

## Editorial

# Solid-State Lighting with High Brightness, High Efficiency, and Low Cost

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In order to achieve the advanced lighting with the energy-saving and environmental-protecting capabilities, the technologies of solid-state lighting have been developed rapidly. In all solid-state lighting applications, light-emitting diode (LED) is the most popular technique due to its advantages of small volume, long lifetime, high reliability, low power consumption, and nonpollution.

The progress in solid-state lighting has been driven by innovations in wide range of technologies in materials, devices, and novel concepts [1–5]. In addition to the progress in visible InGaN-based light-emitting diodes (LEDs) based on III-nitride based semiconductor, the improved understanding in the AlGaN-based LEDs [6, 7] has also resulted in new understanding on the device physics of III-nitride semiconductor physics which in turn results in new concept and approaches to handle the limitation in the fields of nitride-based LEDs. Several of these concepts have resulted in new approaches to suppress the charge separation effect [8, 9], carrier leakage process [10–14], light extraction issue [15–17], and Auger processes [18–21] in the InGaN-based LEDs. The improved understanding on the fundamental properties of InGaN as active regions has resulted in the ability to advance this field into practical technologies being implemented in the daily technologies used in our society.

In this special issue, the editors attempt to bring some of the recent advances in the field of device engineering

and applications of III-nitride based LEDs with the goals of achieving high brightness and low-cost approaches. Up to now, the nitride-based materials are maturely developed to apply for LED applications. However, to obtain the LED devices with high brightness, high efficiency, and low cost, there are still some techniques to be improved, especially for the nitride-epilayer growth with low defect density and device fabrication with high heat dissipation.

In this special issue, there are seven contributed papers to discuss these issues from the LED epilayer quality to the high efficiency package. The implementation and test of LED-based lamp for lighthouse application were discussed at the system level (*Implementation and test of a LED-based lamp for a lighthouse* by L. Mercatelli et al.). Such applications of LED in lighthouse have different requirement from those used in general illumination. The important new application from LED will broaden the new potential innovations required in enabling this technology to be suitable for implementation.

The investigation of novel phosphor material for converting blue/UV LEDs into white LEDs was also discussed specifically for investigating the color rendering index and its thermal stability (*Color rendering index thermal stability improvement of glass-based phosphor-converted white light-emitting diodes for solid-state lighting* by C.-C. Tsai).

Phosphor-based materials are important, and the understanding of its stability at high temperature for ensuring stability in color rendering index in white LEDs is crucial for low-cost white LED.

The use of ZnO:YAG based metal-insulator-semiconductor (MIS) white LEDs was also reported with various insulator designs (“*Low-cost ZnO:YAG-based metal-insulator-semiconductor white light-emitting diodes with various insulators*” by L.-C. Chen et al.). Specifically, the authors investigated the effect of various thicknesses of the silica and MnZnO based insulator on the MIS structure for LED applications.

Recent works have shown the importance of growing GaN-based LEDs on nanopatterned substrates [22–24], and the two related works were reported in this special issue (“*Performance of InGaN light-emitting diodes fabricated on patterned sapphire substrates with modified top-tip cone shapes*” by H.-H. Hsueh et al. and “*Void shapes controlled by using interruption-free epitaxial lateral overgrowth of GaN films on patterned SiO<sub>2</sub> AlN/sapphire template*” by Y.-A. Chen et al.). The use of shape-engineered patterned sapphire substrate and patterned silica mask for achieving improved epitaxy in GaN LEDs was reported (“*Performance of InGaN light-emitting diodes fabricated on patterned sapphire substrates with modified top-tip cone shapes*” by H.-H. Hsueh et al. and “*Void shapes controlled by using interruption-free epitaxial lateral overgrowth of GaN films on patterned SiO<sub>2</sub> AlN/sapphire template*” by Y.-A. Chen et al.). The thermal management is an important issue for high power LEDs, and the use of diamond-like carbon heat-spreading layer was reported (“*Thermal characteristics of InGaN/GaN flip-chip light emitting diodes with diamond-like carbon heat-spreading layers*” by P.-Y. Tsai et al.).

The investigations of high-voltage LEDs in flip chip configurations have tremendous interests and potential impact for enabling reduced droop operation up to high power operation (“*Efficiency and droop improvement in GaN-based high-voltage flip chip LEDs*” by Y.-C. Chiang et al.). The use of high voltage design enables the low current density while the total output power can be accomplished. The droop issue has been one of the key limitations in LED development for low-cost applications, and the high voltage LED has the potential for addressing this droop issue from the circuit and systems level innovation in new solid-state lighting device systems.

We hope that the special issue will be of value for the research community in particular in driving this important topic on solid-state lighting. The great potential and promise of solid-state lighting are coming to reality, and the drive for innovation for achieving high brightness at low cost is important for enabling market penetration of this technology.

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