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High power III-Nitride Deep UV LED Lamps

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III-Nitride visible and UV light emitting diodes (LEDs) have an enormous applications potential for indicator lights, commercial signage, automotive lighting, air & water purification, food disinfection, polymer curing and bio-medical instrumentation. The III-nitride blue-green LEDs were commercialized in the early 1990's followed by white LEDs in the early 2000's. Currently several companies offer large area and high efficiency blue-green and white LEDs and LED lamps as standard off the shelf products.

Since early 2000, our research group has developed III-N deep UV LEDs (emission wavelength < 300 nm) over sapphire substrates. These substrates are low cost, transparent in the visible and the deep UV, and are readily available in large sizes and many different crystallographic planes. The hetero-epitaxy of III-nitride device structures on sapphire results in a large number of threading dislocations ($\sim 3\times10^{9}cm^{-2}$ for GaN and approximately $2\times10^{11}cm^{-2}$ for AlN [1-2]). For the case of deep-UV LEDs which employ high Al-fraction AlGaN active layers, these dislocations lead to fairly low wall-plug efficiency (~1-2 %). Since the thermal conductivity of sapphire is also low (35 W/m K), the device junction temperature increases giving rise to a premature power saturation and lifetime degradation.

To mitigate the junction heating, we have now for the first time developed new device designs and epilayer structures for the deep UV LEDs. These include: a) A micro-pixel device geometry b) A vertical conduction geometry and c) A non polar-device structure. In the micro-pixel device design, the p-electrode of the conventional LED design is broken into 15-30 μm diameter pixels using passivation isolation between them. These micro-pixels share a common n-electrode and they can either be interconnected or individually addressed. The devices are then flip-chip mounted on to carriers and headers. This leads to a large reduction in the current crowding and hence the junction-heating. For monolithic 280 nm deep-UV LEDs with an effective p-electrode area of 800 μm x 800 μm, we measured an unsaturated cw-power of 40 mW at 1 A of pump current.

The vertical conduction design mitigates the heating issue by allowing for much larger device geometries without current-crowding and hence a much lower current density. This translates to higher power devices with superior lifetimes. The non-polar epilayer structures allow for an increase of the internal quantum efficiency due to reduced polarizations. They also lead to polarized light emission which is desired for more efficient coupling in back-lighting. In this presentation details of our work and the latest results will be discussed.

References:

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