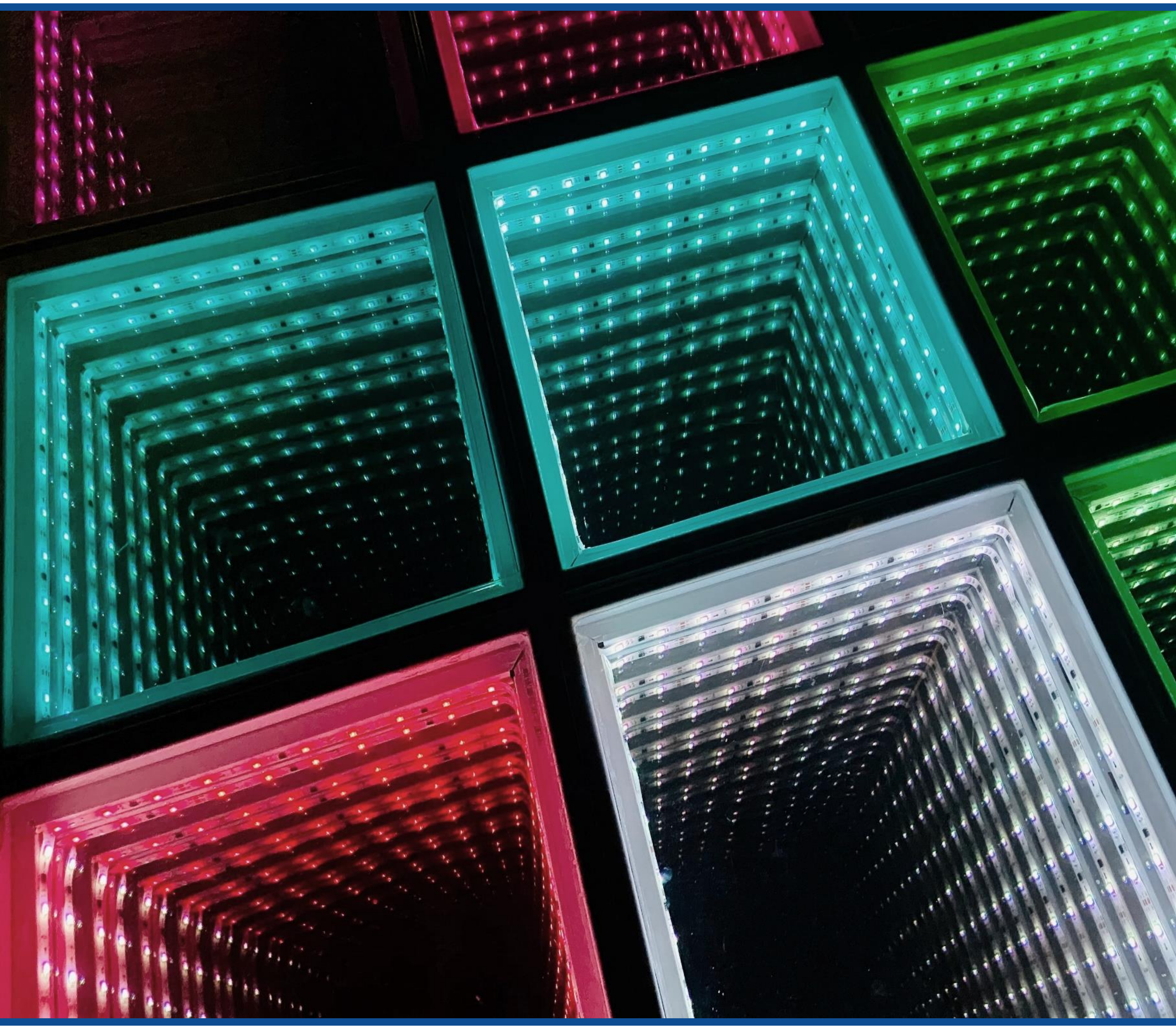
Product Catalog



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SAPHLUX

An Innovative Way to Illuminate the World

Introduction

Saphlux provides the next-generation light source products to customers in the display and lighting industries.

Starting from Yale in 2014, our team always focuses on GaN material innovations and has commercialized the first 4-inch semi-polar GaN template and the unique NPQD™ color conversion technology.

Together with our customers and partners, we now provide the efficient, reliable, and low-cost NPQD™ Mini/Micro-LEDs for various fine-pitch display and Micro-LED display applications.

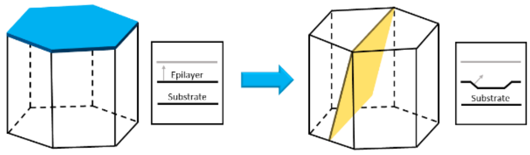
The company operates globally with offices in both the US and China.

Semi-polar Technology

Eliminate Quantum Confined Stark effect

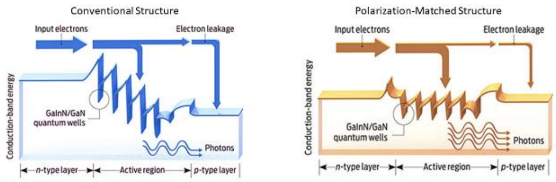
Conventional GaN materials are subjected to a large built-in polarization field that bends energy bands in quantum wells of optoelectronic devices such as LEDs. It causes a separation between electrons and holes, leading to an efficiency reduction by the quantum confined Stark effect (QCSE) and is now limiting further development of LEDs and laser diodes.

To address this issue, Saphlux developed a unique facet controlled lateral (FCL) growth technology to enable large-size semi-polar GaN wafers with eliminated stacking faults. Saphlux now provides high-quality 4-inch semi-polar GaN templates.



Semi-Polar $(\bar{2}021)$ (75°)

To achieve 20-21 semi-polar GaN, a new plane surface is created at an angle of 75 degrees. Then, the GaN is grown directly from this new surface.



Reducing Polarization

One of the clear advantages of semi-polar GaN is the reduced polarization effect, allowing for better electronic terrain for injected carriers to "land" and emit light.

Key Benefits

- one — Reduces polarization effect
- two — Lowers threshold for lasing
- three — Reduces efficiency droop
- four — Resolves green gap
- five — Minimizes wavelength shift

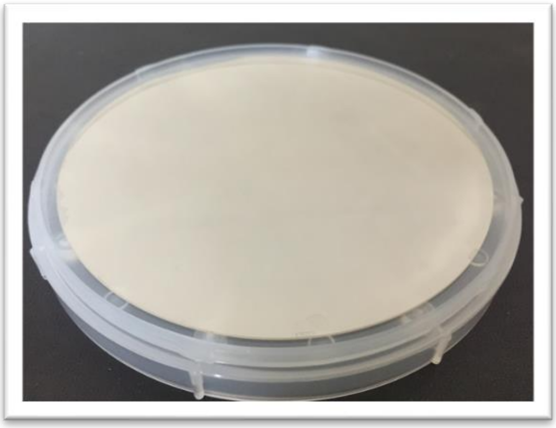
SAPHLUX

4-inch (20-21) Semi-polar GaN on Sapphire

Diameter	4 inch
Substrate	Sapphire
Substrate Thickness	650±25μm
Conduction Type	n-type
XRD@0°(along 11-20)	<250 arc sec
XRD@90°(along 10-14)	<350 arc sec
Threading Dislocation Density	<2E8 cm^{-2}
Stacking Faults	None-Noticeable
GaN Layer Thickness (customizable)	4-6μm
AFM (15μm*15μm)	<1 nm

Product Features

- Stacking fault free
- Low dislocation density
- Large wafer size at a low cost
- Compatible with industry production



Applications

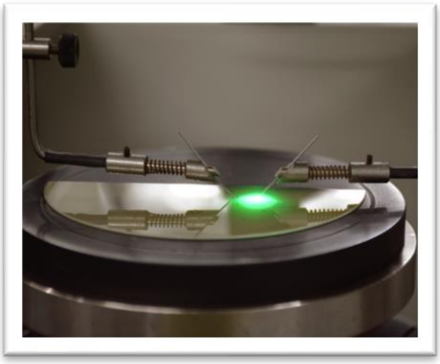
- Green/blue laser diodes
- High-power/long-wavelength LEDs
- Micro-LEDs
- Visible light communications

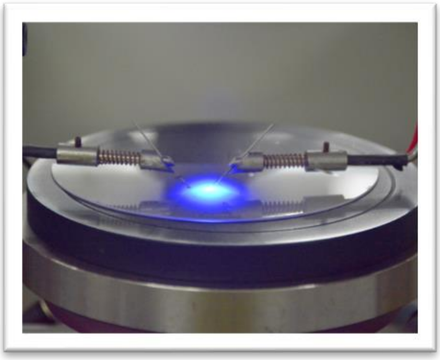
Semi-polar LED Epi-wafer

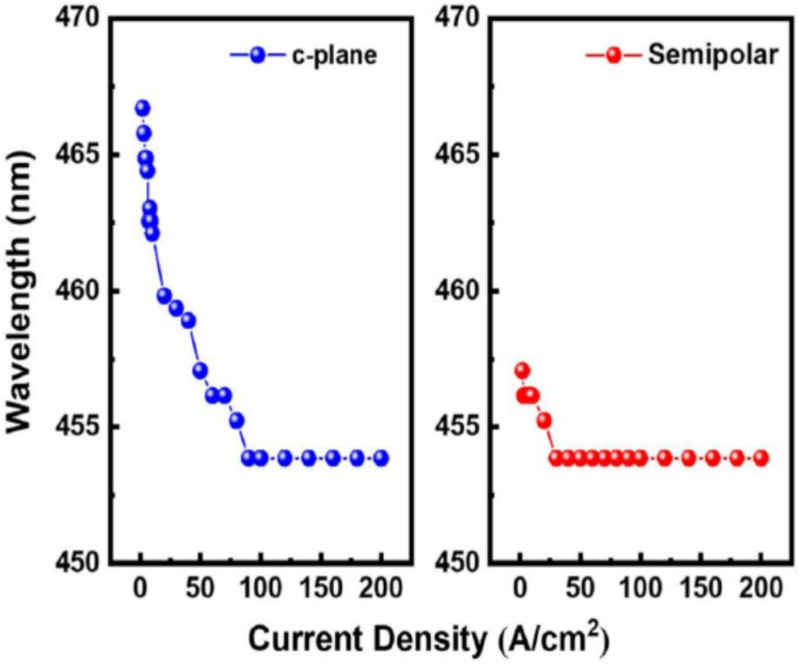
Saphlux can provide blue/green LED epi-wafers on semi-polar GaN templates. Key benefits of semi-polar LEDs include reduced wavelength shift, which helps to resolve color shift issues while changing driven currents in conventional blue/green LEDs and micro-LEDs.

Product Specification

Wafer Size (mm)	Wd (nm)	FWHM (nm)	n-GaN Thick. (μm)	Effective Area
100	450~460	<27	1.5	80%
100	515~535	<38	1.5	80%





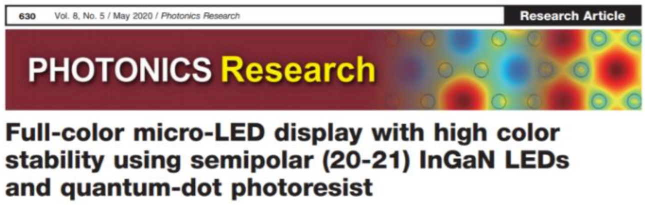


The wavelength shift of Semi-polar Blue Micro-LED is significantly reduced

Micro-LED

Compared with the LCD or OLED, micro-LED display offers higher contrast, faster response, higher efficiency, and longer life-time. However, there are many technical challenges in fabricating the small-pixel-size (<30um) micro-LED displays.

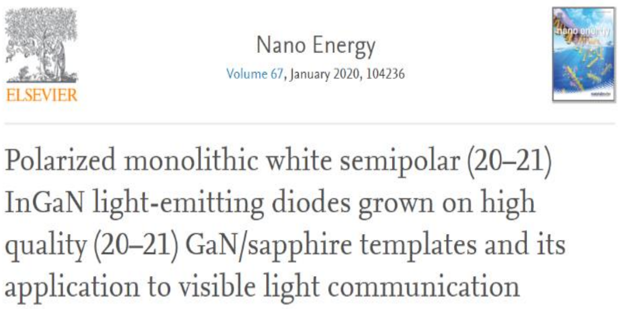
A research team at NCTU adopted our semi-polar GaN LED, taking advantage of its reduced wavelength shift to overcome the problem of color shift. Combining with QD technology, the team at NCTU has achieved RGB micro-LED array with good color stability and wide color-gamut characteristics, showing great potential for display applications.


630 Vol. 8, No. 5 / May 2020 / Photonics Research Research Article

PHOTONICS Research

Full-color micro-LED display with high color stability using semipolar (20-21) InGaN LEDs and quantum-dot photoresist

Visible Light Communication


ELSEVIER

Nano Energy

Volume 67, January 2020, 104236

Polarized monolithic white semipolar (20–21) InGaN light-emitting diodes grown on high quality (20–21) GaN/sapphire templates and its application to visible light communication

Visible light communication refers to a data communication method that uses light in a visible spectrum as information carrier to transmit an optical signal. It is an alternative solution for 5G communication.

A team at UCSB accomplished the first demonstration of efficient polarized monolithic white (20-21) semi-polar LEDs by using Saphlux's 4-inch GaN template, proving the potential of semi-polar GaN materials in the application of visible light communication.

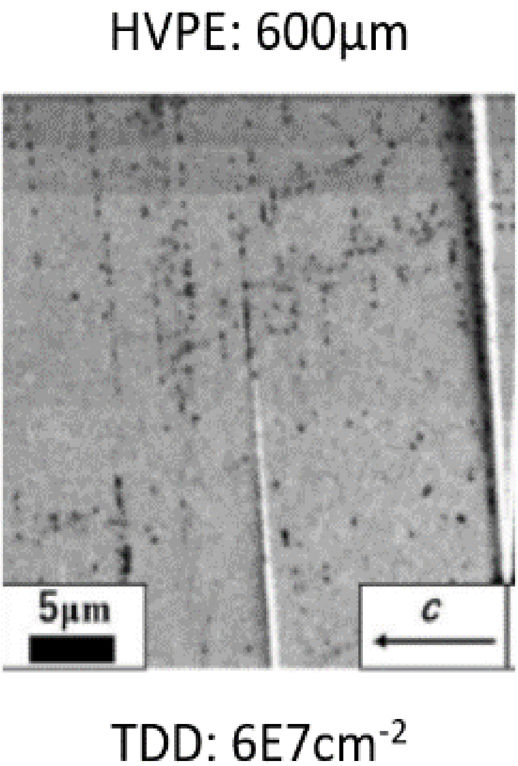
In the future, this technology may be integrated with existing Wi-Fi technology and cellular networks to bring new applications and new experiences in data communications.

Semi-polar GaN Substrates for Lasers (20-21)

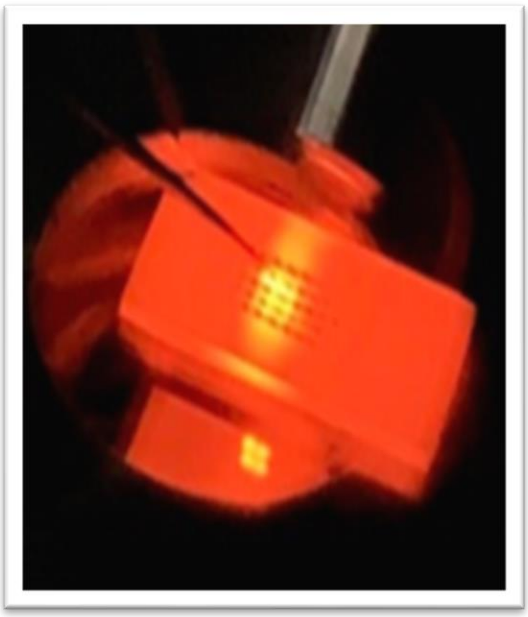
Because of the poor material quality and bent energy band issue caused by the high Indium incorporation, the "green-gap" problem commonly exists in conventional GaN LEDs. The efficiencies are low between 520 and 635 nm (green-gap), which limits the development of high-power green lasers.

After years of exploration, several companies such as Sony and Sumitomo have used small-size semi-polar (20-21) GaN to fabricate green laser diodes with an output power of more than 1W. But due to the lack of large-size semi-polar GaN, the mass-production of such laser diodes is still limited.

Recently, we collaborated with Yamaguchi University, and achieved a 4-inch semi-polar GaN substrate with low-dislocation density for lasers. The substrate is currently under further development.



Semi-polar Red & Green LED



Fabrication of long wavelength devices such as red and yellow LEDs on conventional GaN is usually challenging due to the high polarization effect. Using our semi-polar wafers, our team has successfully lit up red LEDs, proving a new way to achieve long-wavelength devices on semi-polar GaN.

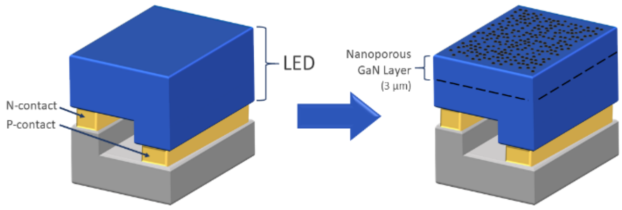
In 2019, a research team at Tokyo University achieved high efficiency green LEDs with Tunnel Junction Method on our semi-polar GaN green LED epi-wafer. This breakthrough may bring a new direction for developing GaN-based white LED on one chip.

NPQD™ Color Conversion Micro-LEDs

NPQD™ stands for "Nano-pores for Quantum Dots."

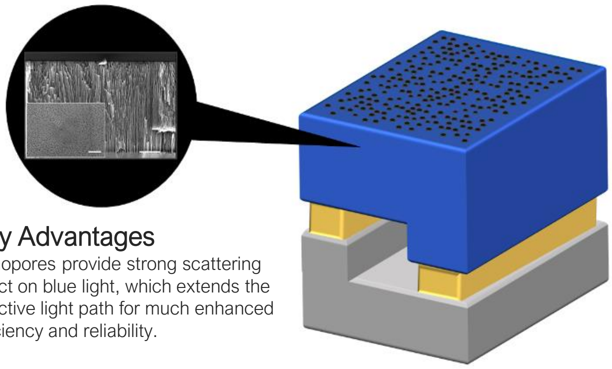
Nano-porous structure can serve as a natural holder for quantum dots. Because of the strong scattering on blue light, the effective path of light traveling inside greatly extends, resulting in a boost of efficiency.

Also, because of the high thermal conductivity of GaN, the reduced congregation, and the scattering, the reliability of QD-in-chip has been improved greatly to meet the requirements in display applications.



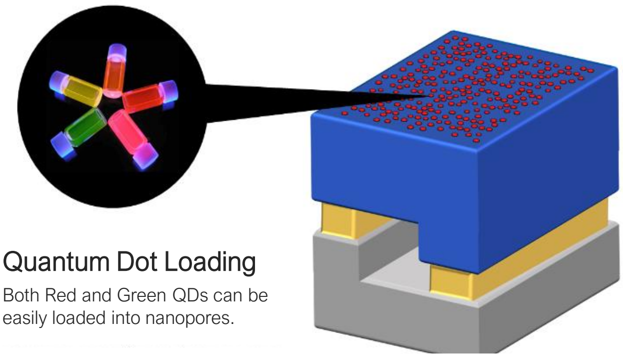
Nanopores Structure

Nanopores can be formed inside the GaN layer of the LED to serve as a nature "sponge" to hold quantum dots.



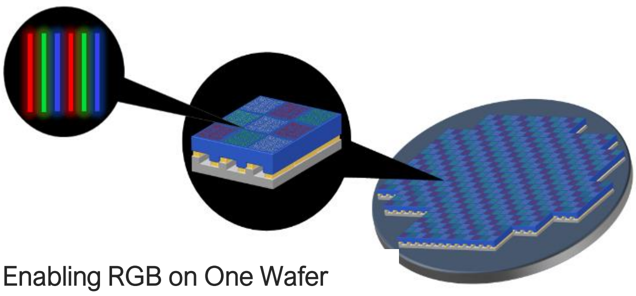
Key Advantages

Nanopores provide strong scattering effect on blue light, which extends the effective light path for much enhanced efficiency and reliability.



Quantum Dot Loading

Both Red and Green QDs can be easily loaded into nanopores.



Enabling RGB on One Wafer

By selective loading of QDs, we achieved RGB micro-LEDs on one wafer, pointing out a low-cost way to fabricate micro-LED displays.

Key Features

- ◻ NPQD™-in-chip mini/micro-LEDs
- ◻ 8x better reliability
- ◻ 2.5x higher conversion efficiency
- ◻ No binning needed
- ◻ Enables RGB micro-LED array
- ◻ Compatible with micro-LED fabrication process
- ◻ Reduces total micro-LED cost

0406 NPQD™ Red Mini-LED

We provide 0406 Red NPQD™ mini-LED for fine pitch displays.

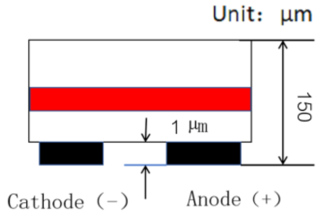
Key Features

- NPQD™-in-chip technology
- Enhanced efficiency and reliability
- GaN-based Red Mini-LED
- No binning required

Specifications

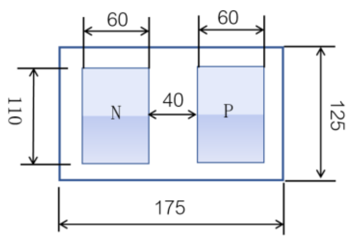
Dimension

- Thickness: 6.0mil (150±10μm)
- Chip size: 5.0mil×7.0mil (125±10μm×175±10μm)
- Anode pad: 2.4mil×4.3mil (60±5μm×110±5μm)
- Cathode pad: 2.4mil×4.3mil (60±5μm×110±5μm)



Metallization

- Electrode pad: Ni/Al/Au



Photoelectric Characteristics (Ta = 22°C)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Forward voltage	V_{f1}	I_f=1mA	2.5	2.7	2.9	V
	V_{f4}	I_f=1μA	1.85		2.3	V
Reverse Current	I_r	V_r=-5V	0		1	μA
Dominant Wavelength	λ_d	I_f=1mA	628	630	632	nm
Half-width	$\Delta\lambda$	I_f=1mA		30		nm
Luminous Intensity*	I_v	I_f=1mA	4		7	mcd

*Luminous intensity is measured by Saphlux equipment on bare chip and is subjected to changes.

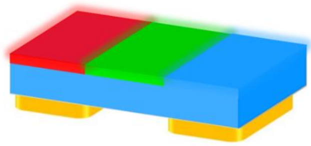
RGB-in-One NPQD™ Micro-LED (Beta)

We're working with our partners to commercialize the RGB-in-one micro-LEDs.

Key Features

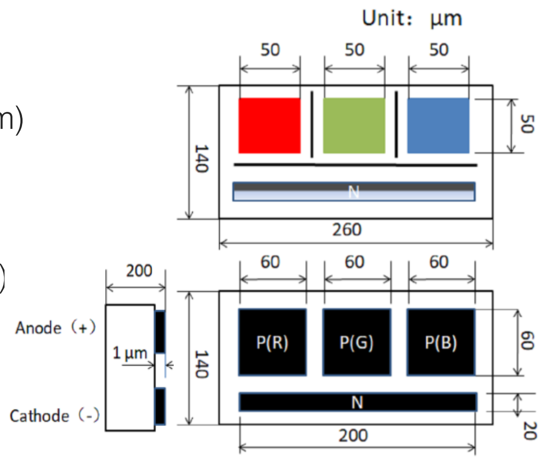
- RGB in one chip
- Enhanced efficiency and reliability
- GaN-based RGB Micro-LED
- No binning required

Specifications



Dimension

- Thickness: 8.0mil (200±10μm)
- Chip size: 10.2mil×5.5mil (260±10μm×140±10μm)
- Anode pad: 2.4mil×2.4mil (60±5μm×60±5μm)
- Cathode pad: 7.9mil×0.8mil (200±5μm×20±5μm)



Metallization

- Electrode pad: Ni/Al/Au

Photoelectric Characteristics (Ta = 22°C)

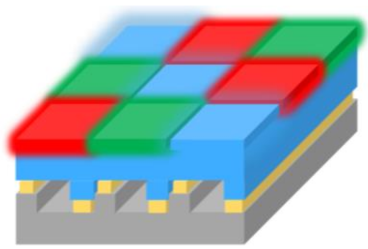
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Forward voltage	V_{f1}	I_f=20μA	2.4	2.5	2.6	V
	V_{f4}	I_f=1μA	1.85		2.3	V
Power density of luminous area				500		mW/cm²
Reverse current	I_r	V_r=-5V			1	μA
Green Wd	λ_d	I_f=0.1mA		540		nm
Green FWHM	$\Delta\lambda$	I_f=0.1mA		30		nm
Red Wd	λ_d	I_f=0.1mA		630		nm
Red FWHM	$\Delta\lambda$	I_f=0.1mA		30		nm
Blue Wd	λ_d	I_f=0.1mA		440		nm
Blue FWHM	$\Delta\lambda$	I_f=0.1mA		25		nm

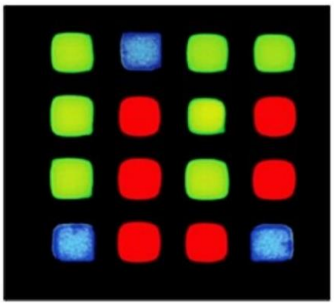
NPQD™ Micro-LED Array

We provide customized RGB micro-LED arrays using NPQD™ technology for customers who are developing small size micro-LED displays.

Key Features

- RGB micro-LED array on one wafer
- Customized pixel size (10μm to 50μm)
- Flip chip and vertical structure available
- Low Leakage Current (<10E-6 A)
- Proven efficiency and reliability
- Mass-producible at a low cost





NPQD™ vs Traditional QD based Micro-LEDs

Comparison	QD Micro-LED	NPQD™ Micro-LED
QD Layer Thickness	15μm to 40μm	3μm
LCE per Volume of QD	Low	High (8×)
Color Uniformity	Good	Good
Structural Reliability	Low	High
Color Gamut	Rec.2020	Rec.2020
Photo Lithography or Inkjet Printing	Challenging	Easy
Cost	High	Low
Scale up	Challenging	Easy

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