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Growth and Optical Properties of AlN/AlGaN Heterostructures on Patterned Si Substrate

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High efficiency deep ultraviolet light emitting diodes (UV-LEDs) based on AlGaN with emission wavelengths of between 200 – 350 nm have attracted considerable attention due to their wide range of applications in air, water purification, disinfection, chemical sensors, bio-medical, etc[1]. However, AlGaN growth on AlN/Si substrates is challenging to achieve and therefore there are only a few reports of AlGaN-based deep UV-LEDs. Because, the large different lattice mismatch between AlN and Si substrate (23.4%) leads to many challenges. In addition, the presence of an oxide on the surface of Si substrate also leads to low coherence between AlN template and the Si substrate. Especially, a low growth rate is the main obstruction factor to grow AlN template on Si and other substrates. Thus, the particular conventional growth of thick AlN template on Si substrate is a challenge for researchers.

In this study, we report the fabrication of micro-circle patterned-Si substrates (mPSiS) for further direct growth of thick AlN template on mPSiS by using the NH_3 pulsed-flow multilayer AlN growth and epitaxial lateral overgrowth (ELO) techniques. Thereafter, an AlGaN multi-quantum wells (MQWs) based deep ultraviolet light emitting diodes (DUV-LEDs) was pre-grown on that template. The experimental results show that a 8-µm-thick AlN template was grown at a very high growth rate on the substrates had the full widths at half maximum of 0.23° and 0.37° for the (002) and (102) reflection planes in X-ray diffraction rocking curves. Transmission electron microscopy confirmed that the dislocation density was very low (1.5×10^8 cm^{-2} (screw), 3.7×10^8 cm^{-2} (edge)). Meanwhile, AlGaN multi-quantum wells grown on that coalescence AlN template shown a sharp photoluminescence (PL) peak at 270 nm. It confirmed that the AlN template which was grown on mPSiS can be used for deep UV-LED applications.

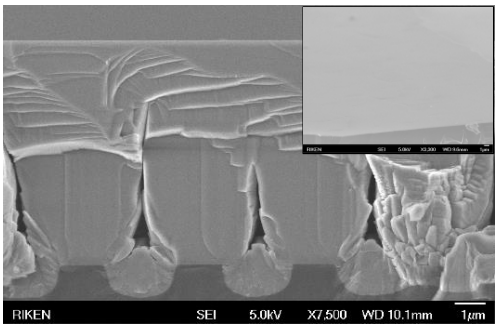

Figure 1. SEM image of AlN template grown on mPSiS and its surface morphology.

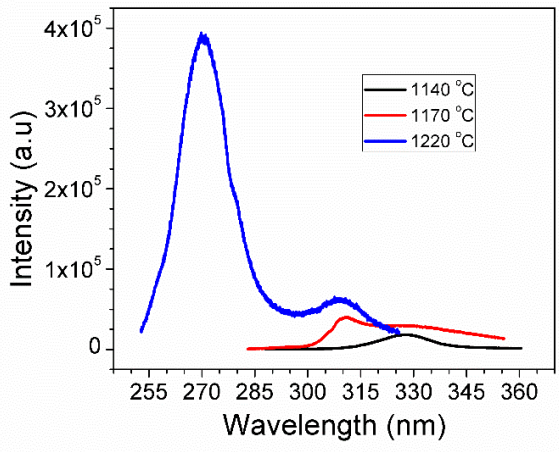

Figure 2. PL spectrum of AlGaN MQWs grown at different temperatures.

References

1. H. Hirayama, Quaternary InAlGaN-based high-efficiency ultraviolet light-emitting diodes. *Journal of Applied Physics* **97**, 091101 (2005).