# High-power impulse magnetron sputtering for nitride thin film deposition

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High Power Impulse Magnetron Sputtering (HIPIMS) is an advanced thin film deposition technique used in materials science and semiconductor industries [1]. In HIPIMS, a high voltage pulse is applied to a magnetron target, creating a high-density plasma composed of metal ions and electrons. This intense plasma bombardment results in highly efficient sputtering of the target material, allowing for precise and uniform deposition of thin films onto substrates.

Deposition of aluminium gallium nitride (AlGaN) thin films using co-sputtering technique using HiPIMS and RF magnetron sputtering method at room temperature. Al target and GaN target (99.999%) purity with a 3 inch-diameter is used. Evacuate the deposition chamber to a base pressure of range $8 \times 10^{-6}$ Torr. The target to substrate distance is ±15 cm and 45° target holder angle from substrate holder. The pre-sputtering of the target must be performed for 30 minutes in sputter at least to remove all the contaminants from the target. The substrate holder will rotate at 5 rpm to enhance the film uniformity. In this study, AlGaN thin films were fabricated using low Ar/$N_2$ ratio of gas flow. Then through the analysis using X-ray diffraction (XRD), Raman spectroscopy, and atomic force microscopy (AFM), the effects of $N_2$ flow rate on the structure and morphological features of aluminium gallium nitride (AlGaN) film were studied.

Figure 1 shows that at 10 % of nitrogen concentration, only pure aluminium thin films were obtained. This result indicates that the supply of N in the form of N atoms and/or N+ plasma is inadequate for the creation of an AlGaN polycrystal. XRD pattern of AlGaN in shows the existence of polycrystalline hexagonal AlGaN peak (ICSD pattern: 98-016-8157) for nitrogen concentration at 20% and 30%. The addition of nitrogen up to 20% has a direct impact on the film structure. The dominant peak for both samples of are (100) plane at 33.33°. Other than that, there are peak of AlGaN (101), (110) and (112) plane at degree of 37.81°, 59.25° and 71.13° respectively.

The full width half maximum (FWHM) of sample N2 and N3 which at 20% and 30% of nitrogen concentration are 0.754° and 0.622°, respectively. FWHM of sample N3 are lower than sample N2 which shows that AlGaN films in that samples have good crystallinity. According to Pandey et al. [2], the smaller the FWHM indicates the film is highly textured (less orientation distribution randomness) with good crystalline perfection. These facts indicate that the crystalline quality could be improve significantly by increase the N2 concentration 30%. However, increasing the N2 concentration above 30% show the AlGaN films were amorphous and disappeared of AlGaN crystal structure. The degree of crystallinity was calculate to determine the crystallinity of the overall samples. The degree of crystallinity of each samples were 44.18%, 58.41% and 47.92% for AlGaN films at 10%, 20% and 30% nitrogen concentration, respectively. From the results, which shows that at 20% of N2 concentration have the highest value of crystallinity followed by 30% and 10% N2 concentration. The degree of crystallinity refers to the degree of structural order in a solid, the higher the degree of crystallinity, the arrangement of the particle in solid was in well-ordered.

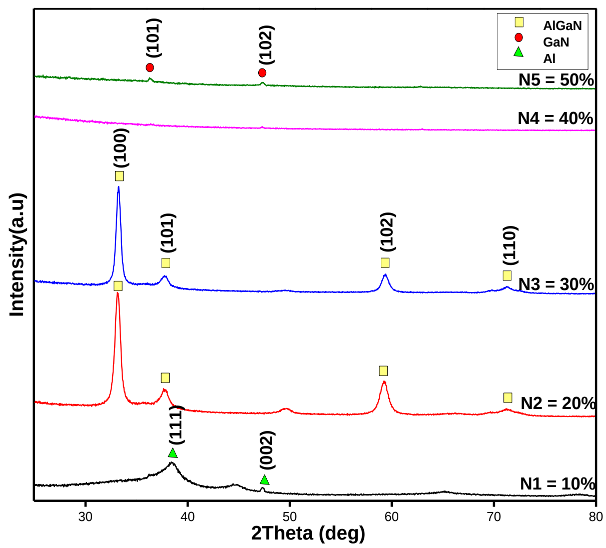


Figure 1: X-ray pattern of sputter deposited thin films at different nitrogen concentration.

References

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