



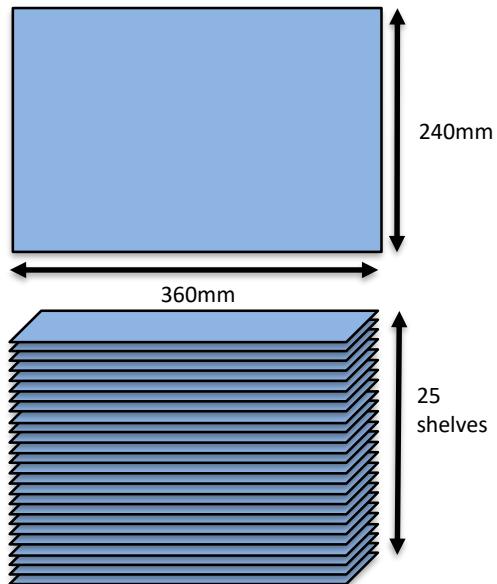
# TMA-NH<sub>3</sub> plasma – Composition



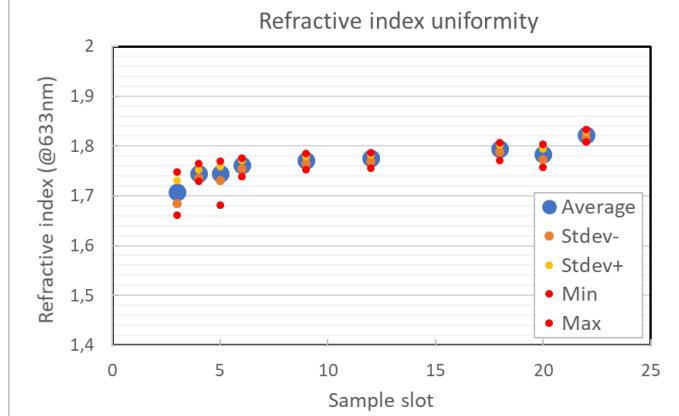
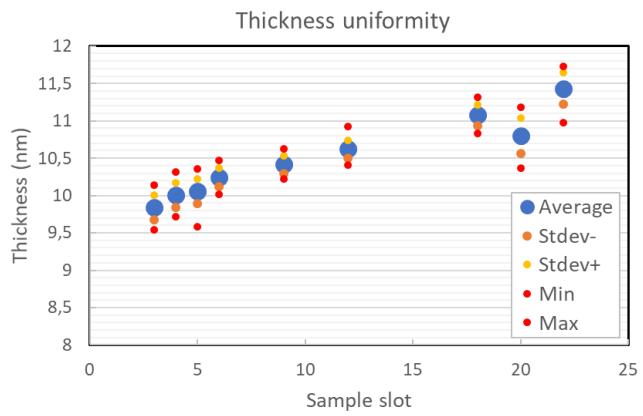
# TMA-NH<sub>3</sub> – Processing



- Batch processing in P400 reactor
  - TMA – NH<sub>3</sub>
  - 350 – 475 °C



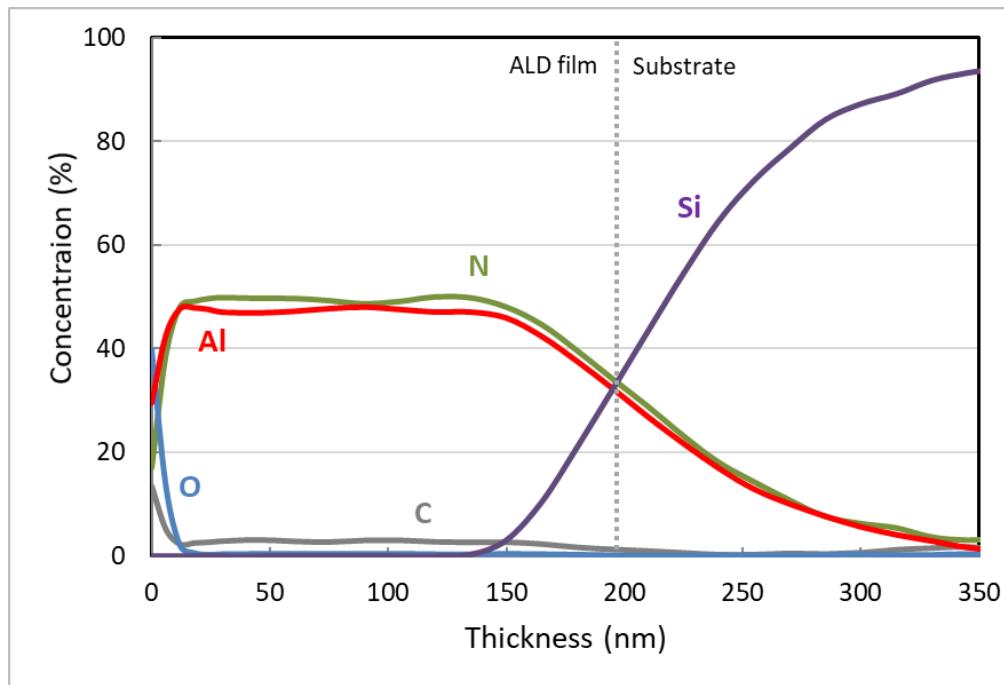
# TMA-NH<sub>3</sub> – Uniformity



# TMA-NH<sub>3</sub> – Composition



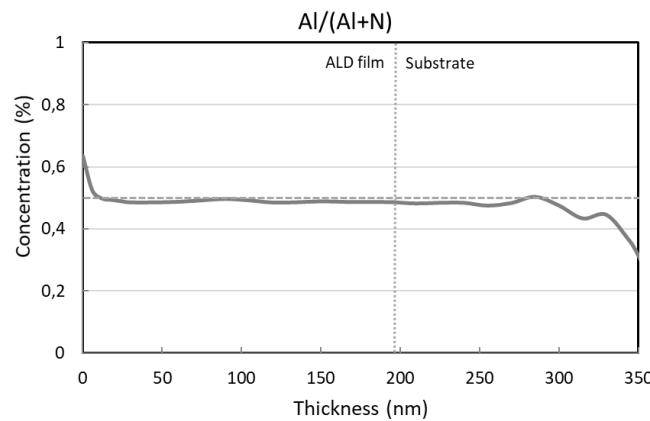
350 °C



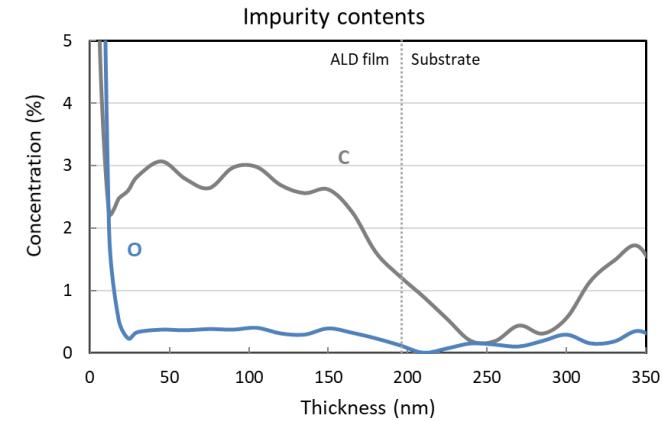
# TMA-NH<sub>3</sub> – Composition



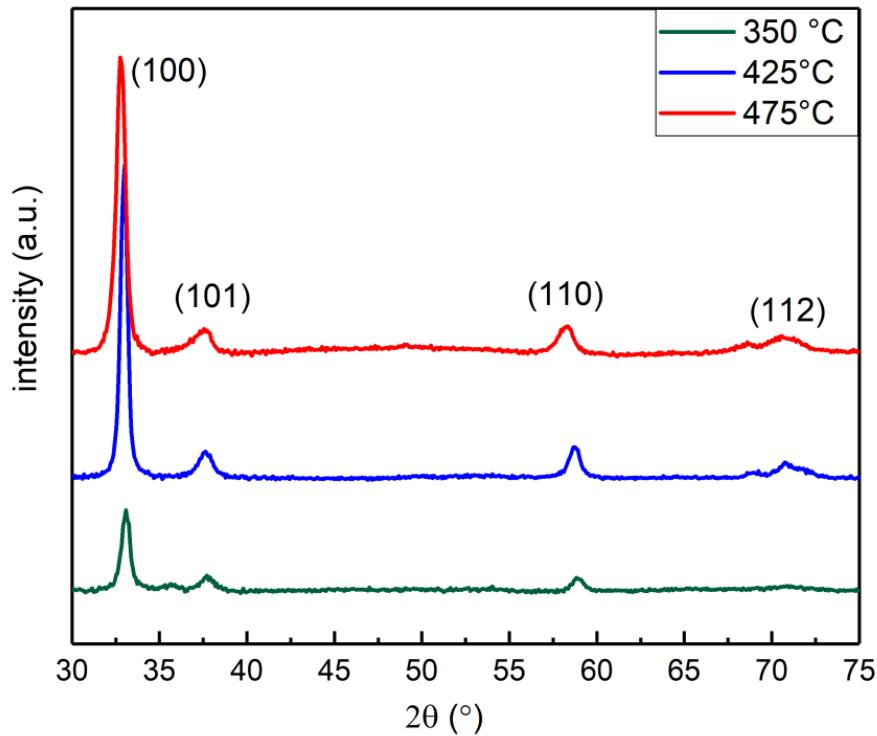
350 °C



350 °C



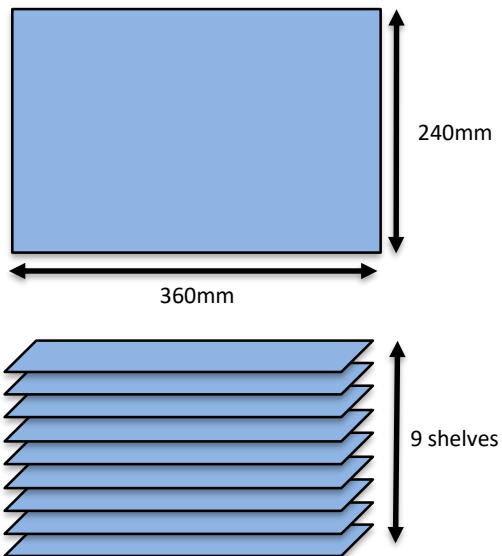
# TMA-NH<sub>3</sub> – Crystallinity



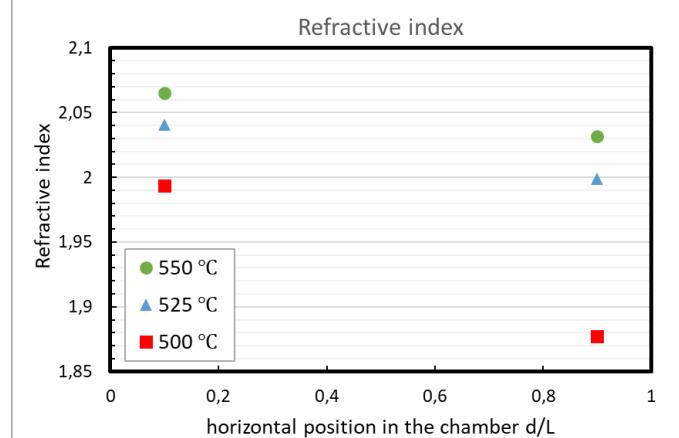
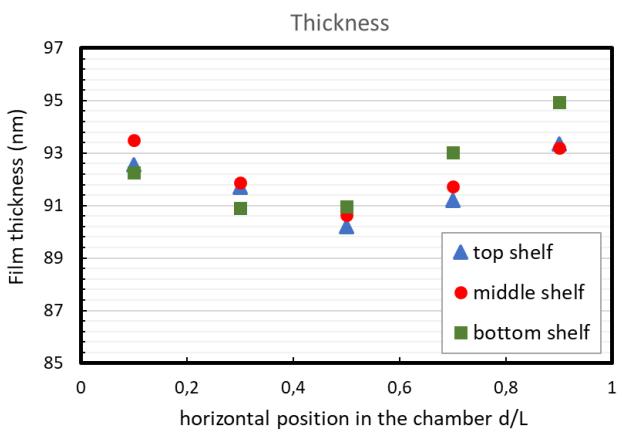
# $\text{AlCl}_3\text{-NH}_3$ – Processing



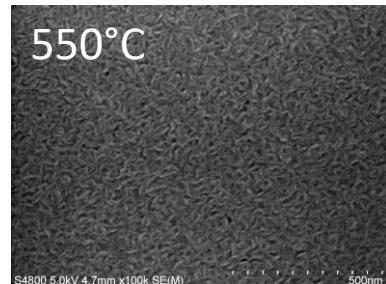
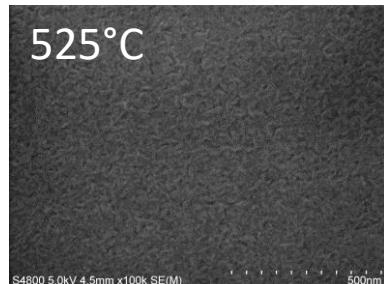
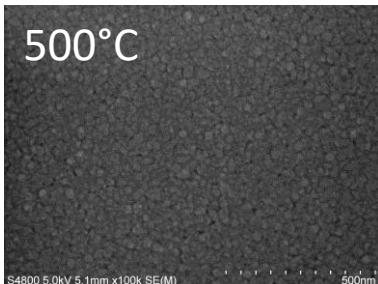
- Batch processing in P400 reactor
  - $\text{AlCl}_3 - \text{NH}_3$
  - 500 – 550 °C



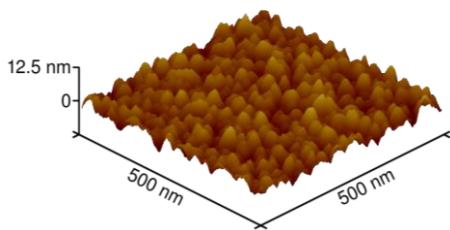
# $\text{AlCl}_3\text{-NH}_3$ – Uniformity



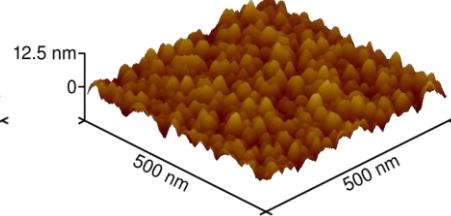
# $\text{AlCl}_3\text{-NH}_3$ – Morphology



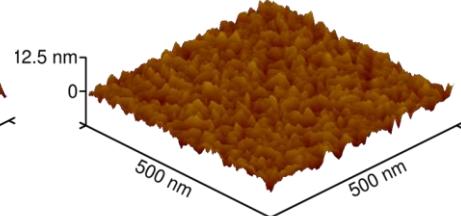
$R_q=1.7 \text{ nm}$



$R_q=1.0 \text{ nm}$



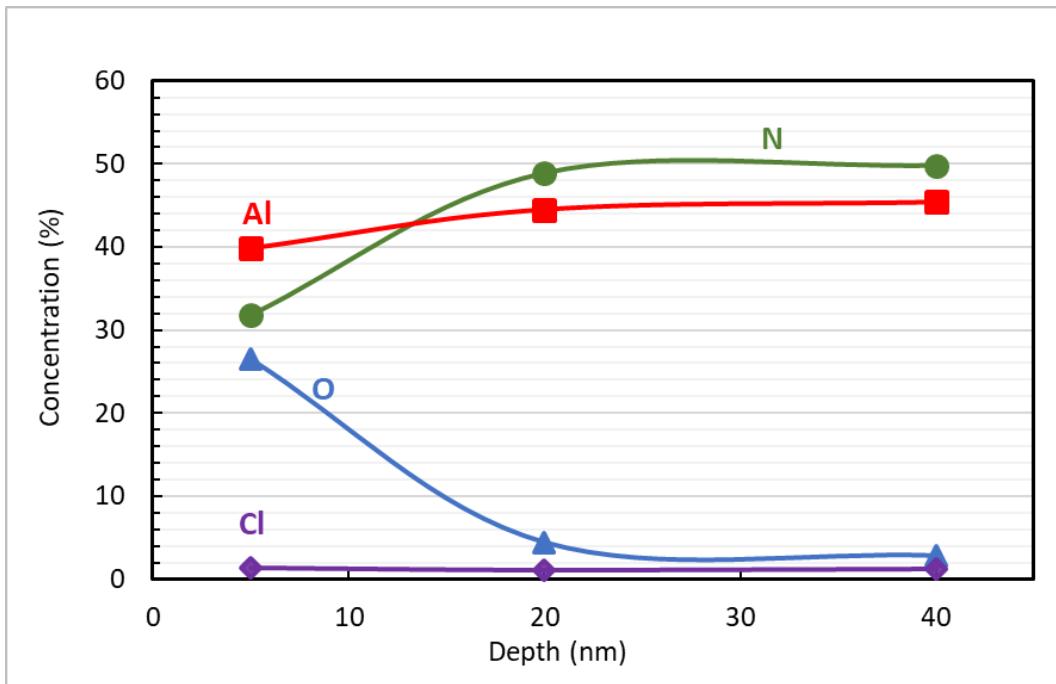
$R_q=1.3 \text{ nm}$



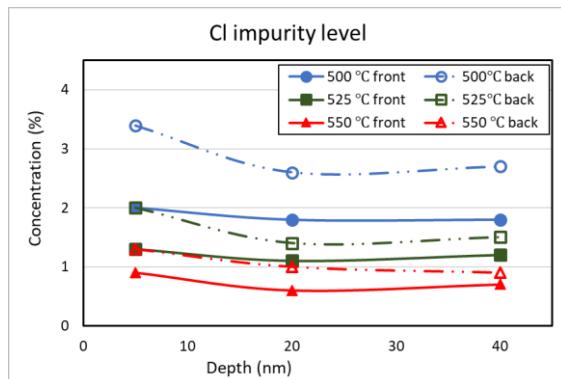
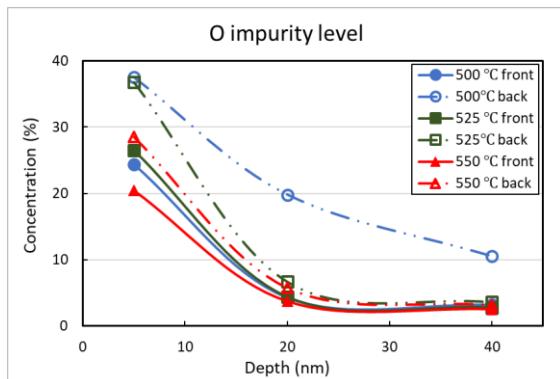
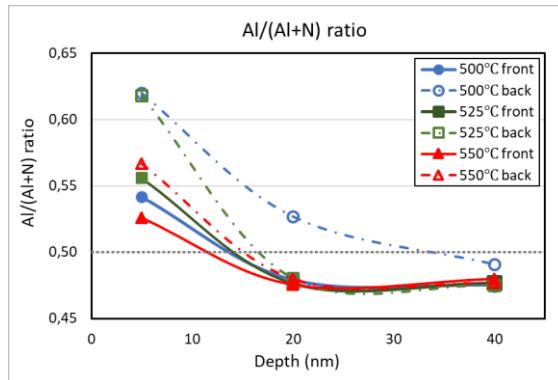
# $\text{AlCl}_3\text{-NH}_3$ – Composition



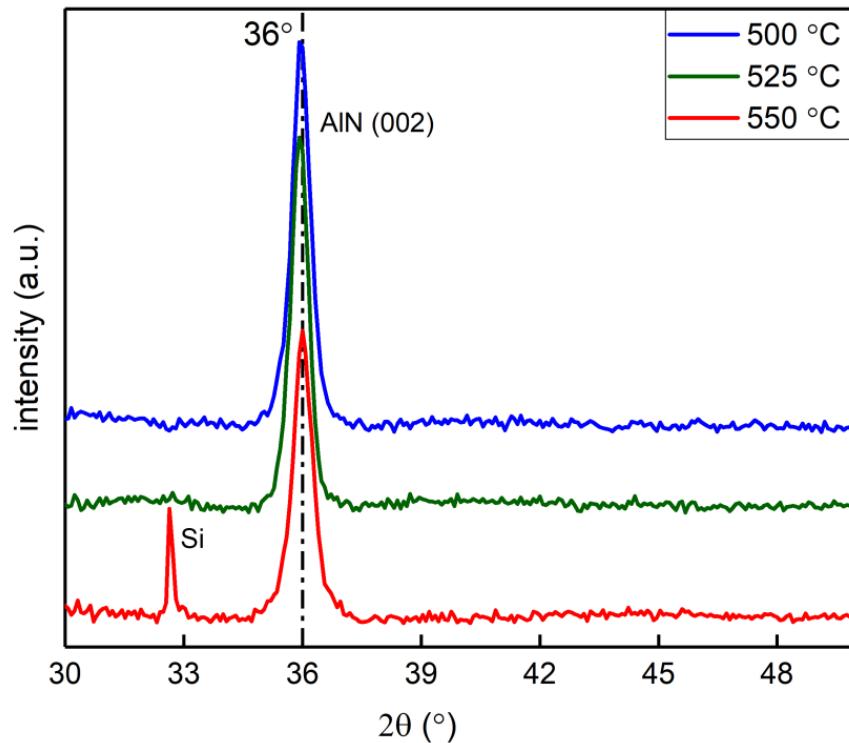
525 °C



# $\text{AlCl}_3\text{-NH}_3$ – Composition

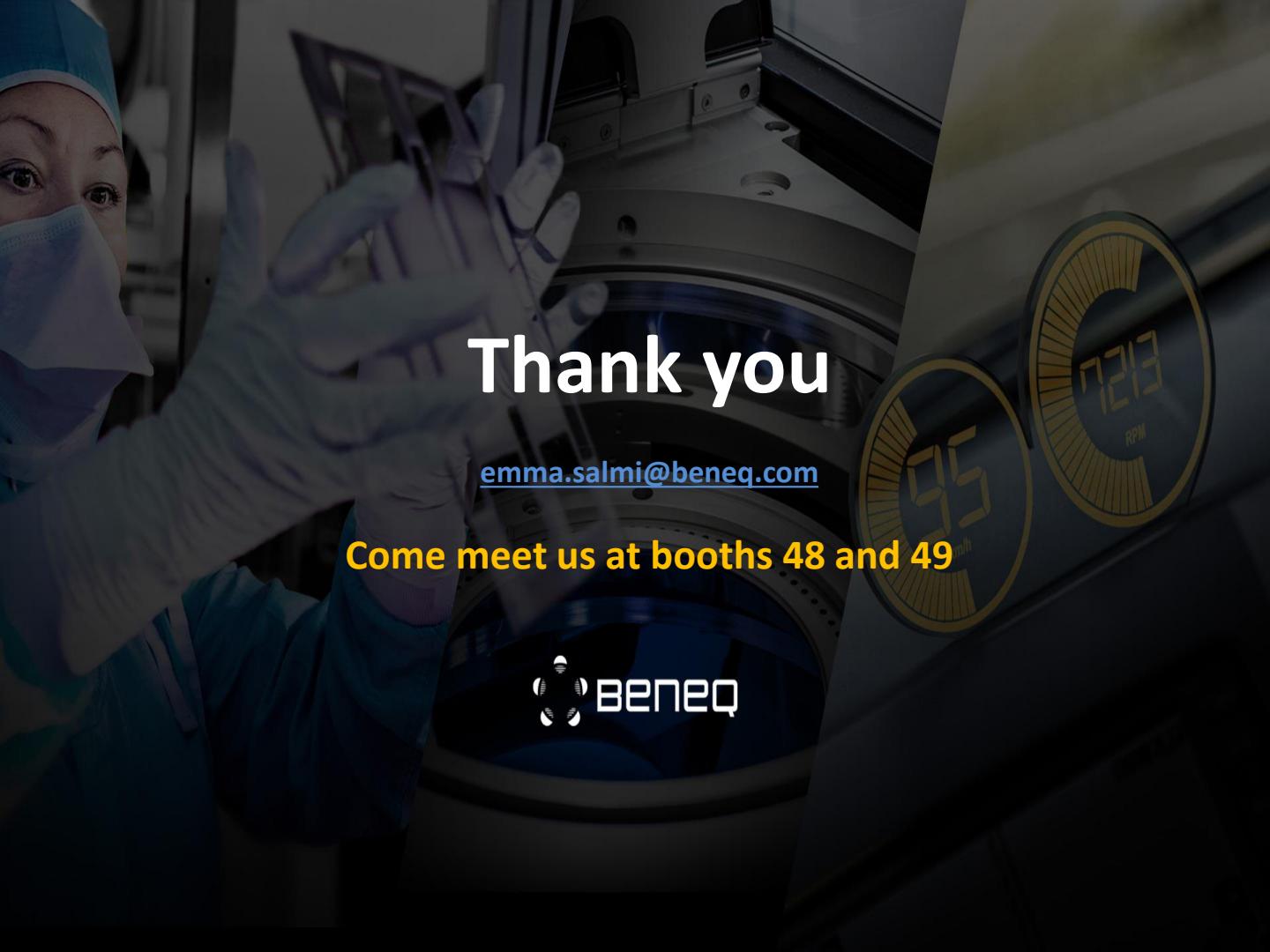


# $\text{AlCl}_3\text{-NH}_3$ – Crystallinity



# Conclusions

- AlN growth with varying crystallinity was shown
  - PEALD TMA-NH<sub>3</sub> plasma resulted in amorphous films
  - Thermal TMA-NH<sub>3</sub> and AlCl<sub>3</sub>-NH<sub>3</sub> resulted in polycrystalline films with differing orientations
- Thermal ALD processes enabled batch processing with good uniformity
  - TMA-NH<sub>3</sub> could be processed with up to 25 shelf configuration
  - AlCl<sub>3</sub>-NH<sub>3</sub> batch processing clearly improved with increasing deposition temperature



# Thank you

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