

A Structural Comparison of AlN Layers Grown on Basal Plane Sapphire and SiC Substrates by MOCVD

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Basal plane sapphire is the most commonly used substrate for the growth of epitaxial II-V nitrides. However, the epitaxial growth orientation of the two crystals produces a large lattice mismatch (-1.3%) between the $(\bar{1}2\bar{1}0)_{\text{Al}_2\text{O}_3}$ and the (T100)_{AlN} planes. Basal plane 6H-SiC has been considered a better substrate for the growth of AlN since the lattice mismatch is only 1%. We have used transmission electron microscopy and atomic force microscopy to study how the mismatch is accommodated for the metalorganic chemical vapor deposition of AlN on both sapphire and SiC.

In the case of growth of the nitride on sapphire, the mismatch contributes to an initial islanded growth mode. Further growth results in a columnar structure for the epitaxial layer with a high density of structural defects. These defects lie along the [0001] direction delineating the boundaries of the individual columns. The AlN columns have a flat-topped pyramidal topography bounded by $\{\bar{1}2\bar{1}2\}$ -type and (0001) facet planes. In contrast GaN grown on sapphire produces generally flat topped columns i.e. bounded by the (0001) plane. Such a faceted surface in the case of AlN would contribute to strain relaxation though at a cost of increased surface energy. This suggests that the different growth modes of the two nitrides is due to a difference in the surface energies of their various crystallographic facets, with (0001) surface energy of the GaN lying at a more pronounced minimum in its Wulff plot.

Although evidence for islanded initial growth is present for AlN layers grown on SiC substrates, coalescence appears to occur within a few monolayer, leading to a planar growth mode. No columns were observed in the AlN layer as seen in the previous case. A high density of threading dislocations were observed ($\sim 10^{10}/\text{cm}^2$ at a thickness of 100 nm from the interface). The high density of dislocations and the initial island type growth mode observed will be discussed in the light of the lattice mismatch, interracial bonding, substrate cleanliness and growth conditions of this system.