Study of Crystalline N-Polar Aluminum Nitride growth on both On-axis and off-axis Si (111)

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Introduction

This study reports the successful growth of high-quality N-polar Aluminum Nitride (AlN) on off-axis Si (111) substrates using plasma-assisted molecular beam epitaxy (PAMBE), along with a comparative analysis of AlN films grown on both on-axis and off-axis Si (111). N-polarity was verified for both on-axis and off-axis samples through in situ Reflection High-Energy Electron Diffraction (RHEED) and post-growth potassium hydroxide (KOH) etching.

Experimental Procedures

The growth starts with surface pre-treatment that includes cleaning the Si (111) substrates with RCA cleaning and buffered oxide etch followed by initial annealing inside load-lock chamber of MBE and later followed by high-temperature annealing inside the vacuum of growth chamber. A few monolayers of Al was pre-deposited following the study of N-polar AlN using on-axis Si (111) by Sansaptak et al. About !50 nm of N-polar AlN was grown and N-polarity was confirmed both from RHEED and KOH etch testing.

Results and Discussion

N-polar Aluminum Nitride (AlN) was consistently achieved in every growth attempt, confirming the robustness and repeatability of the growth process. When using on-axis Si (111) substrates, however, the significant lattice mismatch between AlN and silicon, combined with their large thermal expansion coefficient difference, often results in the formation of surface islands during epitaxy. These islands are attributed to strain relaxation mechanisms that occur early in the growth process and can lead to non-uniform surface morphology and increased defect densities.

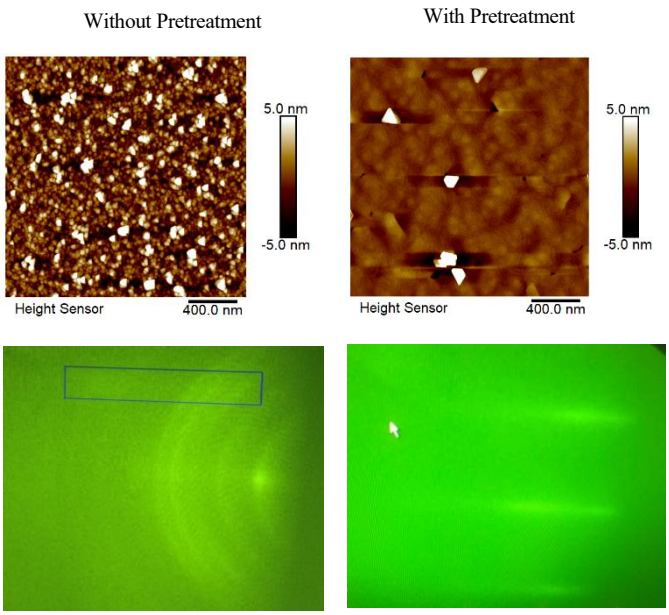

Figure 1: Impact of surface pretreatment helps with good morphology

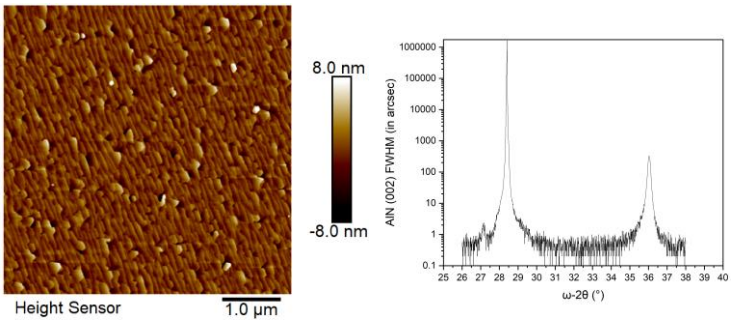

Figure 2: AFM morphology and XRD scan for AlN

References

[1] Dasgupta, S., Wu, F., Speck, J. S., & Mishra, U. K. (2009). Growth of high quality N-polar AlN (0001) on Si (111) by plasma assisted molecular beam epitaxy. *Applied Physics Letters*, *94*(15).