Fabrication of a-plane AlN pseudosubstrates grown by Molecular Beam Epitaxy

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High quality native AlN substrates used to develop ultraviolet (UV) and deep UV (DUV) emitters, such as light emitting diodes (LEDs) and laser diodes (LDs)[1,2] are an extremely successful choice. Unfortunately, suitable low-cost, large-area AlN native substrates are not available, and AlN is typically grown hetero-epitaxially on substrates like silicon, sapphire or SiC. These approaches generate a high density of threading dislocation (TDs)[3,4] which is detrimental to electron mobility and reduces the quantum efficiency of UV emitters[5]. In addition, the strong internal electric field, present along the polar direction, may be detrimental to device performance because it modifies the carrier distribution and potential profile in Quantum Wells (QWs) and favors the emission energy shift by screening effects. These negative effects can be avoided by growing devices on non-polar AlN buffers.

This work reports on the growth by Plasma Assisted Molecular Beam Epitaxy (PAMBE) of a-plane AlN pseudo-substrates on r-sapphire by controlled coalescence of ordered AlN nanocrystals (etched nanopillars, NPs) following three steps: i) growth of a-plane AlN buffer on r-sapphire, ii) etching down of the AlN buffer to obtain an array of ordered AlN NPs, and iii) AlN overgrowth until full coalescence.

Prior the growth of the a-plane AlN buffer, the r-sapphire substrate was nitridated for 30 min with a N flux of 7.5 nm/min at 860 ºC. AlN growth was then performed at 860 ºC under nominal fluxes of 7.9 nm/min and 8.3 nm/min for Al and N respectively. After that, a square pattern of ordered Ni dots was defined by e-beam lithography on the AlN buffer. Etching by inductively coupled plasma with a Cl/Ar mixture resulted in an ordered array of AlN NPs. Finally, PAMBE overgrowth on the AlN NPs arrays was performed with the same nominal fluxes for Al and N (i.e. 3 nm/min).

Two samples were prepared with areas having NPs with different pitch (350, 450 nm) and diameters (110 nm – 200 nm). The samples were analyzed by Scanning Electron Microscopy, Atomic Force Microscopy and Transmission Electron Microscopy to study the AlN coalescence into a continuous film and how the different geometries and sizes of the NPs affect the quality of the final AlN layer. Previous work on *m*-plane GaN[6] using similar approach shows a preferential growth rate on the NPs along the c-direction and a significant reduction of extended defect density in the coalesced film compared to the initial GaN buffer.

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