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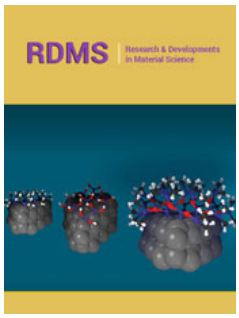
Mini Review

Advances in Solid-State Lighting: A Review

ISSN: 2576-8840



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Submission: June 12, 2023
Published: July 12, 2023

Volume 19 - Issue 2

How to cite this article: Kartik, DV Sunitha*, T P Jyothi. Advances in Solid-State Lighting: A Review. Res Dev Material Sci. 19(2). RDMS. 000956. 2023.
DOI: 10.31031/RDMS.2023.19.000956

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Abstract

Solid state lighting has brought about a revolution in the lighting industry due to its superior performance, energy efficiency and long lifespan in comparison to traditional incandescent and fluorescent lighting technologies. This comprehensive review article aims to provide an overview of recent advancements in SSL technologies as well as their applications. Firstly. We discuss the fundamental principles and materials involved in solid state lighting before providing a detailed examination of the key developments in SSL devices such as Light Emitting Diodes (LEDs) and Organic Light Emitting Diodes (OLEDs). The article also looks into SSL research including novel fabrication techniques, enhanced efficiency, and color rendering properties. Additionally. There is an exploration of how solid-state lighting is applied across general lighting, automotive lighting, and horticultural lighting sectors. In conclusion, this review consolidates future prospects and challenges regarding solid state lighting.

Keywords: Solid-state lighting; Organic light-emitting diodes

Introduction

As technology advances simultaneously with the optimization of solid-state materials like Light-Emitting Diodes (LEDs) and Organic Light-Emitting Diodes (OLEDs), we begin our journey towards illumination through SSL or "solid-state lighting". With advantages over traditional lighting systems such as energy efficiency, longer-lasting bulbs having superior color quality- SSL has taken center stage for those looking for smart use of resources with their illumination needs [1,2].

Fundamentals of solid-state lighting

Light-Emitting Diodes (LEDs): Through ongoing research & development efforts comes further innovation as LED technology progresses through the integration of recent breakthroughs in new material engineering techniques alongside advanced packaging methods that lead to advancements within device efficiency. In the LED fabrication, most commonly materials will be used which include semiconductor compound like gallium nitride (GaN), indium gallium nitride (InGaN), aluminium gallium indium phosphide (AlGaInP) due to specific bandgaps that allow for efficient light emission [3].

Organic Light-Emitting Diodes (OLEDs): Achieving improved color rendering properties alongside cost-effectiveness solutions. Meanwhile OLEDs continue their rise as a reliable option regarding their lightweight design while offering a unique benefit steered by color-tunability using thin organic layers producing safe light emission [4].

Advances in solid-state lighting

Enhanced efficiency and energy savings: Energy savings capitalizing on advancements to provide greater returns than ever before. Strategies are numerous- from optimized phosphor materials enabling resilient performance to advancing system architectures promoting efficient heat dissipation techniques to enhance luminous efficacy and reduce energy consumption [5].

Color rendering properties: When it comes to evaluating the ability of a source of light to accurately render colors, Color Rendering Index (CRI) plays an important role. Recent studies have focused on improving the color rendering properties of SSL by developing phosphor blends. Spectral tuning techniques as well as novel light conversion materials which result in high quality illumination along the color spectrum. Solid state lighting finds practical applications in various sectors like general lighting, automotive industry, and horticultural sectors amongst others [6].

Applications of solid-state lighting

General lighting: For many different settings' requirements of an ideal light source are met by Solid-State Lighting (SSL) because it offers energy efficiency coupled with longer product lifespan at low operating costs, making it a preferred choice. A review article examined its growing adoption in a range of different lighting fixtures such as retrofit lamps, downlights and linear luminaires. SSLs provide distinct advantages, which include being energy efficient, long lasting and cost-effective in multiple fields [7].

Automotive lighting: Some of the most notable breakthroughs offered by SSL have been made in automotive lighting systems. These solutions outperform their traditional counterparts by providing brighter illumination, adaptive lighting features and enhanced design flexibility. The article explores some recent advancements made in SSL for automotive lighting applications like advanced headlamp designs and dynamic signaling systems while integrating advanced driver assistance systems (ADAS) that make the vehicles even safer [8].

Horticultural lighting: The benefits SSL offers has come to light with considerable relevant application across horticulture where tailored light spectra with adjustable intensity via smart control systems have led to optimized plant growth whilst reducing energy consumption leading to lower costs of production & better yields all-around farming [9].

Future prospects and challenges

The review article discusses the future prospects and challenges in the field of solid-state lighting. As technology advances, so is the need for further developments within SSL's spectrum contributing through increasing research focused on unlocking its full potential. Research into areas like advanced manufacturing techniques or making miniaturized LEDs alongside developing efficient phosphor materials could revolutionize business operations completely. It is important to be cognizant of the many challenges faced including ensuring effective thermal management while mitigating looming environmental degradation issues amongst competitors seeking better efficiencies and competitive edge while safeguarding value creation opportunities across corridors from manufacturers downstream through end-users alike without compromising value sustainability.

Conclusion

Recent years have witnessed unparalleled progress in solid-state lighting technology due to non-stop research efforts. The following review article provides a thorough examination of up-to-date findings regarding this industry's four main areas: fundamental principles; device enhancements; improved efficiency; increased color rendering properties; followed by a breakdown of possible applications for use. Further elaborated are potential future avenues presenting both growth opportunities as well as industry-wide challenges which require proactive research solutions tackling intrinsic roadblocks hampering breakthroughs within its many dimensions. Solid-State Lighting is poised for greatness through revolutionizing various industries with its exemplary-energy-efficient characteristics offering top-notch illumination experiences all around.

Acknowledgment

The authors thank REVA University, Bangalore for providing Seed money.

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