ISA
International SSL Alliance

Address: No.35 Qinghua East Road, Haidian District, Beijing, China (100083)
Email: secretariat@isa-world.org
Visit us at www.isa-world.org

Solid state lighting (SSL) after 20 years' development has gradually reached a mature stage in terms of performence such as light quality, luminous efficiency, reliability and intelligent feature. SSL products, services and system solutions have been widely used around the world.

With the in-depth research and development and the continuous innovation of manufacturing technology, the SSL's non-visual functions are also being rapidly explored. Various innovations and applications of "beyond lighting" are entering many aspects of society and life. SSL has been showing its tremendous application potential and R&D depth in high value added application integration e.g. agriculture, health, communications, high-definition display, polymer curing, disease vector control etc. Integrated innovation and interdisciplinary innovations based on SSL technology have yielded a steady stream of achievements, marking a new stage of SSL development.

Innovation drives development, which in turn fosters innovation. From the advent of the first GaN-based blue LED in 1978 to the commercial manufacturing of the first high-brightness blue LED in 1993, and the commercial manufacturing of blue and green LEDs with InGaN quantum well (QW) structures, SSL has gone from laboratory to industrialization in merely decades as well as from manufacturers to thousands of households, all of that are the result of innovation.

The ISA twelfth Executive Member Meeting decided to establish the "Global SSL Award of Innovations Top 100", and start the selection from the year of 2021. The award aims to encourage and inspire the global SSL industry to persist the spirit of innovation in new era to make new discoveries, explore more unknown areas, and create more applications in the field of "beyond lighting", to benefit mankind with more SSL miracle. This is the intention and ultimate goal of this award.

Jianlin Cao

Jianlin Cao
President of ISA

International SSL Alliance

Global SSL Award of Innovations Top 100

Every year, according to the applications we received from all over the world, a certain number of SSL innovations projects will be selected as the winners of the "Global SSL Award of Innovations Top 100", which are judged by international authoritative experts. And medals, certificates and brochures will be given to encourage and praise.

ISA Introduction

ISA is a non-for-profit international organization consists of regional alliances, association/society, leading companies and renowned universities in global Solid State Lighting (SSL) field.

The Business of ISA members have covered the whole SSL value chain of upstream, middle stream and downstream of global SSL industry such as epitaxy, packaging application, materials and equipment, design system integration and testing etc.

The currently ISA 84 members, representing more than 4000 individuals & organizations includes major players . The output of which covers more than 70% that of global SSL industry.

The ISA Board of Advisers consists of leading experts and academic "Founder" level experts, such as the inventors of blue LED, yellow LED, Red LED, and OLED. Amongst Professor Shuji Nakamura, the Laureate of Nobel Prize in Physics in 2014, is the Co-Chair of ISA Board of Advisors (BOA) and Professor Hiroshi Amano, the Laureate of the Nobel Prize in Physics in 2014 is the member of ISA BOA.

The major works of ISA are: provide services to promote the development and application of global SSL, standardization, annually Global SSL Industry Report, annually SSL Awards, promote international, national and regional cooperation on SSL, etc.

The Mission of ISA

Cooperation with the global resources and efforts, ISA looks forward to fostering a more appropriate "eco-system" for the health development of the global SSL and its application. Echo the needs of the society with more added value services to ISA members. Strive to improve people's living and contribute a sustainable human society.

Mission

To promote and stimulate the sustainable development of the global solid state lighting (SSL) industry, demonstrate the application and the innovation of the technology of SSL in the field of "beyond lighting", and push forward the global SSL into a new stage of development.

The Scope of the Application

The applications must be the technological innovation, product innovation or integration innovation etc. related to the SSL technology in the field of beyond lighting.

Include but not limited to the following areas:

1. Smart Lighting
2. Mini/Micro LED
3. Health Lighting
4. Visible Light Communication (LiFi)
5. Agriculture Lighting
6. UV LED Application
7. Others (Please specify)

Criteria for Selection

The application (s) should be innovative in the country, region or the world, and the technology (ies) or product (s) should reach a certain advanced level, and solve some key problems in practical application.

Statement

Global SSL Award of Innovations Top 100

- Accept excellent applications
- Judged by authoritative experts
- Worldwide circulation and promotion
- Manifest the achievement of innovation

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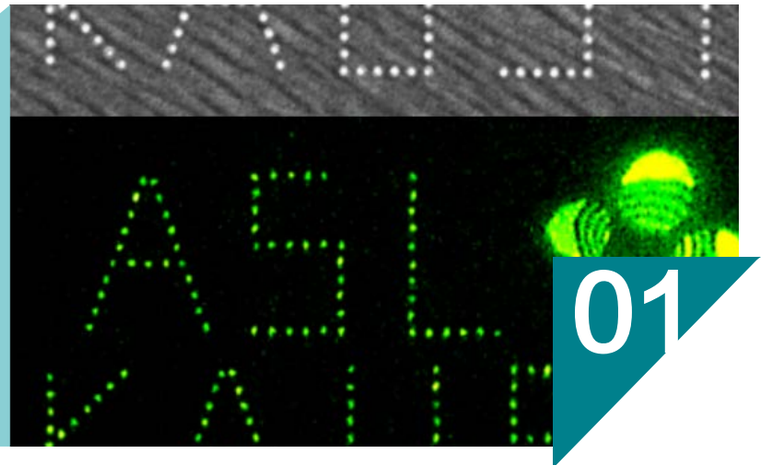


Mini/Micro LED

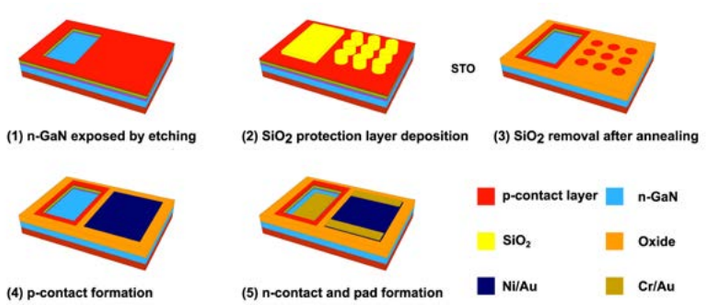
01

Etching-free Pixelation of Efficient and Ultra-small Micro-LEDs Via Selective Thermal Oxidation Technique

Advanced Semiconductor Laboratory, King Abdullah University of Science and Technology (KAUST) (Xiaohang Li and Zhiyuan Liu)

Brief Introduction

The Selective Thermal Oxidation (STO) is a novel semiconductor fabrication technique developed for micro-LED pixelation that replaces the conventional reactive ion etching (RIE) pixelation process. In this approach as shown in Fig. 1, a patterned SiO2 layer is deposited onto the LED wafer to serve as an oxidation mask. During high-temperature annealing in ambient air, regions of the wafer that are not protected by the SiO2 layer undergo selective thermal oxidation, forming insulating oxide layers that define and isolate the pixels. Meanwhile, the areas beneath the SiO2 mask maintain their original epitaxial structure and luminescent properties. By selectively inactivating the (In)GaN-based material between pixels through oxidation, the STO technique enables the fabrication of standalone pixels or pixel arrays without the need for mesa etching.



▲ Fig. 1 Fabrication process flow of micro-LED arrays fabricated using STO.

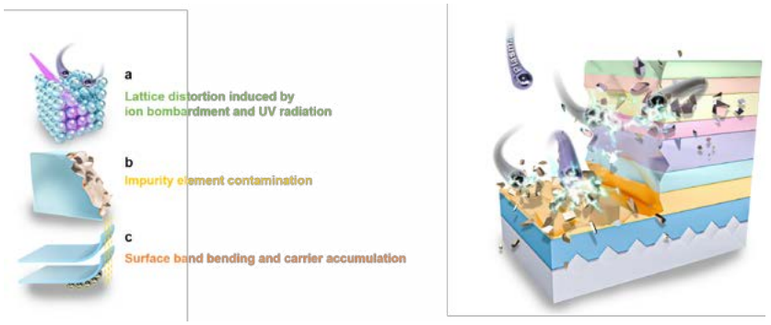
The STO technique primarily addresses two key challenges in micro-LED fabrication. First, it avoids the damage generation caused by the conventional RIE process, which typically introduces defects at the micro-LED sidewalls and degrades micro-LED efficiency. This innovative STO approach contributes to overcoming efficiency bottlenecks in micro-LEDs. Second, thermally formed oxide serves as an effective electrical insulator between electrodes and provides interface passivation for the pixel regions. This omits the need for multiple traditional process steps related to insulation and sidewall passivation. Therefore, the STO technique simplifies the fabrication complexity of micro-LEDs, especially for ultra-small micro-LEDs.

Currently, this technique has demonstrated the capability to fabricate highly efficient micro-LED pixels as small as 2.3 μm. It has been successfully applied to both InGaN-based visible micro-LEDs (including blue and green emission) and AlGaN-based deep ultraviolet micro-LEDs, demonstrating its versatility across different material systems and wavelength ranges. Moreover, the STO process is expected to advance further toward sub-micron micro-LED fabrication, enabling even higher-resolution and more compact device designs in the future.

Micro-LEDs fabricated using the STO process offer strong potential for enabling high-resolution micro-displays such as AR/VR and wearable electronics, smart lighting, and visible-light communication systems. Additionally, this technique is well-suited for producing compact micro-sized ultraviolet emitters for sterilization, sensing, UV communication, color conversion, and maskless lithography. By providing a simplified, scalable, and damage-free fabrication approach, the STO process represents a promising pathway toward next-generation micro-LED technologies with enhanced efficiency, lower manufacturing costs, and a broad range of practical applications.

The Innovation Points

Scaling LED dimensions from conventional sizes of several hundred micrometers to tens or even a few micrometers enables new functionalities and expands potential application areas. For InGaN micro-LEDs, minimizing pixel size is essential for realizing high-resolution display technologies. For example, for high-end display applications such as AR/VR, micro-LED pixel sizes need to be reduced to below 10 μm. Moreover, compared to traditional large-sized LEDs, micro-LEDs offer significantly higher modulation bandwidth and faster transmission speeds in visible light communication applications. For AlGaN-based UV LEDs, reducing device dimensions can significantly enhance light extraction efficiency, making traditional UV applications such as sterilization and curing more energy-efficient. In addition, UV micro-LEDs are well suited for emerging applications including UV photonic integration, pixel-level color conversion, and maskless lithography. Nevertheless, downsizing micro-LEDs also introduces challenges:

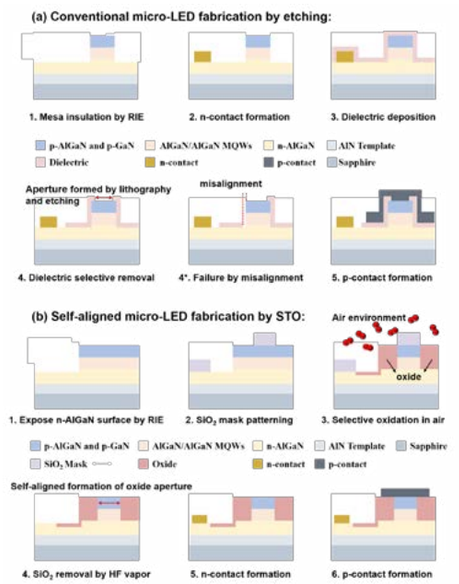


▲ Fig. 2 Schematic diagram of micro-LED sidewall damage. a Lattice distortion, b impurity element contamination, and c surface band bending and carrier accumulation.

1. To define the mesa region and expose the n-layer surface for the n-contact, RIE is conventionally used. However, plasma bombardment and UV photon irradiation on the mesa sidewalls can result in significant defect formation known as sidewall plasma damage, as shown in Fig. 2. These defects act as current leakage paths and non-radiative recombination centers, severely impeding device efficiency. The micro-LED sidewall effect becomes more pronounced as mesa sizes decrease, contributing to size-dependent leakage current density and EQE.

2. In the conventional micro-LED fabrication, as illustrated in Fig. 3 (a), after obtaining the micro-mesa through RIE, it is necessary to deposit insulating dielectrics (usually SiO2 or Al2O3) for sidewall passivation and insulation between the n and p pads. Following it, an oxide aperture should be formed through lithography and etching to expose the p-GaN surface for contact formation. High-precision lithography and alignment are crucial to define aperture size and position, which will ensure that after the aperture is formed, there is still dielectric material present over the n-layer and mesa sidewalls. Otherwise, the device may experience current leakage and even device failure, as shown in step 4* in Fig. 3. As the micro-LED size is smaller, higher precision lithography and alignment are needed, increasing the complexity and cost of the fabrication process, especially challenging for micro-LEDs with sizes below 10 μm.

The full STO-based micro-LED fabrication process is detailed below, with reference to Fig. 1 and Fig. 3 (b): Initially, a RIE process (BCl3, Cl2, and Ar plasma) is employed to expose the n-(Al)GaN layer, facilitating subsequent n-contact formation. It's worth noting that the etching process is not for the pixel definition, and the etched regions were far away from the pixels, thus causing no damage to them. SiO2 is then deposited using plasma-enhanced chemical vapor deposition and patterned by dry etching (C4F8 and O2 plasma with Cr as a hard mask) as a protective layer on the surfaces of n-GaN and p-contact layer. The areas covered with SiO2 on the p-contact layer served as the pixel region. Subsequently, the LED wafers are annealed in ambient air (900 ℃) in the tube furnace to selectively oxidize the portions of the regions not protected by SiO2. The duration depends on the material system and epitaxial structure. Simultaneously, the dense structure of SiO2 blocked the penetration of oxygen from the air, thereby protecting the underlying LED structure. Following annealing, SiO2 was removed by HF vapor at a substrate temperature of 40 °C. Finally, n- and p-contact could be formed by metal deposition and post-annealing process.



▲ Fig. 3 Qualitative flowchart of standalone micro-LED fabrication. a Conventional RIE and b self-aligned selective thermal oxidation for pixelation.

How STO solves key problems:

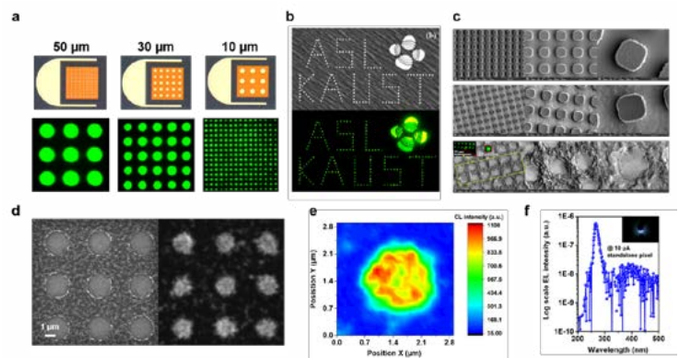
1. STO eliminates sidewall plasma damage entirely by removing the need for RIE to define pixels. Instead, pixel isolation is achieved through controlled thermal oxidation in ambient air, using a patterned SiO2 layer as an oxidation mask. During annealing, only the unprotected regions are converted into insulating oxides, while the protected pixel regions retain their original crystalline structure and optical properties. This etching-free or damage-free approach avoids plasma-induced defects on sidewalls, significantly reducing non-radiative recombination centers and leakage current paths. As a result, it effectively mitigates the size-dependent efficiency degradation that typically worsens for micro-LEDs with sub-10 μm pixel sizes. This will significantly improve the micro-LED efficiency and its application capability.

2. Forming a dielectric aperture naturally through a specialized process flow, without the need for high-precision lithography and alignment, will greatly simplify the fabrication difficulty. This is the so-called self-aligned process. As shown in Fig. 3 (b), the patterned SiO2 achieves the selectivity of the thermal oxidation and the SiO2 on the p-GaN defines the position and the size of the final micro-LED pixels. Following the annealing step, the SiO2 mask is removed using HF vapor. The pixel surface (p-GaN) then completely exposes and self-aligns with the surrounding oxide. Meanwhile, the insulating oxide naturally functions as the insulation between n-p electrodes and pixel interface passivation. Precise lithography and etching for aperture formation are no longer required. The STO-based micro-LED fabrication process is especially advantageous for producing ultra-small micro-LEDs (e.g. below 10 μm), as it significantly lowers fabrication complexity and cost.

Advances of the proposed technique globally:

First, the STO technique for micro-LED pixelation is proposed and demonstrated for the first time in the world. The concept of etching-free or damage-free micro-LED fabrication has been widely disseminated and recognized through our work. At the same time, the STO technique has been applied to the fabrication of both InGaN and AlGaN micro-LEDs, representing the only one in the field where an etching-free micro-LED pixelation technique has been successfully demonstrated across multiple material systems.

Second, we have demonstrated micro-LED pixel sizes down to 2.3 μm for both InGaN blue and green micro-LEDs and AlGaN DUV micro-LEDs. In particular, the 2.3 μm represents the smallest standalone DUV micro-LED reported in the field to date. Relevant device images are shown in Fig. 4 (a) to (f). This capability to achieve ultra-small pixel sizes will enable a wide range of advanced applications such as AR/VR in visible micro-LEDs and maskless lithography in DUV micro-LEDs. Moreover, since there is no etched mesa structure, the entire pixel array remains nearly planar, which facilitates future integration with other electronic and optoelectronic components.



▲ Fig. 4 Micro-LEDs fabricated through STO-based process. a Device images and emission demonstration of 10 to 50-μm InGaN green pixel arrays, b display schematic diagram "KAUST" by micro-LED arrays, c SEM images and emission demonstration of 2.3-μm InGaN green pixel arrays, d SEM images and CL emission of 2.3-μm AlGaN DUV pixel arrays, e CL emission of 2.3-μm AlGaN DUV standalone pixel, f Spectrum and emission image of 2.3-μm AlGaN DUV standalone pixel.

Besides, micro-LEDs fabricated using the STO-based process exhibit state-of-the-art performance within the field, including low leakage characteristics and excellent optoelectronic conversion efficiency. For 10-μm InGaN green micro-LEDs, the unpackaged, on-wafer measured external quantum efficiency (EQE) reaches 6.5%, with a low leakage current density of 1.2 × 10−6 A/cm2 at −10 V. For the 2.3-μm AlGaN DUV micro-LEDs, the on-wafer measured EQE is 0.8%, with a leakage current density of 4 × 10−7 A/cm2 at −5 V. After packaging, the actual efficiency in practical applications is expected to be several times higher than the current measured values due to enhanced light extraction. The excellent efficiency and brightness of these devices provide a strong foundation for supporting a wide range of practical applications.

Possible Economic and Social Benefits

The STO technique for micro-LED fabrication offers transformative potential that extends far beyond process improvements, positioning itself as an enabling technology for the next wave of global industrial and societal change.

For visible-spectrum micro-LEDs, STO-enabled ultra-small pixels will be foundational to the future of display technology. High-resolution micro-displays are essential for delivering immersive experiences in AR and VR, which are rapidly evolving from niche markets into mainstream platforms for communication, education, healthcare, entertainment, and commerce. By making highly efficient ultra-fine-pitch micro-LED arrays more manufacturable and cost-effective, STO lowers the barrier to mass production of advanced AR/VR headsets, smart glasses, and wearable displays that can seamlessly integrate digital information into daily life. This democratization of high-quality displays will have significant economic effects: it can fuel growth across the consumer electronics industry, stimulate content creation and software development ecosystems, and support new forms of remote collaboration and training. In sectors such as healthcare and industrial design, AR/VR solutions enabled by micro-LED displays will improve outcomes and efficiency. By contributing to this technological foundation, STO-based micro-LED manufacturing will help drive competitiveness in the global display industry and support regional ambitions to lead in advanced manufacturing and innovation.

For AlGaN-based UV micro-LEDs, the STO technique enables compact, efficient ultraviolet emitters that open entirely new markets and application scenarios. First, it will make traditional uses in sterilization and disinfection more efficient and energy-saving, critical for public health and safety. In addition, the unique capabilities of micro-scale UV emitters will catalyze cutting-edge technologies such as UV photonic integration, maskless lithography for next-generation semiconductor manufacturing, and pixel-level color conversion for novel display architectures. By enabling these new applications, STO-based UV micro-LED production has the potential to stimulate investment, create high-value jobs, and strengthen the entire optoelectronics supply chain.

Socially, these technological advances will reshape how people interact with information, with their environment, and with each other. From the promise of more inclusive and effective education through AR/VR, to safer water and food supplies through UV sterilization, STO-enabled micro-LEDs offer practical benefits that directly enhance quality of life. The technique's simplified, scalable, and environmentally friendlier approach aligns with broader goals for sustainable manufacturing, reducing resource consumption and electronic waste while increasing the accessibility of advanced technologies globally.

In summary, the STO technique is not merely a manufacturing innovation. It is a strategic enabler for a new generation of micro-LED applications that will power the displays, devices, and infrastructure of tomorrow's digital society, delivering lasting economic growth and social impact on a global scale.

Mini/Micro LED

02

Large Wafer Size GaN-on-Si Micro LED EPI

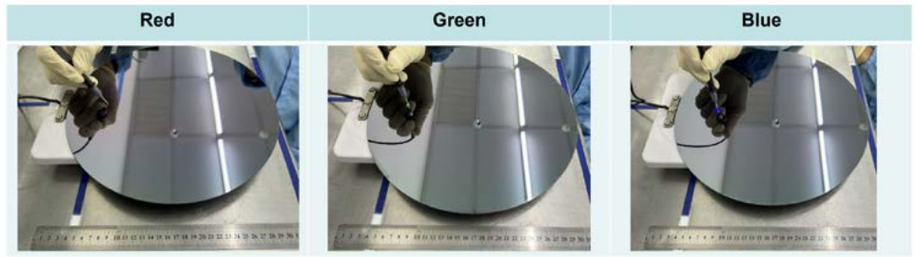
LatticePower Corporation Limited

Brief Introduction

Micro LED technology has achieved significant breakthroughs in wide spread applications in many fields due to its excellent brightness, high efficiency, low power consumption, high stability, and long lifetime. The blue and green micro LEDs are mainly based on gallium nitride (GaN) material, while the red micro LEDs are mainly based on aluminum gallium indium phosphide (AlGaInP) material (InGaN material red LEDs currently don't have high enough efficiency but is actively being researched).

GaN (Gallium Nitride) epi wafer is an important material platform for MicroLED microdisplay technology. GaN based LED epi wafers mainly include GaN grown on sapphire substrates (sapphire based GaN) and GaN grown on silicon substrates (Si-based GaN).

Sapphire based GaN is the most commonly used technology in the general lighting LED industry, with mature technology and lowest cost. However, currently the mainstream for sapphire EPI wafer size is 4 and 6 inches. 8-12 inches GaN/sapphire technologies are technically difficult. The silicon substrate used for GaN EPI wafers has the advantages of low cost and large wafer size for 6 to 12 inches wafers. Meanwhile, the silicon substrate can be easily removed by wet etching during the Micro LED process compared to more



difficult laser lift off process for sapphire-GaN wafers. Moreover, GaN on silicon substrates is more compatible with existing silicon-based CMOS processes. The above properties make silicon-based GaN wafers to have greater advantages in the development of Micro LED technology. Large-sized silicon substrate GaN Micro LED epi has been recognized as the best route to achieve the industrialization of Micro LED micro displays.

Silicon substrate 4/6/8 inch Micro LED epi has been supplied in bulk to customers for the development of Micro LED micro displays, and customers have begun to ship to end application customers, mainly for wearable displays, micro projections, and other scenarios.

The Innovation Points

Compared to epi growth on 4 inch wafers, the growth of gallium nitride materials on large-sized silicon substrates faces more technical challenges：

1. Due to the larger substrate size, the impact of lattice mismatch and thermal mismatch between gallium nitride and silicon during epi growth is greater, resulting in more difficult control of the epi wafer warpage and a higher likelihood of defects such as cracks.

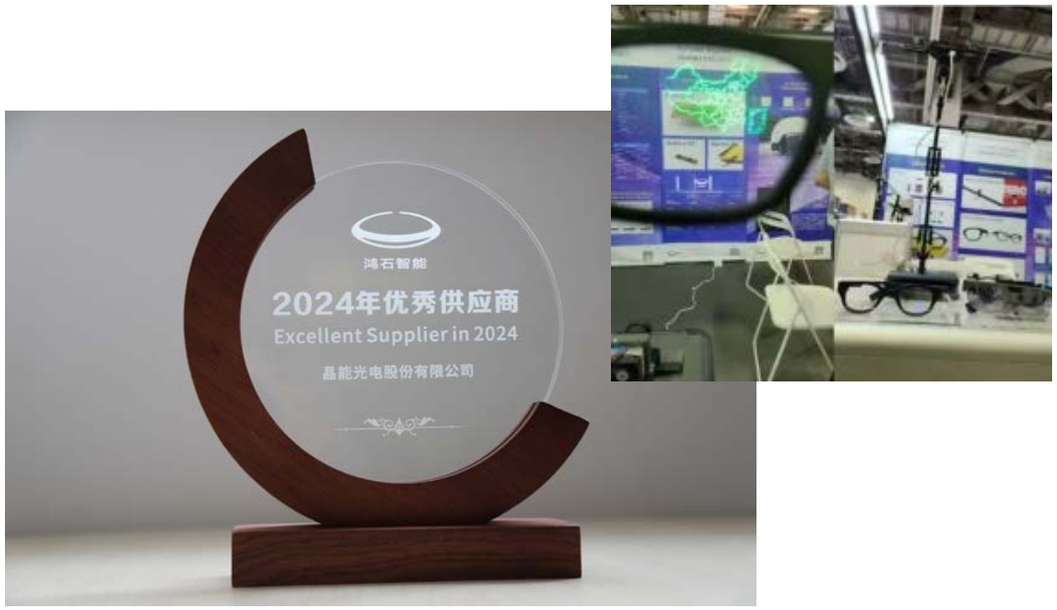
2. The crystal quality of gallium nitride is worse, the defect density is higher, and ultimately leads to a decrease in the luminous efficiency of epi wafers.

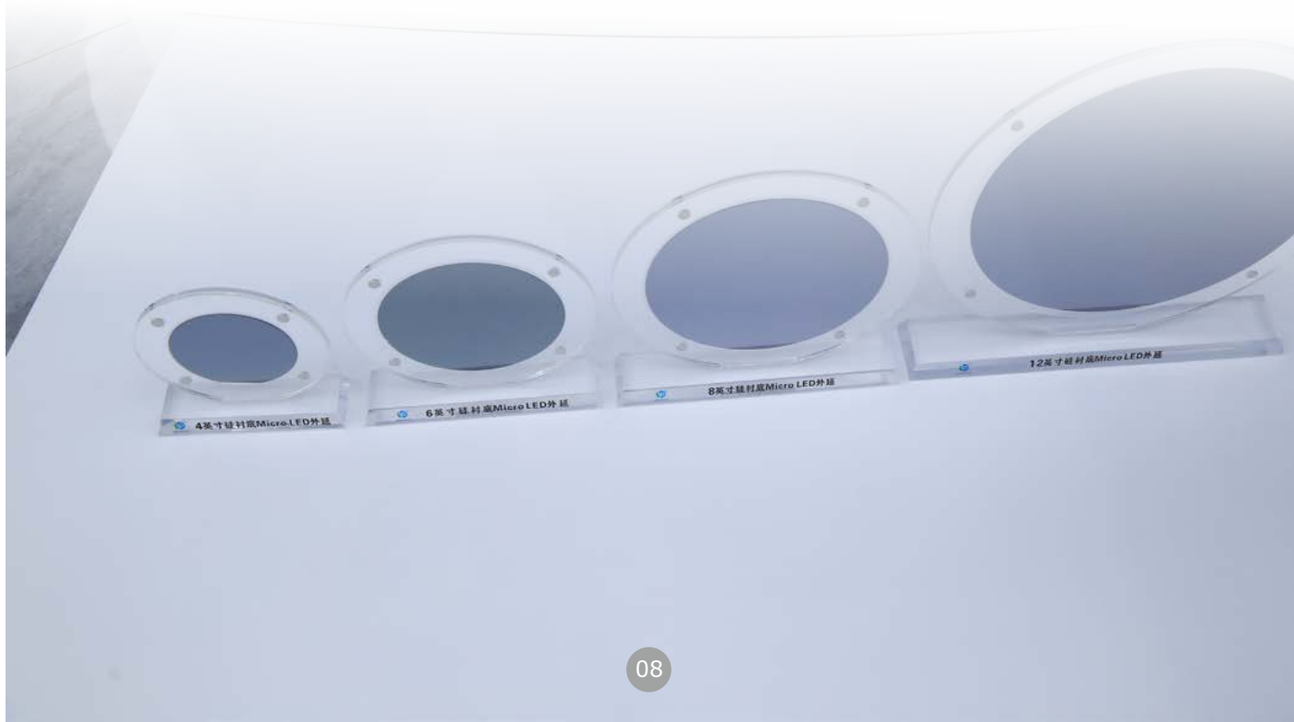
3. In order to better control warpage and cracks, the crystal quality of the epi wafer will be further sacrificed, resulting in a further decrease in the luminous efficiency of the epi wafer.

Due to differences in stress conditions, it is necessary to adjust the growth conditions of various layers to solve the above problems, new buffer layers, u/n GaN layers, and superlattice stress release layers are designed specifically for stress control, which greatly improved the lattice and thermal mismatch problems in large-size silicon-based gallium nitride films, improved crystal quality, and achieved the same level of quantum efficiency as 4inch blue-green epi wafers.

Possible Economic and Social Benefits

The mass production of 8 inches silicon substrate LED can help Micro LED manufacturing align with IC automation, significantly improving the efficiency, yield, and reliability of Micro LED production, while reducing costs and accelerating the adoption of Micro LED products. It is expected to create another trillion market in China similar to the current OLED industry.





Health lighting

03

EPLED Chip with Multi-Wavelength Technology for High Light Efficiency Visual-circadian health Lighting (Application in Human-Centric Full Spectrum (HCFS) Lighting)

Narvellux Technology (ShenZhen) Co., Ltd.

Brief Introduction

Based on years of research on GaN full-spectrum chips, we have developed original new types of single-chip multi-wavelength EPLED technologies and products. Meanwhile, targeting human-centric health lighting, we have developed multi-wavelength technical solutions for Human-Centric Visual Health, Circadian Health, and Visual-Circadian Health Spectral Power Distribution (HC-SPD). The combination of these two aspects provides a brand-new technical route and solution for realizing high-light-efficiency, visual-circadian healthy applications of human-centric full-spectrum lighting.

The new GaN EPLED chip multi-wavelength product series (e.g., 3 blue + cyan + green, blue-green, blue-cyan) used EPLED and Superchip LED technology. We solve the challenges of SPD spectral design and chip- phosphor integration required for LED human-centric full-spectrum visual-circadian health lighting. We offer unique, simple, and feasible mass-production technologies, establishes cost-effective product solutions, and thus

Application Scenarios		Examples of Scenarios	Practical Effects
1	Classroom and office	Classrooms, study rooms, libraries, offices, etc.	① The combination of high color rendering index with circadian health and visual-circadian health effectively prevents myopia and its further progression. ② Circadian health and visual-circadian health inhibit melatonin secretion and promote efficient work.
2	Medical and health care	Medical scenarios such as operating rooms	① High color rendering index ensures the safety of surgeries, treatments, etc. ② Enhanced visual health promotes melatonin secretion, creating a relaxing atmosphere.
		Healthcare and wellness scenarios	Full spectrum + visual health + circadian health + visual-circadian health safeguards circadian rhythm health, relaxes the body and mind, and promotes physical and mental health development.
3	Home and leisure	Home, yoga studios and other leisure scenarios	① The combination of high color rendering index with circadian health and visual-circadian health effectively prevents myopia and its further progression. ② Visual health + circadian health + visual-circadian health comprehensively safeguards circadian rhythm health and promotes physical and mental health development.
4	Commercial	Commercial scenarios such as shopping malls	① High color rendering index restores the true colors of commodities. ② Effectively prevents myopia and its further progression. ③ Comprehensively safeguards circadian rhythm health and promotes physical and mental health development.
5	Public and transportation	Subways, airports, museums, etc.	Effectively prevents myopia and its further progression.
6	Children's activity centers, etc.	Subways, airports, museums, etc.	① The combination of high color rendering index with circadian health and visual-circadian health effectively prevents myopia and its further progression. ② Visual health + circadian health + visual-circadian health comprehensively safeguards circadian rhythm health and promotes physical and mental health development.
7	Industrial workshops, etc.		① High color rendering index restores the true colors of objects, which is more conducive to work efficiency. ② Visual-circadian health promotes alertness and efficient work.
8	Outdoor scenarios		High color rendering index restores the true colors of outdoor objects, improving the safety of outdoor travel.

The Innovation Points

Human-Centric Full-Spectrum Lighting (HCSL) has become a primary development trend in semiconductor lighting. As full-spectrum lighting serves as the core foundational technology of Human-Centric Lighting (HCL), the upgrade from near-natural full-spectrum to beneficial full-spectrum lighting – delivering comprehensive light sources for both visual and non-visual health – is attracting increasing attention. Building on years of research into nitride-based full-spectrum chips, our company has developed an original, new category of single-chip multi-avelength EPLED technology and products. This innovation provides a novel technological pathway and solution

for achieving high-efficacy visual and circadian health applications in human-centric full-spectrum lighting.

EPLED represents an internationally leading, China-originated new category of LED technology. It features a novel device structure, unique operational mechanism, and entirely new characteristics and functionalities, offering expansive application potential across backlighting, lighting, and display fields. To address the spectral power distribution (SPD) requirements of Human-Centric Lighting (HC-SPD), it delivers a series of single-chip multi-wavelength products alongside Human-Centric Full-Spectrum lighting solutions specifically designed for visual and circadian health.

Centered on EPLED technology, the newly developed gallium nitride (GaN) EPLED single-chip multi-wavelength product series fundamentally resolves the core challenges in Human-Centric Full-Spectrum lighting: SPD spectral design and chip-phosphor integration required for visual and circadian health. It delivers a unique, simplified, and production-ready mass-manufacturing technology, establishing a cost-effective product solution. This breakthrough achieves the seamless integration of Human-Centric Full-Spectrum chip technology with lighting applications for visual health and circadian rhythm regulation.

Simultaneously incorporating our proprietary Superchip LED technology, this innovation delivers a groundbreaking approach to significantly reduce lumen costs and sustain Haitz's Law trajectory. The EPLED single-chip multi-wavelength series, enhanced with this technology, demonstrates ultra-high luminous efficacy, superior lumen cost efficiency, and exceptional reliability – perfectly aligning with sustainable development principles of energy-efficient, low-carbon, and eco-friendly lighting.

Concurrently, our company has established a multi-faceted systematic intellectual property portfolio, cementing the core technological supremacy of single-chip multi-wavelength EPLED chips in premium applications for Human-Centric Full-Spectrum lighting supporting visual and circadian health.

1. Technical Innovation Points

1) Chip & Epitaxial Technologies: Exclusive patented innovations featuring single-chip multi-wavelength EPLED + Superchip LED epitaxy and chip technologies.

① EPLED Technology:

A globally pioneering China-originated LED technology combining electroluminescent + photoluminescent mechanisms within a single chip. It introduces: Novel device architecture and operational dynamics, Groundbreaking characteristics and functionalities, Establishing an entirely new LED product category with expansive applications across backlighting, general lighting, and displays.

② Superchip LED Technology:

A revolutionary enabling technology that comprehensively outperforms existing LEDs in: Current spreading efficiency, Thermal management design, Chip efficiency optimization, Droop effect suppression, Strain relief engineering, Light extraction efficacy, Driving radical reductions in lumen cost and extending Haitz's Law trajectory.

2) Lighting Solutions: Patented multi-wavelength spectral power distribution (HC-SPD) technologies for human-centric visual health, circadian regulation, and dual-purpose applications.

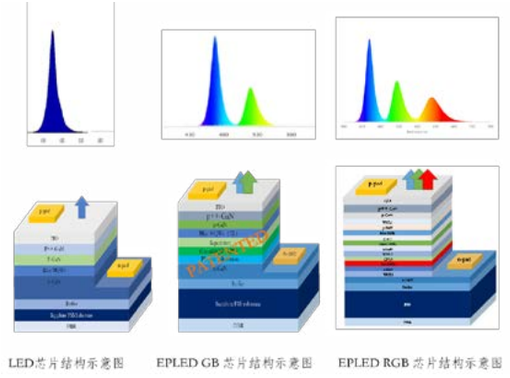
① Full-Spectrum Visual Health SPD Technology: Night Mode implemented through EP-BG chip packaging

② Full-Spectrum Circadian SPD Technology: Morning Activation Mode enabled by EP-BC chip packaging

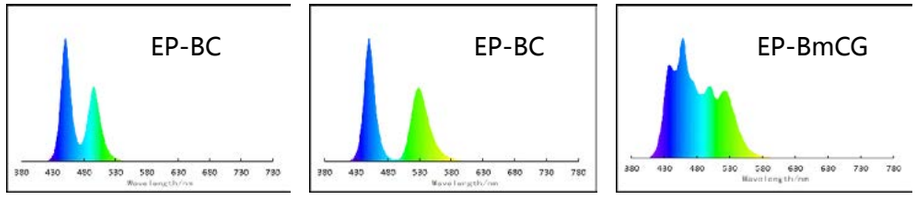
③ Full-Spectrum Dual-Mode SPD Technology: Daytime Mode powered by EP-BmCG chip packaging

2. Explanation of Technological Leap and Advantages

1) Epitaxial & Chip Technology Evolution: Achieving quantum leap from single-wavelength-per-chip to hybrid electroluminescent-photoluminescent single-chip multi-wavelength architecture.



LED芯片结构示意图　EPLED GB 芯片结构示意图　EPLED RGB 芯片结构示意图



Item	Conventional Single-Wavelength Chip	Existing single-chip with Multi-Wavelength	EPLED chip with Multi-Wavelength
Number of Wavelengths	1	≥2	≥2
Colors	1wa (UVA/blue/ Green…)	Multi blue wavelength	Full Spectrum Programmability
Luminescence Mechanism	Electroluminescent	Electroluminescent	Electroluminescent + photoluminescent
Spectral Stability with Current Changes	Bader	Bad	good
Blue-Green Light Coverage Capability (Without Phosphor)	narrow (range:440-460nm)	median (range:440-480nm)	wide (range:440-530nm)
Overall Luminous Efficiency Under Ultra-High Color Rendering Index	low	middle	high
Ra	>80	>95	>99
Spectral Continuity	bad	OK	idea

2) Leap in packaging solutions:

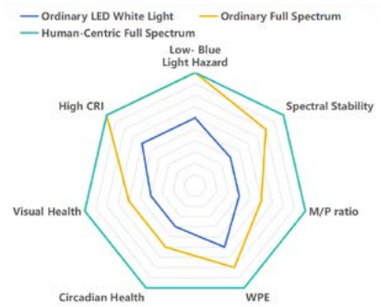
①Transition from single blue chip + phosphor solutions to single-chip multi-wavelength + phosphor solutions, delivering enhanced spectral continuity, higher luminous efficacy, simplified packaging/driving, and lower costs.

② Upgrade from multi-chip full-spectrum solutions to single-chip high-efficacy full-spectrum solutions,

featuring high luminous efficacy, visual and circadian health benefits, stable spectrum, simplified packaging/driving, and low costs.

3. Leap in lighting solutions:

Upgraded from ordinary full-spectrum solutions to human-centric full-spectrum solutions, which features prominent advantages such as low blue light harm (avoiding irreversible damage to eyesight), full spectrum, high color rendering index, health-vision benefits (promoting rapid physical and mental relaxation, effectively preventing and controlling myopia or its further progression), health-rhythm benefits (natural awakening, stimulating human vitality, and improving efficiency in study and work), health-vision-rhythm benefits (reducing visual fatigue, effectively preventing and controlling myopia or its further development, maintaining mental alertness, avoiding drowsiness, and enabling efficient work and study), and high luminous efficiency (energy-saving, low-carbon, and environmentally friendly).



Possible Economic and Social Benefits

Social Benefits:

1) The new GaN EPLED single-chip with multi-wavelength (multi-blue + cyan + green, blue-green, blue-cyan) series products built with EPLED and Superchip LED technologies at their core fundamentally solve the problems of SPD spectral design and chip-phosphor integration required for LED human-centric full-spectrum health-vision and health-rhythm applications. They provide unique, simple and feasible mass production technologies, lay a cost-effective product solution foundation, and thus thoroughly realize the perfect integration of human-centric full-spectrum chip technology with visual health and rhythmic health lighting applications.

2) Align with the national strategic plan for myopia prevention, and protect the visual health of children and adolescents: The prominent advantages such as low blue light harm, full spectrum, high color rendering index, health-vision benefits (avoiding visual fatigue and effectively preventing myopia), health-rhythm benefits (maintaining human rhythm and improving sleep quality), and high luminous efficiency will greatly help children and adolescents prevent myopia and prevent its further progression.

3) Comprehensively safeguard human rhythmic health and promote the overall development of all mankind towards a healthier direction.

4) Improve the safety of travel at night and in rainy or foggy weather, and protect human travel safety.

Economic Benefits:

Disruptive functional and cost-performance advantages: The cost per chip is 20% lower than the industry average, and the value of each chip product is at least 20% higher than the industry average. The EPLED single-core multi-wavelength series products integrated with Superchip technology also have advantages such as ultra-high luminous efficiency, lumen cost advantages, and high reliability, which are in line with the sustainable development path of "energy conservation, low carbon, and environmental protection".

Health lighting

04

Su Kangyang Geriatric Hospital Comprehensive Full-Light Circadian Rhythm Ward

Jiangsu inSona Communication Technology Co., Ltd.

Brief Introduction

1. General Introduction:

This project is a comprehensive full-spectrum circadian rhythm ward, leveraging the core patented technologies of our health lighting product series and supported by professional research data from medical teams. It targets patients with sleep disorders and geriatric conditions, establishing an intelligent and dynamic circadian phototherapy system.

Utilizing a multi-channel mixed-light algorithm and the Blubee control system, it achieves precise regulation of color temperature (1000K-8000K), spectrum (adjustable 480nm circadian factor), and brightness to meet patients' 24/7 activity needs—from morning wake-up, daytime diagnosis/treatment, to nighttime sleep assistance—forming a closed-loop phototherapy intervention.

As China's first fully integrated sleep disorder ward solution, it has commenced clinical operations and has been featured in reports by CCTV and Jiangsu Television.

2. Application Scenarios:

Six basic intelligent scenarios have been set up in the ward, including night-time bathroom use, awakening, diagnosis and treatment, sleep assistance, circadian rhythm regulation, and patrol, which have been adapted to the most basic medical care solutions.

In addition to using customized light sources that meet medical requirements, the project can dynamically adjust different spectral therapy plans for various wards based on physicians' medical protocols. It can also collaborate with professional medical detection equipment to track the effectiveness of light therapy.

The full set of solutions operates locally without relying on the network. Through the backend system, the company opens all interfaces to specifically connect with various medical devices. Physicians can carry out continuous tracking and management for each patient. Meanwhile, with portable lighting devices, doctors can continuously monitor the patients' home-based consolidation therapy process.

For example, in the morning, high-color temperature and specific band strong light are used to inhibit melatonin secretion, helping patients wake up quickly; at night, it switches to a specific low-color temperature spectrum to reduce the EML value, promote melatonin release, and assist in deep sleep. In the diagnosis and treatment mode, specially customized light sources ensure that doctors can clearly observe patients' physical signs while avoiding light interference. Additionally, the special band spectrum configured in the lamps can assist physicians in observing the pharmacological reactions of patients' skin, providing better services for medical staff.

3. Practical Effects:

Since the acceptance and opening of the clinic in September 2024, it has served more than 100 patients, with significant improvements in circadian rhythm disorders. By simulating natural light curves and adopting multi-band spectral fusion technology, the project effectively solves problems such as insomnia and emotional fluctuations, becoming the first benchmark for circadian rhythm wards with phototherapy characteristics in China.

The Innovation Points

1. Technical Advancement:

Patented Multi-Channel Mixed-Light Algorithm:

(1) Dual-Color Temperature Full-Spectrum Algorithm: Achieves full-spectrum lighting close to the blackbody

locus within the color temperature range of 2700K-6500K, eliminating spectral and color inaccuracies in traditional single-color temperature lamps.

(2) Dynamic Regulation of Circadian Factors: Independently adjusts the energy intensity of the 480nm band within 2200K-6500K to directly intervene in melatonin secretion, precisely matching patients' treatment-stage needs (e.g., morning inhibition, nighttime promotion).

(3) RGBCW Five-Channel Mixed-Light Algorithm: Supports an ultra-wide color temperature range of 1000K-12000K, with adjustable color saturation, chromaticity deviation, and full-spectrum colors to assist emotional therapy in medical scenarios.

Medical Data Backend Processing System: Establishes phototherapy archives for each sleep disorder patient through a large data model, dynamically adjusts spectral output based on physicians' treatment plans, and regularly summarizes data.

Customized Intelligent Lamps:

The entire ward uses customized products from the health lighting series. Bedside lamps adopt upper-lower light separate control to meet dual needs of diagnosis/treatment and patient activities. Optimization of Cyanosis Observation Index (COI<3.3) improves the accuracy of medical observation.

Space-Time Synchronized Phototherapy:

By simulating solar trajectories in different global time zones and coordinating with the system for full-ward light management, it provides personalized rhythm adjustment solutions for cross-time zone patients, filling a gap in the international medical lighting field.

Integrated Full-Scheme Treatment:

The system supports comprehensive solutions, providing systematic interventions for sleep disorder patients through integration of light, sound, electrodes, olfaction, and touch.

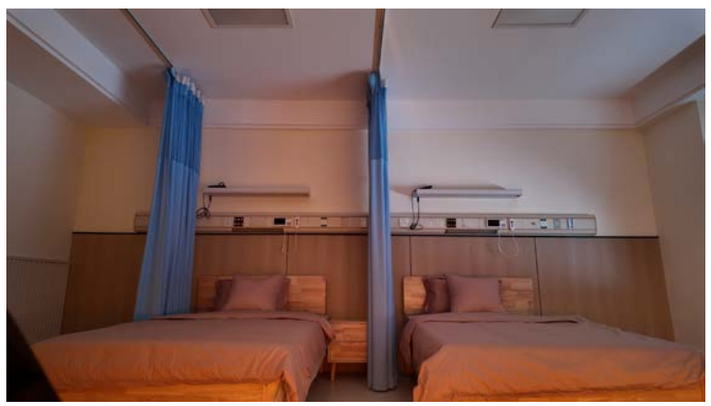
2. Key Issues Addressed:

(1) Clinical Pain Points:

Traditional medical lighting cannot adapt to biological clocks or intervene in patient emotional healing through light color. This project uses health lighting products to assist melatonin secretion, emotional regulation, and improve sleep disorder treatment and postoperative recovery efficiency.

(2) Conflict Between Doctor-Patient Needs:

The night patrol mode is linked with a sensor system, ensuring clear observation for doctors while avoiding strong light interference with patients' sleep.



(3) Scenario Expandability:

The technology has been extended to educational lighting (Chasing Light series) and health care lighting (Healing Light series), covering scenarios such as improving learning focus for adolescents and enhancing sleep quality for the elderly, forming a complete healthy light environment solution.

Possible Economic and Social Benefits

Economic Benefits:

(1) Cost Advantages:

Through intelligent lighting scenario adjustment to assist treatment, the hospital stay cycle of patients is reduced, and the medical cost of single-ward rooms is significantly lowered.

(2) Market Prospects:

China's demand for health care lighting continues to expand under the trend of population aging, and national policies strongly promote the transformation of light environments in medical and elderly care scenarios, injecting strong momentum into industry development. The circadian rhythm lighting solution has been successfully implemented in multiple medical health care projects and university psychology rooms. By optimizing the medical experience through dynamic spectral technology, it has also expanded horizontally to educational and office fields: designing eye-protecting light environments for adolescent visual health, providing intelligent office lighting solutions for enterprises, achieving multi-scenario coverage of "medical-education-workplace", and demonstrating high adaptability and market potential.

Social Benefits:

(1) Patient Well-Being:

Improves sleep quality and treatment efficiency, reduces drug dependence, and is particularly suitable for elderly groups and postoperative rehabilitation patients.

(2) Industry Promotion:

Provides a standardized model for the medical lighting field, helping to implement the "Healthy China 2030" strategy.

(3) Green Health:

The entire system complies with the IEC 62471 standard for no blue light hazard, reduces light pollution, and contributes to the construction of green hospitals.

05

Visible Light Communication (LiFi)

LIFI Lighting Communication Equipment

Wuhan Liubo Photoelectric Technology Co., Ltd.

Brief Introduction

LIFI Lighting and Communication Equipment Developed by the Company

The LIFI lighting and communication equipment developed by the company can turn light into a high-speed network in seconds. LIFI lighting transmits data using visible light, with a network speed 10 times faster than WiFi. It is secure and anti-leakage, making it applicable in hospitals and banks. Although it has the limitation of not being able to penetrate walls, it has unlimited potential in the future—one light can handle both lighting and internet access. Among its key components, the LB-WHLED-6 high-speed modulated white LED light panel** is an innovative device that integrates high-brightness lighting and high-speed optical signal transmission functions. Equipped with six high-efficiency white LEDs, its core advantage lies in a maximum modulation rate of 30Mbps, while also supporting downward rate compatibility. It can provide high-optical-power lighting while achieving high-speed data transmission through the rapid switching of LEDs. Perfectly adapting to the core principle of the LiFi system, it is an integrated terminal device that combines practical lighting performance and high communication performance. LIFI Lighting Communication Equipment Developed by the Company the LIFI lighting communication equipment developed by the company integrates "lighting + high-speed network" functions, transmitting data via visible light. Its network speed is 10 times that of WiFi, and it features security and anti-leakage performance, making it suitable for scenarios with high security requirements such as hospitals and banks. Although it has the limitation of not being able to penetrate walls, it has broad application potential in the future. Among its components, the core part is

the LB-WHLED-6 high-speed modulated white LED light panel, which integrates high-brightness lighting and high-speed optical signal transmission functions. Equipped with 6 high-efficiency white LEDs, it has a maximum modulation rate of 30Mbps and supports downward compatibility. While providing high-optical-power lighting, it can achieve high-speed data transmission through the rapid switching of LEDs, accurately adapting to the core principle of the LiFi system. It is a core terminal that combines lighting practicality and high communication performance.

Application Scenarios

1. LiFi System Scenarios: As a core device of LiFi terminals, it is applicable to indoor environments such as homes, offices, and shopping malls. By utilizing the optical signal transmission characteristics of white LEDs, it enables high-speed Internet access, and is particularly suitable for places sensitive to electromagnetic interference (e.g., hospitals, laboratories).

2. Smart Lighting Network Scenarios: In smart buildings and smart homes, it can not only meet daily lighting needs but also support real-time communication between devices through high-speed data transmission (such as feedback of lighting control signals, upload of environmental sensor data, etc.), building an integrated "lighting + Internet of Things" network.

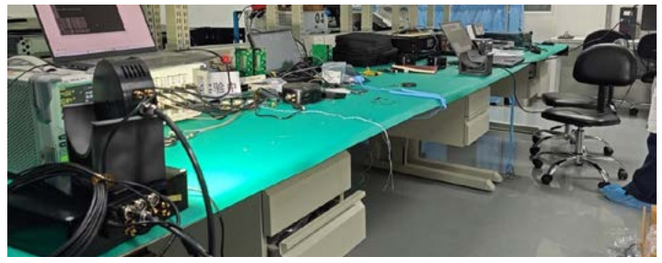
Practical Effects

1. Convenience and Integration: It realizes "Internet access as soon as the light is turned on" without the need for additional deployment of dedicated communication equipment. A single light panel can meet both lighting and high-speed communication needs, reducing the number of devices, lowering installation and maintenance costs, and solving the problem of resource waste in the traditional separate deployment of "lighting + communication".

2. Performance Adaptability: The high-speed modulation rate of 30Mbps meets the demand for high data transmission of the LiFi system, while high optical power ensures lighting effects. The downward compatibility of the rate adapts to the transmission needs of different scenarios (from low-speed control signals to high-speed data interaction), improving system flexibility.

3. Scenario Advantage Adaptation: Relying on the characteristics of LiFi technology, it produces no electromagnetic interference or radiation during use, is environmentally friendly and energy-efficient (LEDs themselves have low energy consumption). Moreover, the directional transmission of optical signals brings strong confidentiality, effectively solving the application pain points of traditional wireless communication in electromagnetic-sensitive scenarios and privacy protection scenarios, and providing a practical terminal solution for the civil application of optical communication in the future 6G network.

The Innovation Points



▲ Experimental Scene Usage Diagram

The Company's R&D of Four Core Optical Communication Products The company has developed four core optical communication products, covering two major technical directions of white light communication and infrared light communication, to meet the needs of different scenarios:

1. White Light Communication Products -LB-WHLiFi-10M White Light Communication Module: Integrates high-speed signal modulation and demodulation functions. The modulation end realizes optical signal transmission by loading electrical signals onto LEDs; the demodulation end uses a high-sensitivity photomultiplier tube (PMT) to capture weak optical signals and convert them into electrical signals for processing. The maximum communication rate reaches 30Mbps. -LB-WHLED-6 High-Speed Modulated White LED Light Panel**: Equipped with 6 high-efficiency white LEDs, it has a maximum modulation rate of 30Mbps and can simultaneously achieve high-brightness lighting and high-speed optical signal transmission. It is an ideal choice for "lighting + communication" scenarios such as LiFi systems and smart lighting networks.

2. Infrared Light Communication Products-LB-RELED-6 High-Speed Modulated Infrared LED Light Panel: Integrates 6 high-performance infrared LEDs, specially designed for high-speed optical communication. It supports a maximum modulation rate of 10Mbps and enables stable and efficient infrared optical signal transmission. -LB-RELiFi-10M Infrared Light Communication Module**: Composed of an FPGA information processing module, an LED modulation module, and a demodulation module, it can complete integrated operations of data encoding, transceiving, and decoding, with a maximum communication rate of 10Mbps.

Core Technological Innovations

(1) Breakthrough in High-Speed Modulation Technology It achieves a maximum modulation rate of 30Mbps with downward compatibility, breaking through the limitations of traditional white LEDs. By optimizing the LED drive circuit and optical signal modulation algorithm, efficient and high-frequency switching of optical carriers is realized. Its technical indicators are leading in the industry, filling the gap in the integration of medium-to-high-speed optical communication and general lighting.

(2) Integrated Design of Lighting and Communication It integrates high-brightness lighting and high-speed data communication into a single light panel. Relying on 6 high-efficiency white LEDs, it not only meets the demand for high-optical-power lighting but also undertakes optical signal transmission. Abandoning the separate deployment mode of lighting and communication equipment, it realizes multi-functional reuse of equipment, expands the application scenarios of traditional LEDs, and provides a new idea for the miniaturization and cost reduction of optical communication terminals.

Advanced Technical Level

From the perspective of industry technology, the 30Mbps modulation rate ranks among the advanced levels in China in the field of white LED optical communication. Especially under the premise of taking into account the lighting function, this rate is far higher than the average level of similar integrated products (most products have a modulation rate of less than 10Mbps). Its core technical indicators are close to the transmission capacity of mainstream international dedicated LiFi equipment. Moreover, relying on the compatibility with general lighting, it has greater advantages in applicability to civil scenarios (such as homes and offices), demonstrating a technological breakthrough in "high performance of general-purpose equipment".

Practical Application Problems Solved

1. Addressing the Coordination Dilemma of "Lighting + Communication": Traditional lighting and communication equipment require separate deployment, which leads to high costs, large space occupation, and easy interference. With an integrated design, the light panel simultaneously realizes high-brightness lighting and high-speed optical communication, reducing the number of equipment, simplifying installation, and lowering the deployment cost in scenarios such as smart buildings.

2. Meeting Core Needs of LiFi and Smart Lighting: Existing LiFi equipment has poor compatibility, and traditional LEDs cannot meet the high-speed requirements of smart lighting. The light panel balances the 30Mbps high rate and high optical power, which not only meets the needs of LiFi but also adapts to smart lighting, solving the pain points of insufficient communication rate and conflicting lighting-communication performance.

In conclusion, relying on high-speed modulation technology and integrated design, the light panel reaches an advanced technical level in China. It solves the problems of lighting-communication coordination and scenario adaptation, provides an efficient and economical solution for LiFi and smart lighting, and demonstrates significant application value.

Possible Economic and Social Benefits

Open Up Incremental Markets and Drive Industrial Chain Expansion

High-value application scenarios expanded by LiFi lighting and communication equipment

LiFi has irreplaceable advantages (no electromagnetic interference, no spark risk) in electromagnetic-sensitive scenarios (such as hospitals, aircraft, and industrial control), security-sensitive scenarios (such as military, finance, and government), and flammable and explosive scenarios (such as mines and gas stations). It can open up new markets that are difficult to cover by traditional communication technologies.

Stimulate demand in upstream and downstream industries

The promotion of LiFi will drive the R&D of core technologies such as LED chips (with higher modulation rates), optical receiving modules (high-sensitivity photodetectors), and signal processing algorithms. It will promote the upgrading of industries including semiconductors, communication equipment, and lighting, form new economic growth points, and create a large number of jobs.

Save energy, reduce consumption, and lower long-term operating costs Advantage in energy efficiency

LEDs themselves are high-efficiency and energy-saving light sources, with energy consumption only 1/10 of traditional incandescent lamps and 1/3 of fluorescent lamps. LiFi directly uses LED lighting systems to achieve communication, without the need for additional power supply for communication equipment (traditional WiFi routers and base stations require separate power consumption). In the long run, it can significantly reduce energy consumption costs.

Reduce carbon emissions

Based on the low-energy characteristics of LEDs, the full-life-cycle carbon emissions of LiFi networks are much lower than those of traditional communication networks (such as the high power consumption of base stations and routers). It conforms to the "dual carbon" goals and indirectly reduces the overall environmental protection costs of society.

Smart Lighting

06

Tianyan Series Unmanned Aerial Vehicle Smart Treet Lamps

Longt Lighting Group Inc.

Brief Introduction

Main application:

The series of unmanned aerial vehicle (uav) wisdom eye lamp light pole to city as the carrier, through innovative design to achieve "one pole is multi-purpose", significantly improve efficiency of urban management and emergency response ability and provide wisdom city construction and the digital transformation of high efficiency, energy saving, intelligent solutions.

Technical principle:

By air and ground "collaborative perception and execution, the static lighting upgrade for the dynamic intelligence service, is an important exploration direction of wisdom city new infrastructure. With the maturation of self-driving drones and AIoT technology, their application scenarios will be further expanded.

Key technology and innovative:

Through "light pole - unmanned aerial vehicle (uav)" depth fusion, realizes the dynamic response and resource intensive. The core technologies include: rapid response platform, multi-modal perception, low-altitude networking communication, and modular expansion. Innovation is to reuse, reduce 30% deployment cost through infrastructure, and realize the unmanned aerial vehicle (uav) inspection, covering all scene, such as traffic monitoring, environment monitoring to promote green wisdom urban construction.

Application and benefit condition:

This project has applied for 1 invention patent (patent name: a kind of unmanned aerial vehicle (uav) automatically charging the apron of the LED street lamp wisdom, patent no. 2024118426036), 1 received patents of appearance (201930616644.7)

The Innovation Points

1. Project background

Tianyan series unmanned aerial vehicle (uav) smart street lamp is the apron, intelligent lighting, environmental monitoring, security monitoring, 5 g communications and urban public service in the integration of a new generation of intelligent urban infrastructure. This product takes urban street lamp poles as its carrier and achieves "one pole with multiple uses" through innovative design, significantly enhancing urban management efficiency and emergency response capabilities. It provides efficient, energy-saving and intelligent solutions for smart city construction and digital transformation.

2. The content of detailed technical

(1) Core function and advantages:

Unmanned aerial vehicles (uavs) quick response platforms: built-in drone aircraft downtime and automatic charging device, support uav real-time take-off, greatly shorten the emergency events, such as traffic accidents, disasters inspection response time, improve urban safety monitoring and the rescue efficiency.

Multi-functional intelligent integration: integration of intelligent lighting, environmental sensors, high-definition cameras, public wi-fi and broadcast system, realize data real-time acquisition and linkage analysis, power precision urban governance.

Efficient space utilization and energy conservation and environmental protection: reuse existing light pole resources, avoid duplication of construction;

The adoption of solar power supply and LED energy-saving lighting reduces energy consumption and is in line with the concept of green urban development.

Support for unmanned aerial vehicle (uav) inspection: the inspection for the city (traffic, electric power, environmental protection) to provide all-weather landing node, promote urban services to upgrade.

(2) Application scenarios:

Public safety accident uavs quick survey, scene real-time feed-back.

Environmental protection: air quality monitoring and pollution source tracking. Intelligent traffic: traffic monitoring, illegal capture and traffic guidance.

(3) Industrial design:

A. The modular design light pole at the top of the unmanned aerial vehicle (uav) hangar use fast disassembly type design, unmanned aerial vehicle (uav) hangar with light pole at the top of the fusion.

B. Reduce the wind resistance to streamline modelling lamp holder adopts streamlined design, reduce wind resistance.

C. The lightweight design of lightweight material to reduce the overall weight, ease of installation and maintenance.

3. The main point of technology integration innovation of technological innovation:

A. To integrate the uav hangar and wisdom light pole, power and communication network using light pole, realize unmanned aerial vehicle (uav) "the box".

B. Resource intensive design: reuse infrastructure and save 30% of urban space, reduce the deployment cost.

C. Modular extensions: support on-demand loaded environmental sensors, 5 g micro base station, etc., adapted the future city needs wisdom.

D. Light pole assignment of base station can drone low-level networking: using the light pole deployed tiny 5 g base stations, for unmanned aerial vehicle (uav) with low latency (< 10 ms) communication with local support, real-time video analysis (such as license plate recognition, fire warning).

E. Visual tracking task: real-time display uav location, estimated time of arrival and task schedule, improve the public trust.

Possible Economic and Social Benefits

The Tianyan series of unmanned aerial vehicle (UAV) smart street lamps integrate intelligent lighting, UAV, Internet of Things (iot), and artificial intelligence technologies to create multi-functional urban nodes, achieving functions such as intelligent dimming, emergency response, traffic monitoring, and environmental monitoring. Its economic benefits are remarkable, capable of reducing energy consumption and operation and maintenance costs by 30% to 60%. Enhance public safety, traffic efficiency and convenient services in terms of social benefits; The ecological benefits are reflected in energy conservation and emission reduction, precise environmental monitoring and reduction of light pollution. Despite challenges such as high initial investment and privacy issues, these can be gradually addressed through the PPP model and technological optimization. It will become the core infrastructure for smart city construction in the future, promoting the coordinated development of the economy, society and ecology.

Smart Lighting

07

Light & Emotion --
AI Smart Desk Lamp “Senbao”

MLS Co., Ltd.

Brief Introduction

AI smart desk lamp "Senbao"

"AI Lighting Robot v2" is the world's first desktop-level AI lighting service robot, integrating robot technology, AI large language models and dynamic light scene solutions to redefine human-light interaction. The product provides users with a healthy, intelligent and emotional lighting experience through a six-axis collaborative robotic arm, TruWave full-spectrum technology, dynamic tracking and multimodal interaction technology.

Application scenarios

- Work scenario: Dynamic tracking of users' faces and visual targets, providing focused lighting mode to reduce visual fatigue and improve work efficiency.
- Home scene: Supports gesture control, voice conversations (such as asking about the weather, adjusting ambient light), combined with BIOLUX technology to simulate the dynamic curve of natural light, from morning wake-up to night companion, adapting to different life scenarios.
- Creative and educational scenarios: Enhance the fun of artistic creation and learning through immersive dynamic light interaction.

Practical effects

- Health and eye care: TruWave technology provides low short-wave blue light, high color rendering light sources close to the daylight spectrum, reducing eye fatigue and enhancing alertness.
- Smart interaction: Supports voice, gesture, and facial emotion recognition to achieve "light following the person"; Emotional design (such as actively approaching the user) enhances the emotional connection between humans and machines.
- Energy efficiency: AI dynamically adjusts light intensity and patterns to reduce ineffective energy consumption, achieving an overall energy saving rate of over 30%.

The Innovation Points

Technological advancement

1. AI-driven dynamic light scene technology:

- For the first time in the world, a large language model (Doubao AI) has been combined with lighting systems to enable natural language dialogue control of light environments (such as "ambient mode" voice commands).
- The six-axis collaborative robotic arm tracks the user's face and movements in real time and dynamically adjusts the Angle and intensity of light with millimeter-level precision, leading industry standards.

2. TruWave full-spectrum technology

- Full-spectrum design based on natural light, color rendering index (CRI) > 95, short-wave blue light less than 5%, meets the International Commission on Illumination (CIE) healthy light standard, and addresses the flickering and blue light hazards of traditional LED light sources.

3. Multimodal interaction system:

- Combining gesture recognition, facial emotion analysis and voice interaction to achieve scenarios such as "light dancing" and "mood ambient light", breaking through the limitations of traditional one-way lighting control.

4. BIOLUX Emotional Lighting:

- Simulate daylight dynamic curves and adaptively adjust lighting patterns with GIS information; Bionic interaction design (such as the "dawdling response") has pioneered the emotionalization of lighting equipment.

Practical problems solved

- Health pain points: Relieve eye fatigue through low blue light, high color rendering light sources, especially suitable for long-term eye users such as students and office workers.
- Insufficient intelligence: Traditional lighting relies on manual adjustment, AI robots achieve "insensitive" adaptive lighting to enhance the user experience.
- Energy waste: Dynamic adjustment technology reduces ineffective lighting to help achieve the "dual carbon" goals.

Global leadership

- 12 international patents, core technology certified by TUV Rheinland Health Light.
- Was named one of the "Top 10 Global Lighting Innovations 2025" by Lighting Design.

Possible Economic and Social Benefits

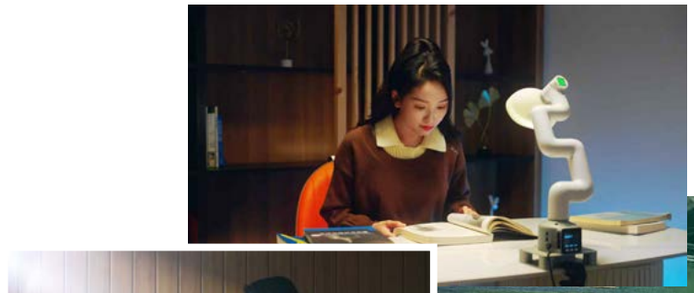
Economic benefits

- Market expansion: Relying on Landsea 'global sales network of 140 countries and online traffic on Douyin / TikTok, it is expected that sales will exceed 500,000 units in the first year and revenue will exceed 1.5 billion yuan.
- Industrial chain synergy: By collaborating with technology providers such as Volcano Engine and Doubao AI, we have promoted the upgrading of the smart lighting industrial chain, driving an increase in the output value of the upstream and downstream sectors by over 3 billion yuan.

Social benefits

- Health value: Reduce over 100,000 cases of vision impairment caused by poor-quality light sources each year and improve the eye health of the nation.
- Energy efficiency and environmental protection: Life-cycle energy efficiency design, reducing carbon emissions by about 200kg per unit per year, contributing to global carbon neutrality goals.

Technology for all: Lowering the threshold for the elderly and children to use through emotional interaction, promoting the popularization of smart technologies.



08

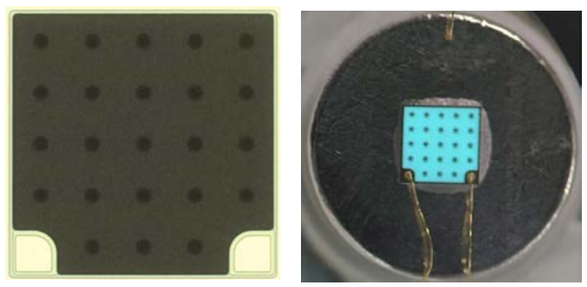
UV LED Application

340nm Short-Wave Near-Ultraviolet Vertical LED Chip

Suzhou LEKIN Semiconductor Co., Ltd.

Brief Introduction

Through a breakthrough epitaxial growth technology combined with a substrate lift-off process, the world's first vertical-structure LED chip operating at the 340nm band has been successfully fabricated. After substrate removal, the chip incorporates interface texturing and optimized thermal engineering solutions, demonstrating exceptional performance and significantly extended operational lifetime. This achievement successfully overcomes long-standing technological barriers in the field.



▲ Figure 1: LEKIN 340nm Chip and Its Illumination Effect

Three Key Performance Advantages Driving Industry Innovation

1. Doubled Light Efficiency:

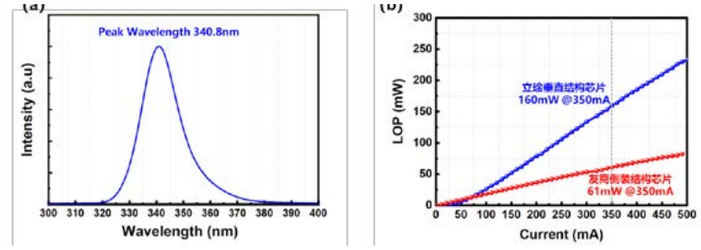
The vertical-structure chip at 340nm band achieves a breakthrough luminous power of 160mW@350mA, 2.5x higher than traditional flip-chip counterparts, meeting high-energy-density ultraviolet output requirements.

2. High-Current Driving Capability:

With superior heat dissipation, the vertical-structure chip enables 1A high-current driving, tripling the driving current of traditional flip-chips.

3. Extended Lifespan:

After 1,000 hours of continuous operation, the vertical-structure chip maintains >95% luminous flux retention rate, with reliability far surpassing traditional flip-chips, suitable for industrial-grade harsh environments.



▲ Figure 2: LEKIN 340nm UV Chip (a) Spectrum and (b) Light Output Power Comparison

Continuous spectral coverage enables customized global solutions:

1. Industrial Manufacturing:

Enabling high-precision fabrication in photoresist curing, deep-layer curing of high-transparency materials, spray coating curing, and 3D printing, driving upgrades in automotive electronics and smart manufacturing.

2. Biomedical:

Advancing precision medicine innovations through pharmaceutical detection, targeted therapy, skin repair & rejuvenation, and blood component analysis.

3. Environmental Technology:

Promoting green sustainability via water quality monitoring, photocatalytic purification, plant growth regulation, and pest trapping.

4. Cutting-Edge Research:

Accelerating breakthroughs in fundamental science with photochemical synthesis, semiconductor material characterization, and specialized material aging experiments.

The Innovation Points

Currently, two technical pathways exist for manufacturing UV LED chips: sapphire substrates and silicon-based substrates. Internationally, leading enterprises predominantly adopt sapphire substrate technology. However, sapphire-based UV LED still face critical challenges such as low external quantum efficiency (EQE), high operating voltage, and limited output power, which constrain their large-scale market applications. Fundamentally, these limitations stem from the flip-chip structure of conventional UV LED based on sapphire substrates: TM-mode ultraviolet light propagating parallel to the in-plane interface tends to undergo total internal reflection at smooth material boundaries. Consequently, most light is absorbed internally rather than emitted, resulting in extremely low light extraction efficiency.

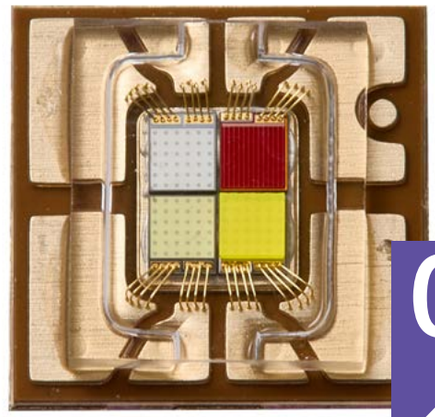
Through proprietary technologies in high-Al-content AlGaN heteroepitaxial growth on silicon substrates, non-destructive substrate removal, and interface texturing during chip processing, we achieved the industry's first vertical-structure LED chips operating in the 340–360 nm band. This series of chips significantly enhances light extraction efficiency by suppressing total internal reflection via textured light-emitting interfaces. Combined with thermal management engineering post-substrate removal, they demonstrate exceptional performance and longevity, delivering 2.5 times higher luminous efficacy than conventional flip-chip designs. These advancements enable broad applications in photocuring, photocatalysis, and medical detection.

▲ Figure 3: LEKIN UVA Chip Application Scenarios

Possible Economic and Social Benefits

As mercury lamps are gradually phased out, they leave behind a substantial market void. Concurrently, technological advancements in UV optoelectronic chips continue to unlock diverse new application fields. Currently, the global UV optoelectronic chip market remains in its nascent stage, projected to reach $2.466 billion by 2026, indicating immense market potential. Developing UV LED chips now will seize the first-mover advantage, generating significant economic benefits for enterprises and regional economies. In China, UV optoelectronic chips have flourished, yet the overall technical level remains relatively low, with UV LED chips still heavily reliant on imports. Through self-developed R&D in vertical-structure UV LED chip technology, key process barriers have been overcome, resulting in multiple proprietary patents that significantly enhance China's core competitiveness in this domain.

Other Type： LED Packaging Device



09

Novel Ultra-High Power RGBL (Red-Green-Blue-Lime) Quad-Color LED Light Source

Luminus Devices (Xiamen) Co., Ltd.

Brief Introduction

With the continuous maturation and advancement of LED lighting technology, using LEDs as light sources for stage lighting offers advantages such as richer colors, ease of use, longer lifespan, and higher energy efficiency. Consequently, LED stage lights are gradually replacing traditional stage lights and becoming the market mainstream. However, they also face challenges like limited variety, insufficient brightness of mixed-color sources, narrow tunable color gamut, and inability to be used in high-power applications.

Novel Ultra-High Power RGBL (Red-Green-Blue-Lime) Quad-Color LED Light Source achieves high lumen output under high current density (4.8A 60W, 4A/mm^2) through its unique chip-level thermoelectric separation technology, chip-integrated lateral heat spreading layer, and high thermal conductivity copper substrate packaging technology. By updating the traditional white light version using "Blue-to-Green" ceramic phosphor plate technology, it achieves high color rendering index (CRI > 85) and richer mixed light effects.

Novel Ultra-High Power RGBL Quad-Color LED Light Source is suitable for a wide range of applications, not

only including entertainment and stage lighting, but also supporting architectural lighting, spotlights, pool and fountain lighting, medical technology, fiber-coupled lighting, and image processing, among many other fields. It enables optimization of luminaire performance and design, providing core device support for product series of globally renowned lighting manufacturers.

The Innovation Points

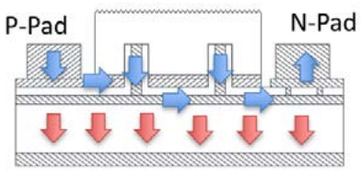
Innovation 1: Chip-Level Electro-Thermal Separation Technology

To address the thermal management challenges under ultra-high current density injection, the product design achieves chip-level electro-thermal separation. Utilizing substrate transfer technology, a high-thermal-conductivity AlN insulating substrate chip structure (as shown in Figure 1) was realized. This structure separates the heat flow from the current flow, directing the current through the top of the AlN substrate (indicated by the blue arrow) while dissipating heat downward through the AlN substrate (indicated by the red arrow).

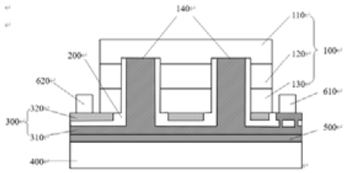
Innovation 2: Chip-Embedded Lateral Heat Spreading Layer

The product incorporates a lateral heat spreading layer within the chip to enhance heat dissipation, reduce resistance, and improve reliability. As illustrated in Figure 2, the designed 500-layer lateral heat spreading

layer ensures more uniform heat conduction from the active region downward to the AlN substrate. This prioritizes lateral heat diffusion, minimizing localized vertical thermal bottlenecks and lowering the chip's thermal resistance.



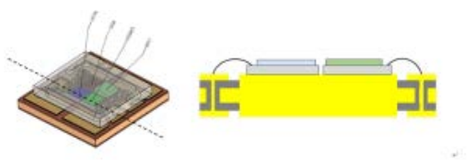
▲ Diagram of Thermoelectric Current Shunting in a Chip



▲ Diagram of Thermal Spreader Location

Innovation 3: High-Thermal-Conductivity Package Substrate Technology

On the packaging side, the product adopts a high-thermal-conductivity copper substrate solution. An array-based packaging design forms the multi-color integrated module SBM-50X-RGBL, as shown in Figure 3. The four color channels are individually controlled, enabling wide-range color temperature adjustment while maintaining a color rendering index (CRI) of ≥90. Figure 3 also presents cross-sectional schematics of the blue and green channel structures.



▲ Product Diagram and Cross-Section View

Possible Economic and Social Benefits

Novel Ultra-High Power RGBL Quad-Color LED Light Source technology not only provides outstanding color mixing and brightness but also enhances the reliability and flexibility for a wide range of lighting applications. Luminus's RGBL LED is suitable for extensive applications, including:

- Entertainment and Stage Lighting: Create stunning light shows with vibrant colors and high brightness.
- Architectural Lighting: Impressively highlight buildings and monuments.
- Spotlights: Ideal for accent lighting and targeted illumination.
- Pool and Fountain Lighting: Create captivating water features with brilliant colors.
- Medical Technology: Optimal lighting solutions for medical applications.
- Fiber-Coupled Lighting and Image Processing: Precise and reliable lighting for professional applications.

The new RGBL LED product series optimizes luminaire performance and design with innovative features and advantages, making it the ideal choice for those who do not want to compromise on lighting solutions. Invest in the future of lighting and experience the outstanding performance of the new RGBL LED. Explore the various possibilities and bring new brilliance to projects for global luminaire manufacturers.

The "Novel Ultra-High Power Quad-Color LED Light Source" has also been recognized by numerous authoritative organizations. At the recent 12th China LED Pioneer Awards ceremony, this product won the "Gold Award at the 12th China LED Pioneer Awards". This award acknowledges company's continuous efforts in technological innovation and demonstrates the company's technical strength within the industry.

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