

SAMSUNG

Luminous Efficacy Improvement of Phosphor Converted White LED

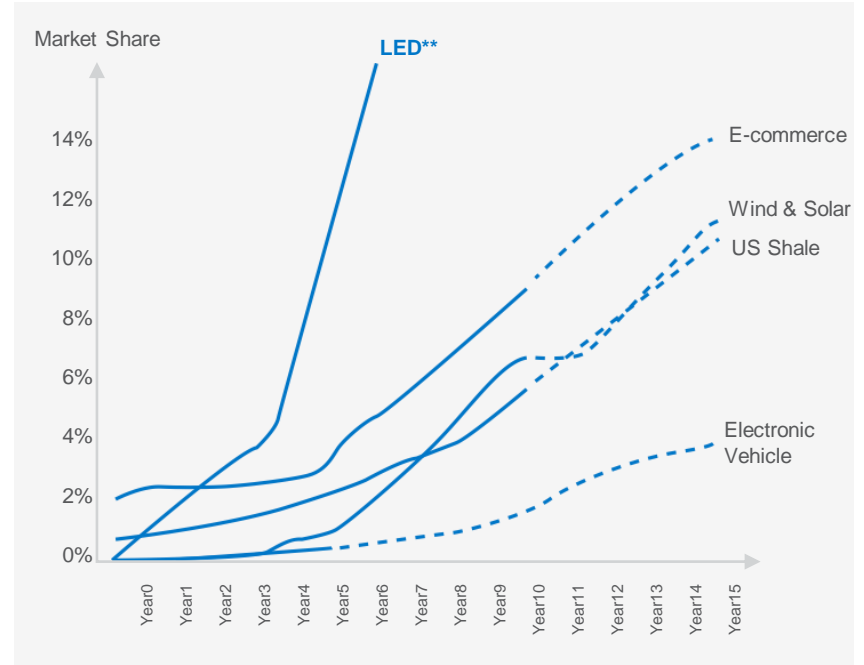


Overview

One of The Fastest Technology Shifts on Record

LED is rapidly penetrating the market by offering energy and cost savings with higher lighting quality

Growth Paths for Transformative Low-carbon Technologies*



*Source: Euromonitor, BCG, HIS, IRENA, BP, & Goldman Sachs Global Investment Research.

** 2020 LED penetration ratio: 35% (2019 SSL R&D roadmap, DOE)

Regulations for Efficacy Improvement

Regulations are demanding higher efficacy for lighting

DLC 5.1

Standard 10 lm/W ↑
Premium 5 lm/W ↑

*2020

ErP

A Class 210 lm/W
B Class 185 lm/W

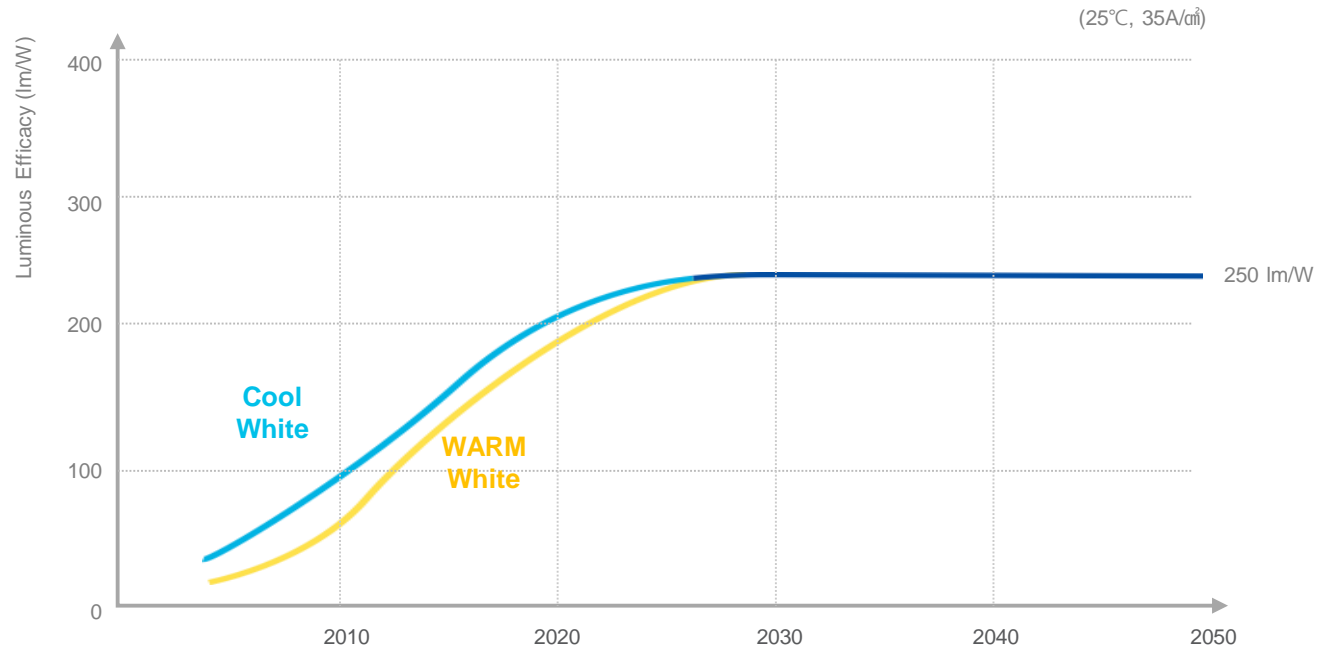
*Non-directional Lamp
Mar 2021



	2019		2035
	Troffer	A-lamp	Goal
LED Package	200 lm/W	200 lm/W	249 lm/W
Luminaire Efficiency	75%	65%	86%
Thermal	93%	86%	95%
Driver	88%	84%	95%
Optical	92%	88%	95%
Luminaire (lm/w)	150 lm/W	130 lm/W	214 lm/W

Limitations in Efficacy Improvement

250 lm/W is expected as limit of phosphor convert white LED



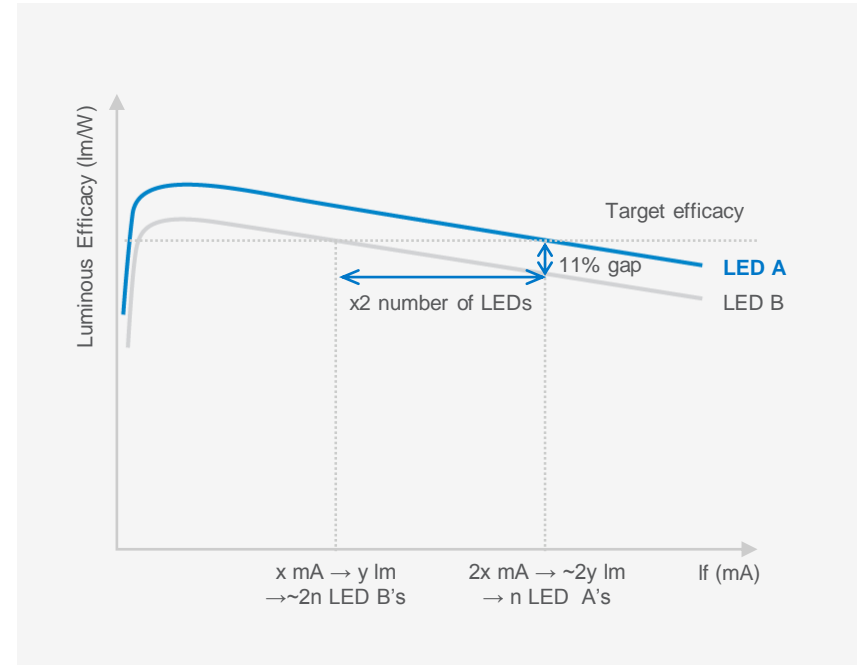
Benefit of Using High Efficacy LED

Lighting system cost can be significantly reduced by high efficacy LEDs

- Target lumen: 47,000lm \uparrow
- Target efficacy: 196lm/W \uparrow

	PKG A*	PKG B**
Series x Parallel	17S x 28P	17S x 80P
IF/LED (mA)	180	65
Watt (W)	247	243
lumen (lm)	48,532	47,629
efficacy (lm/w)	196	196
Number of LEDs	476ea	1360ea

\uparrow
75% \downarrow
 \uparrow

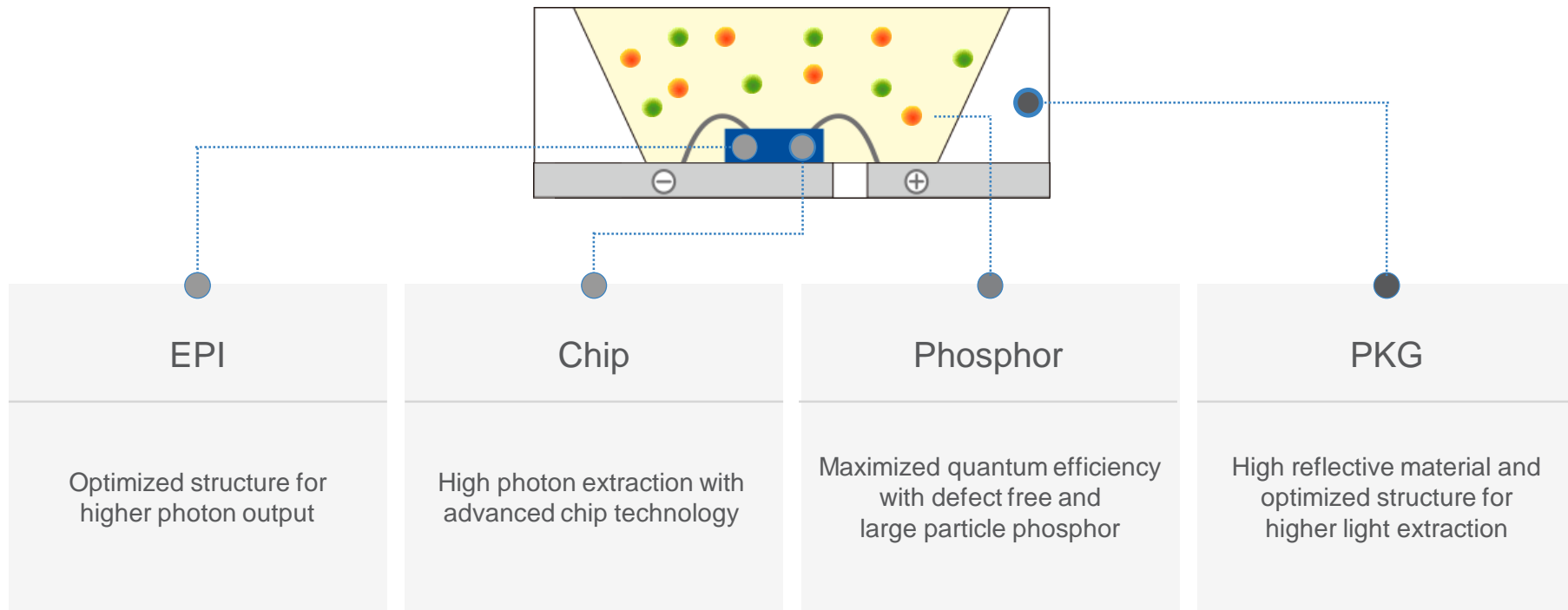


* PKG A: 39 lm, 218 lm/W @ 65 mA

** PKG B: 35 lm, 196 lm/W @ 65 mA

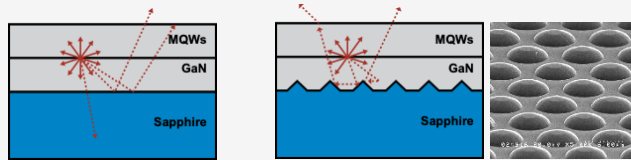
Technology

Key Factors for High Efficacy LEDs

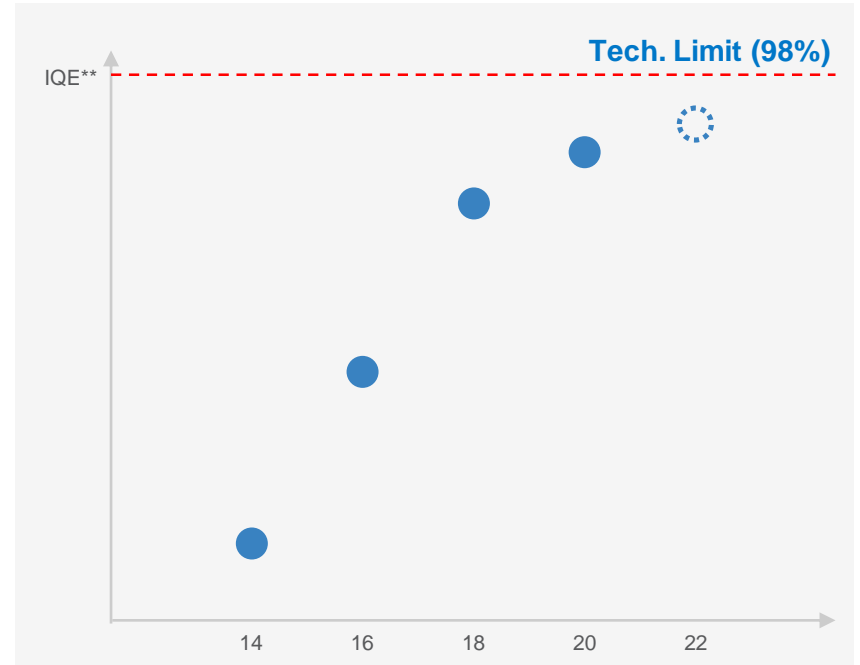
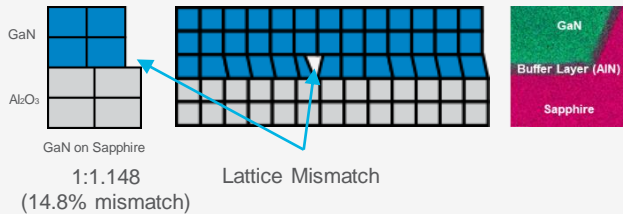


Optimized structures improve IQE close to theoretical limit

CIS* - Maximize Light Extraction



Buffer Layer - Minimize Defect Generation

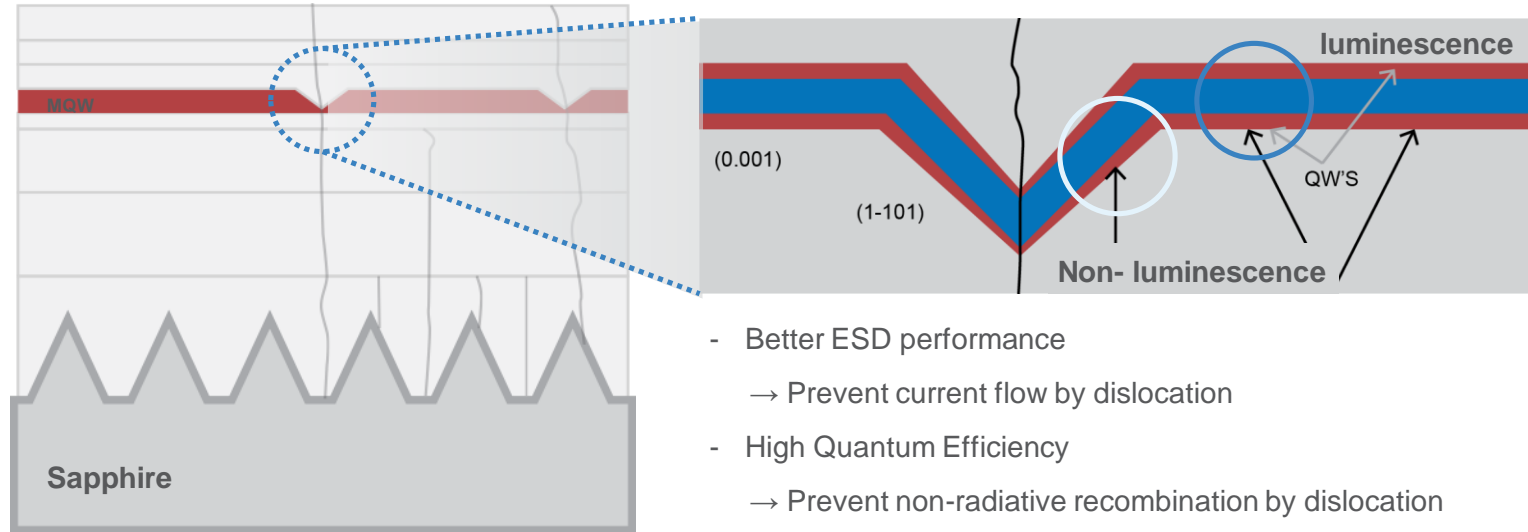


*CIS: Corrugated Interface Substrate
**IQE: Internal Quantum Efficiency

EPI

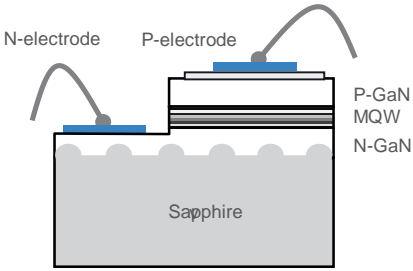
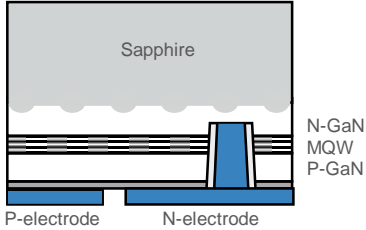
V-pit helps higher quantum efficiency and improve ESD performance

V-pit: Intentional V-pit to concentrate defects



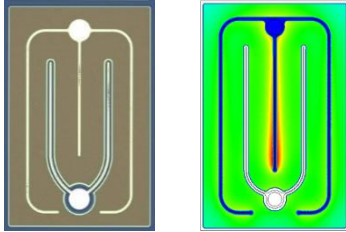
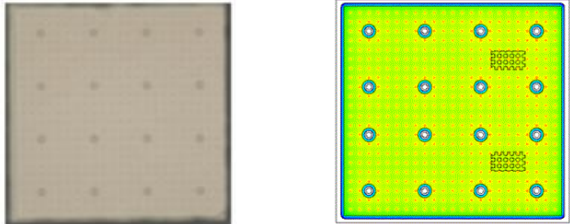
Chip

Flip chip structure enables higher photon extraction and better reliability

	Epi-up	Flip Chip
Structure	 <p>N-electrode P-electrode P-GaN MQW N-GaN Sapphire</p>	 <p>Sapphire N-GaN MQW P-GaN P-electrode N-electrode</p>
Photon Extraction	Lower	Higher
Vf	Higher	Lower
Rth	Higher	Lower
Current Spread on Die	Concentrate	Homogeneous

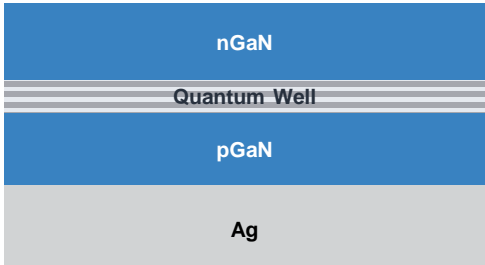
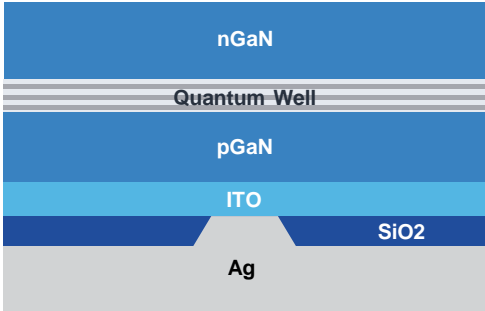
Chip

Flip chip has more homogeneous current distribution and higher IQE

	Epi-up	Flip Chip
Image & Current Distribution		
Max. Current Density	24 A/cm ²	10 A/cm ²
V _f	2.85 V	2.82 V
Average IQE	81%	93%

Chip

Flip chip's re-designed reflector has better reflectance

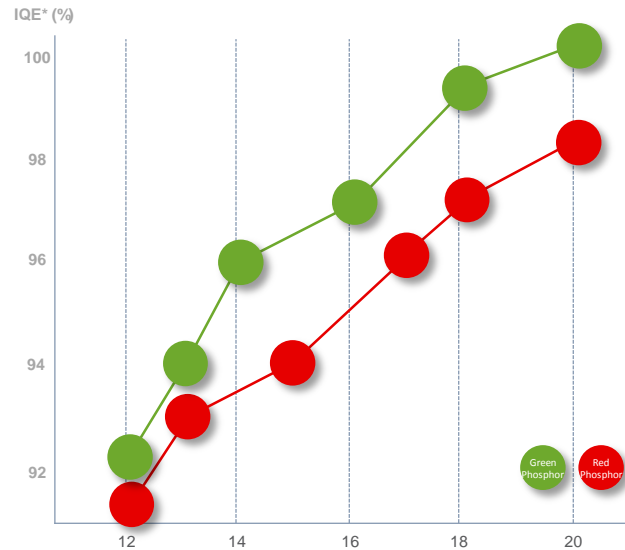
	Metal Reflector	Dielectric / Metal Reflector
Structure		
Reflectance	92%	97%

* ITO: Transparent Electrode

Phosphor

Defect-free phosphor enables higher IQE

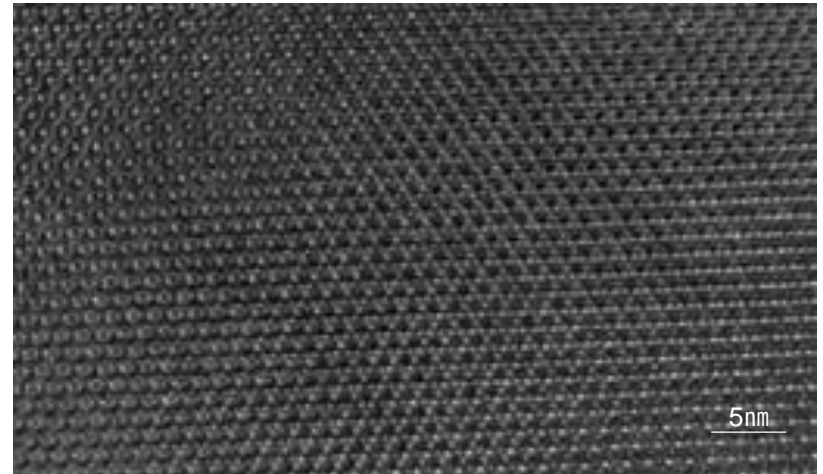
IQE Improvement



*IQE: Internal Quantum Efficiency

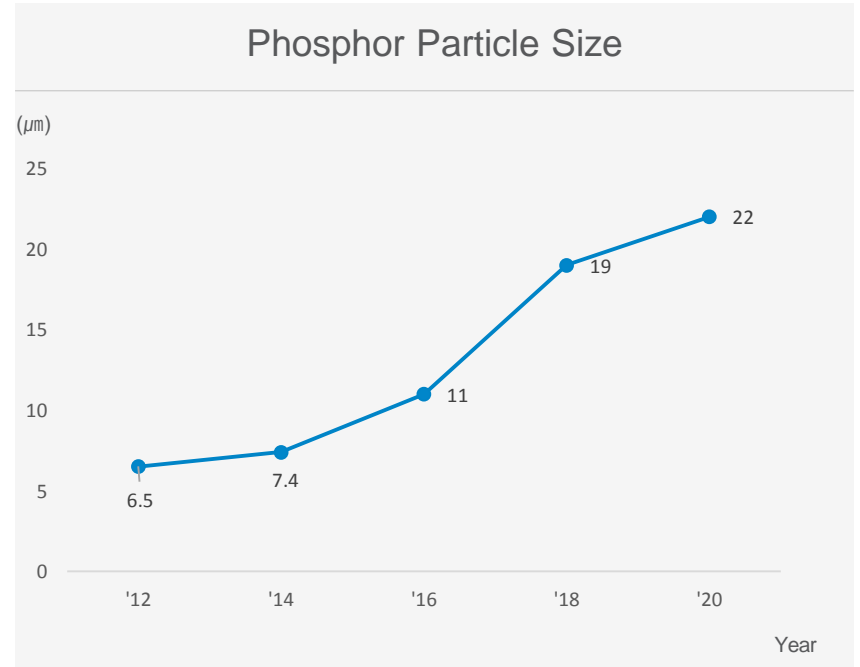
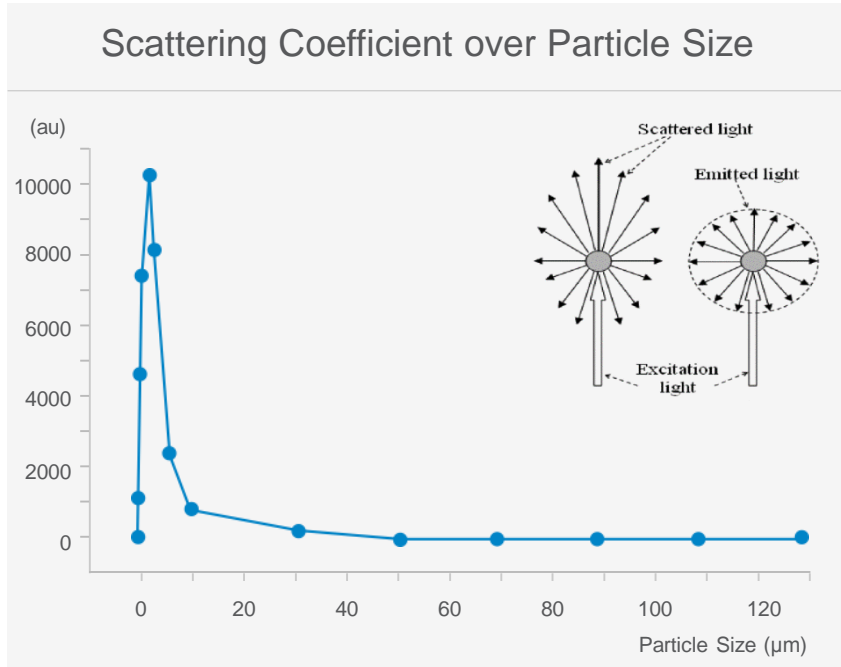
Transmission Electron Microscopy of Green Phosphor ($\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Ce}$)

Defect-free phosphor



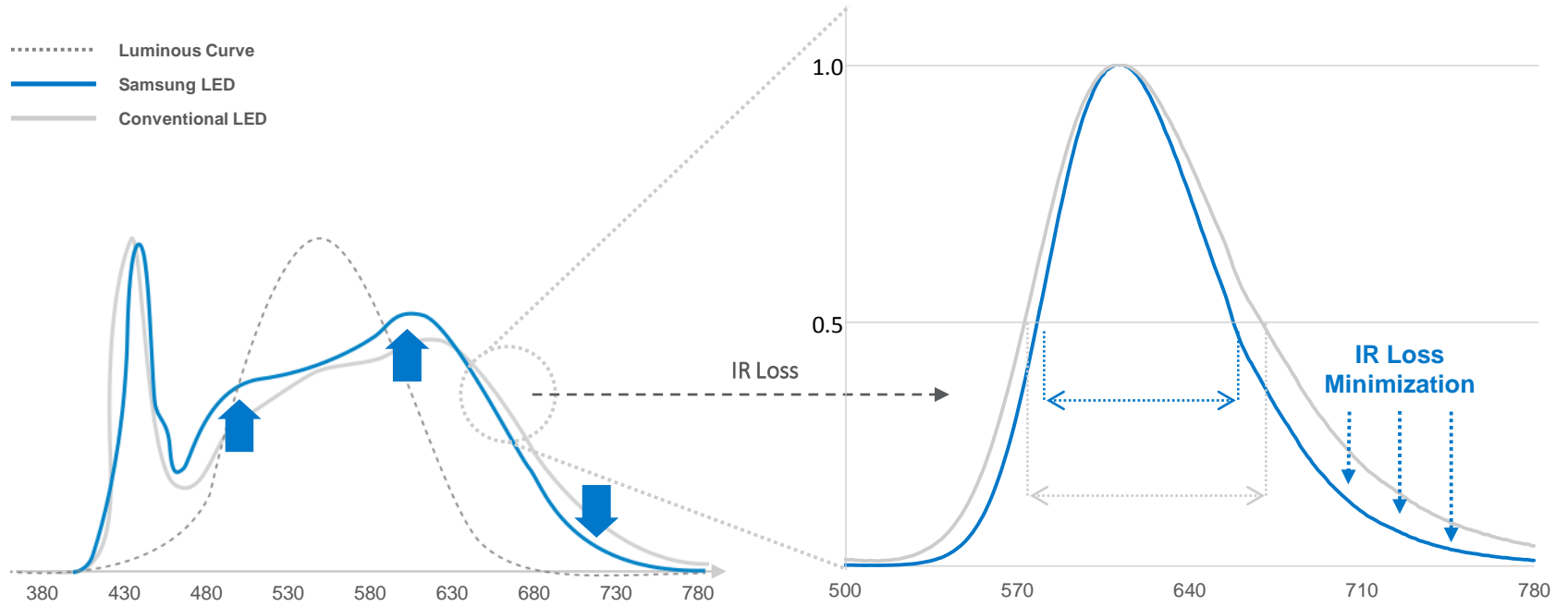
Phosphor

Large phosphor particle minimizes scattering effect with higher lumen



Phosphor

High Green intensity and narrow Red enables higher lumen

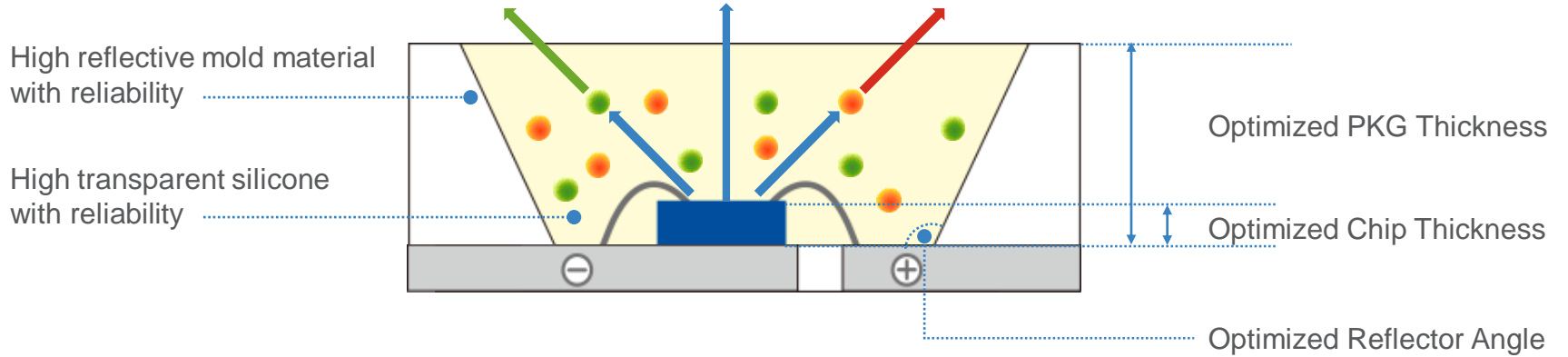


PKG

High reflective material and optimized structure aim for better light extraction

Material

Structure

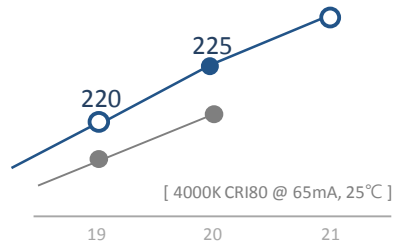


Leading Efficacy with Cutting Edge Technologies

MPL

(lm/W)

LM301B

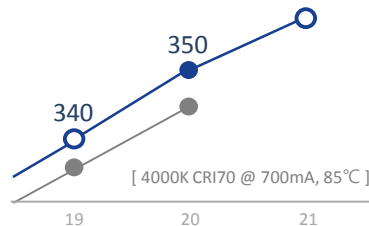


LM301B, LM301H

HPL

(lm)

LH351C

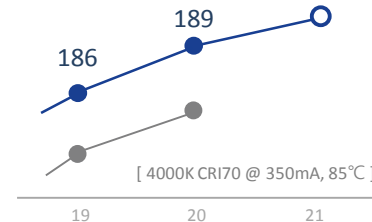


LH351B, LH351C, LH351D
LH351B-H, LH351C-H, LH351D-H

CSP

(lm/W)

LH181B



LM101B, LH151B
LH181B(+), LH231B(+)
LH241H, LH281H

Thank you