Blue Lasers on Copper: The Integration of InGaN Laser Diodes on Dissimilar Substrates by Wafer Bonding and Laser Lift-off

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In many cases, the integration and enhancement of thin-film microsystems by direct deposition involves substantial sacrifices in the thin-film quality and performance. The ability to combine III-nitride- based thin-film devices with dissimilar substrate materials through a lift- off and transfer process allows for the direct integration of materials systems selected and pre-fabricated exclusively for optimal device performance rather than for growth compatibility. For example, integrating silicon with GaN-based devices creates opportunities to combine Si-based integrated-circuit technology with III-nitride optoelectronics for display and sensor applications. Furthermore, transferring pre-fabricated devices from common sapphire growth substrates onto more thermally and electrically conductive substrates such as Cu may achieve enhanced GaN- based device performance.

In this talk, a robust, simple and fast cut and paste methodology for materials integration is described using wafer bonding and excimer laser lift-off (LLO). Examples ranging from the integration of (In,Ga)N-based light-emitting diodes (LEDs) with Si by means of transient liquid phase (TLP) Pd-In bonding and LLO, in which the separation of the GaN is accomplished by laser irradiation through the transparent sapphire substrate, to blue lasers on copper substrates will be discussed. By using a low-temperature TLP bonding process in conjunction with LLO, blue LEDs on sapphire were transferred onto Si substrates. The resulting LEDs on Si could be driven up to forward currents of 100 mA at 5.4 Volts with an emission wavelength of 455 nm. In addition, the fabrication of continuous- wave InGaN multiple-quantum-well laser diodes will be described. Reduced threshold currents and increased differential quantum efficiencies were measured for LDs on Cu due to a 50compared to LDs on sapphire. Light output for LDs on Cu was three times greater than comparable LDs on sapphire with a maximum output of 100 mW demonstrating the effectiveness of the cut and paste methodology to enhance thin-film microsystems.