Editorial

Advanced LED Solid-State Lighting Optics

Ching-Cherng Sun 1,* , Shih-Hsin Ma 2 and Quang-Khoi Nguyen 1

1 Department of Optics and Photonics, National Central University, Chung-Li 320, Taiwan; quangkhoigialai@gmail.com
2 Department of Photonics, Feng Chia University, Taichung 40724, Taiwan; shma@fcu.edu.tw
* Correspondence: ccsun@dop.ncu.edu.tw

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Abstract: Light-emitting diodes (LEDs) have been intensively studied for white-light lighting since their luminous efficacy exceeds 50 lm/W. Currently, the luminous efficacy of an LED light tube/bulb is almost above 100 lm/W. LED solid-state lighting (SSL) has unequivocally become the major light source in general lighting. The fact of high efficiency and other advantages of LED SSL is enough to penetrate all lighting scenarios. However, what people demand from new-generation lighting is not only in energy efficiency but also in lighting quality. Thus, how to make the lighting more user friendly is one of the important issues, and, here, optics is the key point. For making a collection with the discussions of the novel optical design in enhancing lighting efficiency in a more uniform illumination pattern, in higher sharpness for special lighting, in a higher signal-to-noise ratio for communication, in more functions for new applications, etc., this Special Issue of “Advanced LED Solid-State Lighting Optics” focuses on advanced applications in all aspects.

Keywords: optical design LED; solid-state lighting; non-imaging optics; light extraction; auto-forward lighting; cutoff line; spot light; transmissive liquid crystal lens; micro-LEDs

This issue collects 12 contributions, starting with the paper of Tseng et al. [1], which presents a design of a secondary freeform lens of an ultraviolet light-emitting diode (UV LED) mosquito-trapping lamp for enhancing trapping efficiency. The results show that the trapping range can be expanded to $100 \pi \cdot m^2$ and the number of captured mosquitoes can be increased by about 300%. This solution is quite meaningful for human life in controlling diseases with the advantage of solid-state lighting.

In the second article, Zhang et al. [2] presents a design of optimal linear precodings for a multi-color, multi-user visible light communication system with fairness considerations. Utilizing both the spatial and multi-color resources, the authors proposed precoding designs to mitigate the impact of the multi-user interference and the multi-color crosstalk. With the constraints of chromaticity, luminance, and signal range, the precoding designs are formulated to achieve the max–min fairness and the maximum sum rate.

Related to the multiple-input multiple-output technology as an efficient approach to improve the transmission rate in visible light communication, the paper by Xiao et al. [3] focuses on the MIMO VLC system using multi-color LEDs in the typical indoor scenario. Taking the advantages of solid-state lighting, the utilization of multi-color LEDs with the proposed precoding method can promote the practical applications of high-speed indoor optical wireless communication in contrast to the conventional method of chromaticity-fixed schemes and zero-forcing precoding designs.

In the fourth paper, Le et al. [4] proposes a design of a curved retroreflector for enhancing optical efficiency and working area. By taking the advantages of compact size and high brightness of LED, this designed retroreflector does not only meet the requirements of the US Society of Automotive Engineers (SAE) regulations but also can be demonstrated that 28% higher efficiency and 33% more working area.
In the fifth paper, Lee et al. [5] proposes a designed structure that shows a simultaneously improve white LED omni-directional package efficacy and spatial color uniformity on scattered photon extraction technology. Using the concept of light guiding to design the lens, the authors minimize the deviation of forward and backward correlated color temperature (CCT) from 2720 K to 657 K, and the overall efficiency can be further enhanced by 12% compared to typical lens.

A micro-LED with a chip size of less than 100 µm is a potentially disruptive piece of display technology because of its outstanding features, such as low power consumption, good sunlight readability, true black state, high dynamic range and wide color gamut. However, it still needs new solutions to achieve a higher color performance and light conversion efficiency. In the sixth paper, Gou et al. [6] report the optical efficiency enhancement of color-converted micro-LED displays with funnel-tube array. With the funnel-tube array, the optical efficiency of the color-converted micro-LED display can be improved by ~3X, while the crosstalk is eliminated.

In the seventh paper, He et al. [7] provide an overview of recent advances in perovskite nanocrystals-enhanced solid-state lighting and liquid crystal displays (LCDs). The authors discuss the development, optical properties, and stability issue of materials, and then we evaluate the performance of solid-state lighting (SSL) and LCDs with perovskite downconverters adopted. Moreover, the authors discuss two future challenges: materials development and device integration. It is believed that the emerging perovskite nanocrystals are highly promising for next-generation SSL and LCDs.

Designing an optical elements for LEDs in traffic signs is interesting and important. The traffic sign should meet the national standard of luminance and contrast and avoid glare. In the eighth paper, Lee and Chen [8] propose the construction and optimization of through-hole LED used in designing traffic signboards. The modeling process starts from finding or estimating some key factors of the LED for the Monte Carlo ray tracing. The precise model has constructed through-hole LEDs to apply in designing traffic signboards.

In the ninth paper, Fang et al. [9] report an application of dimming compensation technology via liquid crystal lens for non-imaging projection laser systems. This study mainly uses the liquid crystal display backlight dimming technology in the illumination design for optical projectors. The light source was designed to output as a laser light source that uses a micro-scanning array. The main purpose was to compensate for the dim spots between the lenses in each unit of the liquid crystal when the liquid crystal lens array performs local dimming, as well as to compensate for the uniformity when adjusting the light.

How far can an LED lamp reach is complicated and interesting problem. In the tenth paper, Wu et al. [10] design a spot light system with an illumination range reaching 10 km. The module’s power injection was only 68.2 W. The projection distance of the LED spot light module was 3.37 km, according to the ANSI regulation. Finally, a spot light system containing nine modules achieving a projection distance of 10 km was successfully fabricated.

Vehicle head lamps are crucial for traffic lighting to allow high visibility of the driver, pedestrians, and other people on the road. In the eleventh paper, Lin et al. [11] present a design of a bicycle head lamp using a low-cost and atypical white light-emitting diode with separate dies. This is the first demonstration of a design for a bicycle head lamp using an atypical white LED with two separate dies. A modified two-color optical model was created to describe the yellowish patterns and explain the yellowish effect. The yellowish effect was effectively reduced through masking the white LED in a certain area.

In the twelfth paper, Le et al. [12] propose a design of a low-glare LED rear light of an automobile for United Nations Economic Commission for Europe (ECE) regulations by using optimized micro-prisms array. The full rear light is a combination of a position lamp and a braking lamp, and LED light bars and micro-prisms are involved as their essential components. It is shown that ECE R07 regulation can be met in the proposed rear light, and 12% (position lamps) and 26.5% (braking lamps) higher candela can be enhanced after the optimization of micro-prisms.
In summary, this Special Issue highlights novel advances in terms of new optical approaches, including light extraction enhancement, novel design in LED packaging for better performance, a new approach on LED light source modeling, novel design in secondary optics, optical design for anti-glare, outdoor lighting, indoor lighting, displays, a bicycle headlamp or auto-forward lighting, projection laser systems, optical design for special lighting, and an optical scheme for enhancing free space communication with LED lighting. The presented papers show that impressive progress has been made on LED solid-state lighting wherein the optics aspect is a key point to provide more powerful and wider applications for human life.

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References
1. Tseng, W.; Juan, D.; Hsiao, W.; Chan, C.; Ma, H.; Lee, H. Design of a Secondary Freeform Lens of UV LED Mosquito-Trapping Lamp for Enhancing Trapping Efficiency. Crystals 2018, 8, 335. [CrossRef]
2. Zhang, D.; Yu, H.; Zhu, Y.; Sun, Z. Optimal Linear Precodings for Multi-Color, Multi-User Visible Light Communication System with Fairness Considerations. Crystals 2018, 8, 404. [CrossRef]
3. Xiao, Y.; Zhu, Y.; Sun, Z. Linear Precoding Designs for MIMO VLC Using Multi-Color LEDs under Multiple Lighting Constraints. Crystals 2018, 8, 408. [CrossRef]
4. Le, L.; Le, H.; Lee, J.; Ma, H.; Lee, H. Design of a Society of Automotive Engineers Regular Curved Retroreflector for Enhancing Optical Efficiency and Working Area. Crystals 2018, 8, 450. [CrossRef]
5. Lee, T.; Huang, Y. Simultaneously Improve White LED Omni-Directional Package Efficacy and Spatial Color Uniformity on Scattered Photon Extraction Technology. Crystals 2019, 9, 21. [CrossRef]
6. Gou, F.; Hsiang, E.; Tan, G.; Lan, Y.; Tsai, C.; Wu, S. Tripling the Optical Efficiency of Color-Converted Micro-LED Displays with Funnel-Tube Array. Crystals 2019, 9, 39. [CrossRef]
7. He, Z.; Zhang, C.; Dong, Y.; Wu, S. Emerging Perovskite Nanocrystals-Enhanced Solid-State Lighting and Liquid-Crystal Displays. Crystals 2019, 9, 59. [CrossRef]
8. Lee, T.; Chen, Y. Construction and Optimization of Through-Hole LED Models for Use in Designing Traffic Signboards. Crystals 2019, 9, 96. [CrossRef]
9. Fang, Y.; Tsai, C.; Cheng, D. Application of Dimming Compensation Technology Via Liquid Crystal Lens for Non-Imaging Projection Laser Systems. Crystals 2019, 9, 122. [CrossRef]
10. Wu, C.; Chen, K.; Lee, X.; Lin, S.; Sun, C.; Cai, J.; Yang, T.; Yu, Y. Design of an LED Spot Light System with a Projection Distance of 10 km. Crystals 2019, 9, 524. [CrossRef]
11. Lin, H.; Sun, C.; Wu, C.; Lee, X.; Yang, T.; Lin, S.; Lin, Y.; Yu, Y. Design of a Bicycle Head Lamp Using an Atypical White Light-Emitting Diode with Separate Dies. Crystals 2019, 9, 659. [CrossRef]
12. Le, H.; Le, L.; Liao, H.; Chen, M.; Ma, H.; Lee, H. Design of Low-Glared LED Rear Light of Automotive for EU ECE Regulation by Use of Optimized Micro-Prisms Array. Crystals 2020, 10, 63. [CrossRef]

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