

# Output Power Enhancement of GaN Light Emitting Diodes with p-type ZnO Hole Injection Layer

B. J. Kim<sup>1</sup>, Y. R. Ryu, T. S. Lee, and H. W. White<sup>1,2,a</sup>

<sup>1</sup>Department of Physics and Astronomy, University of Missouri, Columbia, MO 65211

<sup>2</sup>MOXtronics, Inc, 1309 Elsdon Ct., Columbia, MO 65203

<sup>a</sup>Contact: [WhiteH@missouri.edu](mailto:WhiteH@missouri.edu); Tel: 573-424-2666

The efficiency for LED lamps designed for replacement of incandescent bulbs for use in general home and commercial illumination has been steadily increasing, with an accompanying decrease cost in \$/lumen. These LED lamps are based on GaN-based devices. We report a new structural design for these devices that increases the efficiency by an added 20 – 40%. The design incorporates a p-type ZnO layer sandwiched into the GaN-based device during growth. The reported efficiency jump is due to an increased number of hole-type carriers that reduce the so-called “efficiency droop” that occurs at high drive current operation. This increase in efficiency is in addition to other efficiency improvements reported. This result is useful for development of highly-efficient GaN LEDs operating at high current densities that will play a critical role in replacement of incandescent lamps by high efficiency solid-state light bulbs.