Semiconductor Nanostructured Semipolar Light Emitters for Efficient Solid-State Lighting

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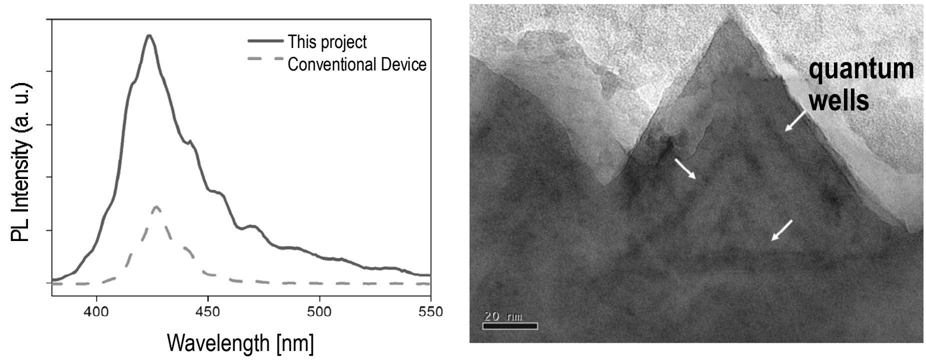

Photoluminescence shows a much improved light output intensity compared to conventional devices with planar quantum wells. Cross-sectional transmission electron micrograph confirms the formation of quantum wells on semipolar planes.

Solid-state lighting using semiconductor group-III nitride light emitting diodes (LEDs) is promising in reducing the overall electricity consumption by 25%. However, to reach that goal, LEDs need to reach >50% efficiency at all primary colors. Current devices exhibit efficiency <20% at the green wavelength. This is largely attributed to the strong internal electric field inherent to conventional light emitters that are fabricated on the (polar) c-plane sapphire substrates. The electric field separates the electrons and holes in the quantum wells, resulting in inefficient radiative recombination. To improve light-emitting efficiency, the internal electric field must be greatly suppressed. This can be achieved by fabricating the quantum wells on semipolar or nonpolar planes. In this project, we demonstrated by using *in situ* silane treatment followed by high-temperature GaN overgrowth, nanostructured semipolar structures can be formed. Subsequent deposition of quantum wells on these nanostructures can exhibit negligible internal electric field effect as confirmed by excitation dependent photoluminescence measurement. The light-emitting efficiency is measured by temperature dependent photoluminescence. A factor of 260% improvement in efficiency at the violet-blue wavelength is measured as compared to a c-plane planar quantum well device fabricated under similar conditions. Currently, we are extending the wavelength to the green range. This project is supported by the University of Michigan, Spring/Summer Research Grants, and College of Engineering Start-Up Funds.