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Through Physics and Smart Materials, Breaking the Efficiency (Droop) Barrier in Light Emitting Diodes for the Ultimate Solid-State Lighting

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Abstract

Light emitting diodes (LEDs) promise energy-efficient, durable, environmental, and compact lighting for a variety of applications including general illumination and optogenetics. GaN materials (i.e. III-nitrides) are the backbone of LEDs emitting in the ultraviolet, blue, and green spectra. LED layers, grown conventionally on sapphire and silicon carbide substrates, are wurtzite in phase and possess inherit polarization fields along the common growth direction. However, recent studies showed polarization fields to contribute droop phenomena in LEDs. Thus, it is essential to focus on polarization-free designs to improve GaN photonic and vertical transport device performance. In this talk, I will report on a novel means of enabling polarization-free GaN devices via controlling material phase. In another aspect, with exciting developments in optogenetics, thin film devices capable of biomonitoring, biomanipulation, and biointegration are becoming essential. However, visible LEDs used in optogenetics are lateral-oriented, thick, and rigid – limiting their efficiency, thermal budget, and bio-integration. In this respect, I will talk about our promising results in enabling vertical-oriented, thin, and flexible LEDs. Vertical thinking is shown to be critical for enabling innovative and exciting opportunities for GaN-based LEDs.