

# Glancing angle deposition and characterization of AlN inclined nanostructures using reactive magnetron sputter epitaxy

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Glancing angle deposition (GLAD) could be considered as a spin-off from the oblique angle deposition, which has been widely used to grow complex nanostructures by manipulating the substrate and/or source orientation during the deposition process. [1] Films deposited in such a fashion have been used in various applications such as optical, sensor and energy devices, etc. [1,2]. AlN with its large bandgap (6.2 eV), refractive index (2.1), high electrical resistivity ( $10^9$ – $10^{11}$   $\Omega$ m) and high thermal conductivity ( $180$  mWm<sup>-1</sup>K<sup>-1</sup>) [3] is already a well-documented material of choice for various applications ranging from electrical isolation, surface acoustic wave devices, vibrational gyroscopes, microelectromechanical systems (MEMS) oscillators, etc. [3].

GLAD of AlN nanostructures was performed at room temperature using a reactive magnetron sputter epitaxy and characterized by scanning electron microscopy (SEM) and x-ray reflectivity (XRR). With varying working pressure, angle of incident flux, and working distance, the AlN nanostructures with a large inclined angle  $\sim 40$  degree from substrate normal was achieved. An increase of growth rate from 1 to 1.8  $\text{\AA}/\text{s}$  with increasing working pressure from 1.5 to 10 mtorr was also observed at a working distance of around 5 cm, indicating sputtering under non-poisoning target condition. XRR results show that the AlN growth rate is highly dependent on the working distance and pressure with about 4 times reduction when the working distance is increased to 10 cm (at a constant 5 mtorr pressure, AlN growth rate at 5 cm working distance was measured to be 1.3  $\text{\AA}/\text{s}$ , but for 10 cm working distance it reduced to 0.3  $\text{\AA}/\text{s}$ ). SEM images show that the film grown at low pressure of 1.5 mtorr is consisted of discrete fan-shaped layers, constructed with coalescent nanorods, with a tilting angle of  $\sim 40$  degree. At higher working pressure, the film morphology turns to be less layered structure consisted of bundles of nanorods while reducing tilting angle. The above results indicate that the growth mode changes from directional ballistic shadowing to ambient/scattered flux from low to high working pressure [1]. The study is being made to optimize and establish the basis for growth and characterizations of other nitrides, such as InN and InAlN.

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