About Samsung Electronics Co., Ltd.

Samsung Electronics Co. Ltd inspires the world and shapes the future with transformative ideas and technologies. The company is redefining the worlds of TVs, smartphones, wearable devices, tablets, digital appliances, network systems, and semiconductor and LED solutions. For the latest news, please visit the Samsung Newsroom at http://news.samsung.com.

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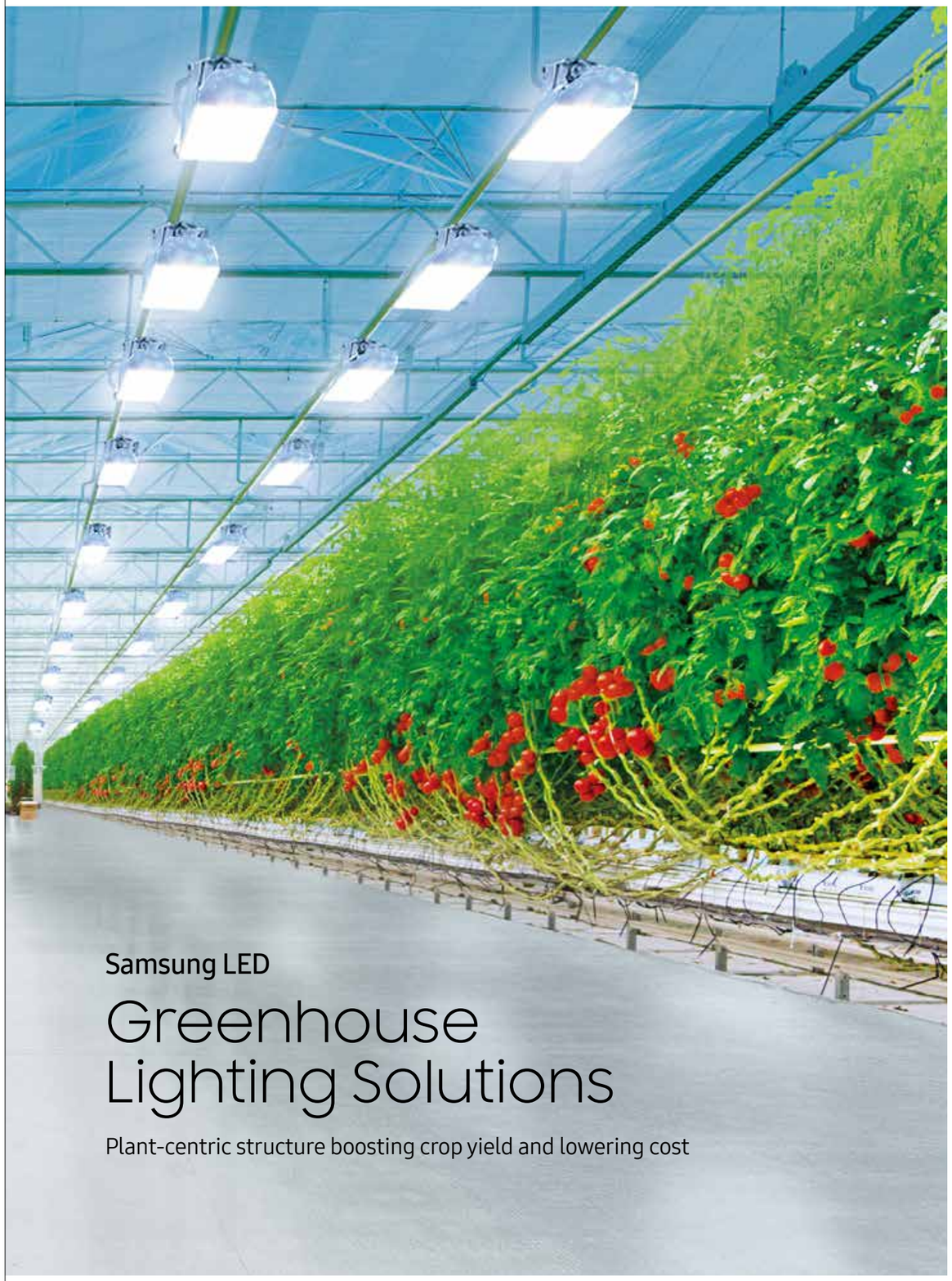
2021 H2

SAMSUNG



Samsung LED

Greenhouse Lighting Solutions

Plant-centric structure boosting crop yield and lowering cost

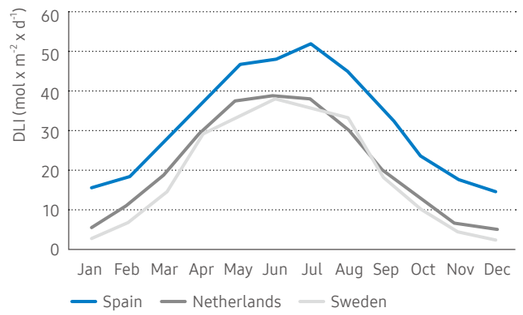
2021 H2

SAMSUNG

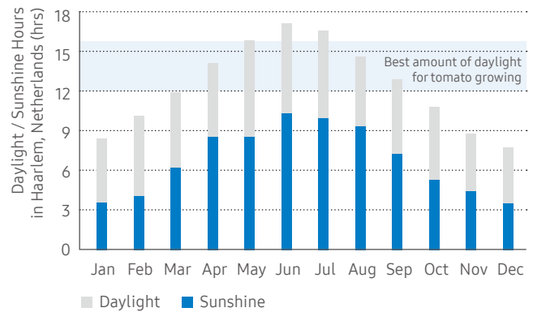
The Importance of Greenhouse Lighting

The Need for Supplemental Lighting in Greenhouse

High latitude regions lack sufficient daylight, or DLI (Daylight Integral) for farming.
Plentiful light supply is critical for most crops, such as tomatoes, which require at least 12 hours of daylight per day.



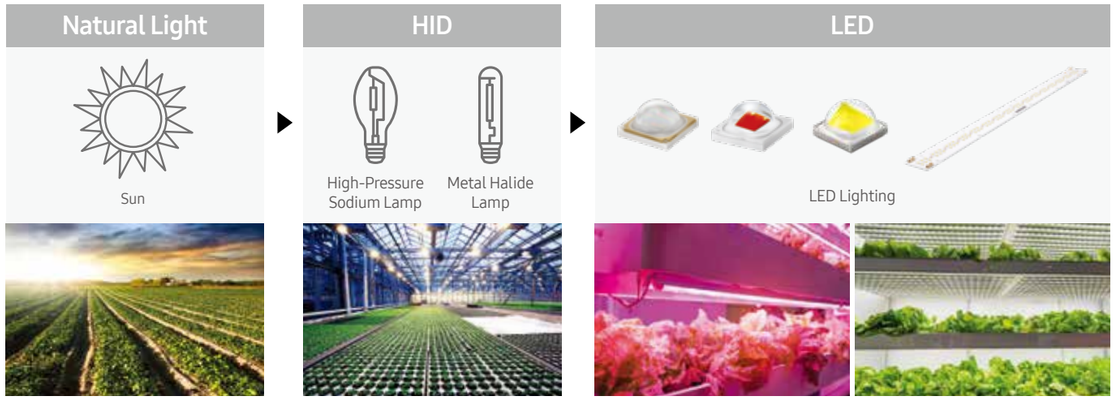
* Source: DLI Calculator



* Source: Weather Atlas

Evolution of Horticulture Lighting

Growers are switching to LEDs, which produce higher crop yield and reduce the total cost of lighting system ownership and operation.



	Conventional			LED	
	Fluorescent	MH	HPS	Narrow Spectrum	**Full Spectrum**
Efficacy (μmol/J)	1	1.4	1.8	> 2.5	**> 2.5**
Heat	Low	High	High	Low	**Low**
Lifetime (hrs)	< 20,000	< 20,000	< 20,000	> 50,000	**> 50,000**
Lighting System Cost	Low	Low	Low	High	**Mid**
Spectrum Controllability	n/a	n/a	n/a	Low	**High**
Visibility (Human Eye)	Good	Good	Good	Bad	**Good**
Warm-up Time	Short	Long	Long	Short	**Short**
Design Flexibility	Low	Low	Low	High	**High**

Samsung White-based Full Spectrum LEDs for Greenhouse Lighting

Low Cost

Low initial lighting system cost to minimize investment

Saving Energy

Highly efficient light sources to reduce power consumption

Balanced Growth

Light optimized for plant growth to increase crop yield

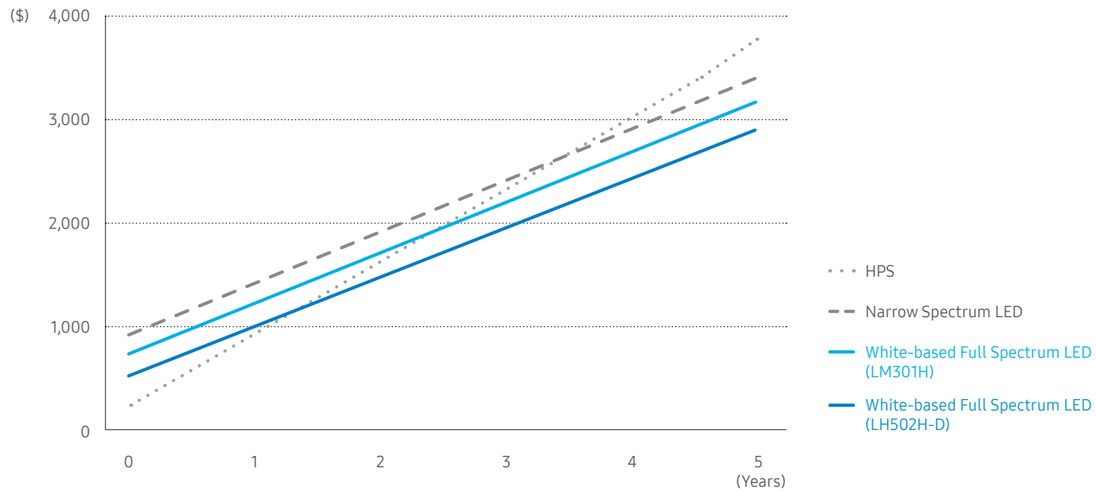
Robustness

Durable in high temperatures and humidity with strong sulfur resistance

Cost-effectiveness

Lower Initial Investment

The initial investment for cost-effective full spectrum LEDs is lower than HPS lighting, narrow spectrum LEDs, and conventional full spectrum LEDs.

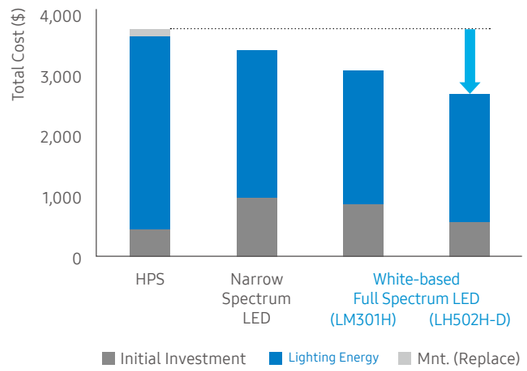


* Unit Price: HPS 1000W ($400), Narrow 720W ($1000), Full 700W ($850), Cost Full 700W ($600) /
Lifetime: HPS (20k hrs.), Narrow (60k hrs), Full (60k hrs.), Cost Full (60Khrs) / Electricity Rate : $0.15 per kWh / 12hrs a day

Lower Operation Cost

Samsung's white-based full spectrum LEDs bring down operation cost by reducing energy consumption with its industry-leading performances and high efficacy LEDs

	Mid Power White 65mA, 5000K, 25℃	High Power White 180mA, 5000K, 25℃
Samsung White-based Full Spectrum	**3.14 umol/J**	**2.90 umol/J**
Normal Full Spectrum	3.08 umol/J	2.76 umol/J
Remark	**+ 2%**	**+ 5%**

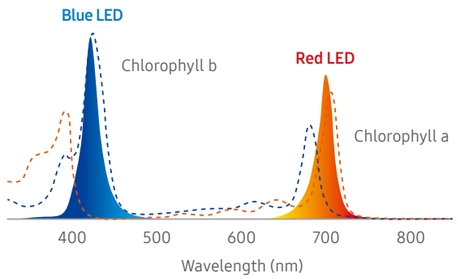


Balanced Growth

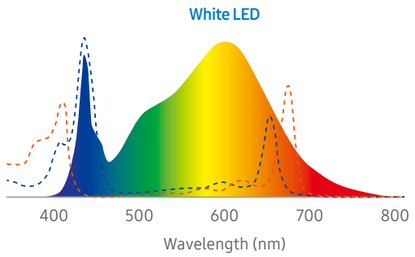
White-based Full Spectrum LED

Full spectrum is recent trend with more cost-effective, productive, and favorable solution

Narrow Spectrum



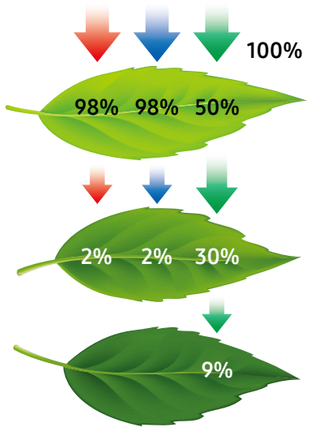
Full Spectrum



Healthier Crops under Full Spectrum

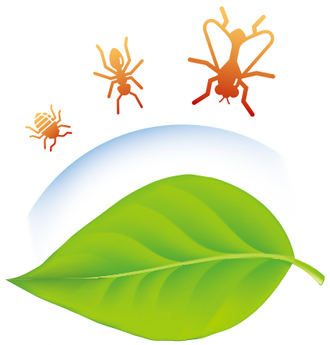
Full spectrum LEDs are better at stimulating photosynthesis, preventing disease, and making more bioactive compounds

Photosynthesis



1. Kozai, Ohmsya Pub P227. (2015)
2. Jindong, Plant Cell Physiol. (1998)

Anti-disease



1. Kudo, SRI Res Rep. (2009)
2. Kudo, Horti Res. (2013)
3. Kudo, SRI Res Rep. (2010)

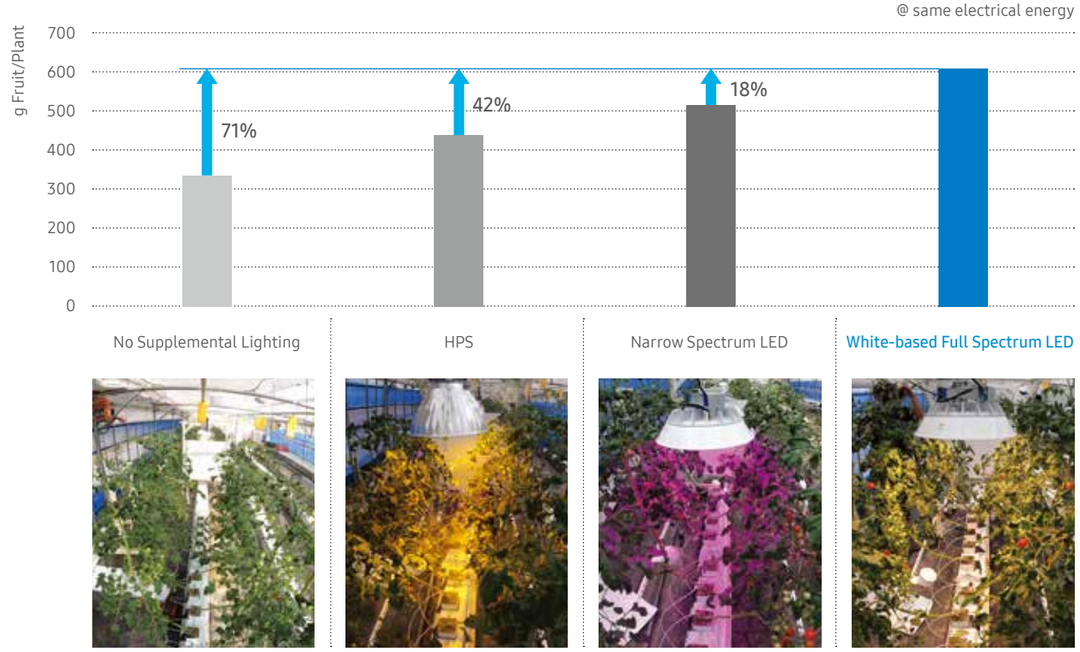
Bioactive Compounds

1. Tao, J. Biochem Biotech. (2017)

Spectrum Comparison Experiment

- Plants: Cherry Tomato
- Environment: 28.8 ±14°C, RH 76±20%, On/Off=8hrs/day
- Test Period: 49 days
- Variable: Light Spectrum

@ same electrical energy

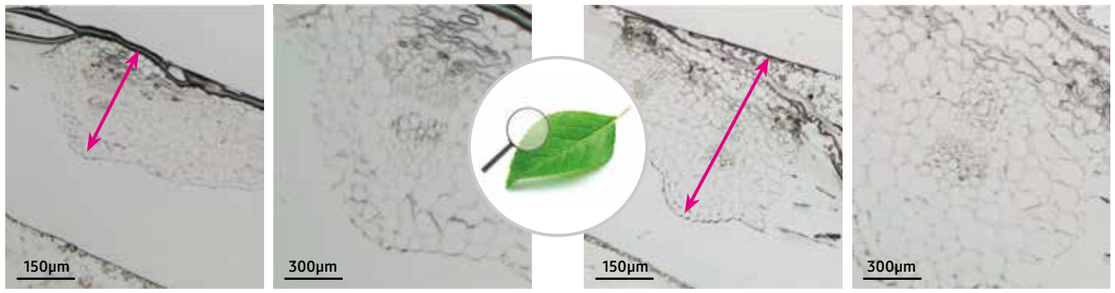


Acknowledgement: Prof. Son at Gyeongsang National Univ.

- Examined cross sections of leaves under narrow spectrum vs. full spectrum
- Leaves under full spectrum grew thicker and more well-formed in structure (xylem, phloem, etc)

Narrow Spectrum

Full Spectrum



Acknowledgement: Prof. Chun at Seoul National Univ.

Favorable Environment

Improved Working Environment

White-based full spectrum LEDs enable quicker disease detection and create a more pleasant work environment

Narrow Spectrum

Full Spectrum

Preventing Light Pollution

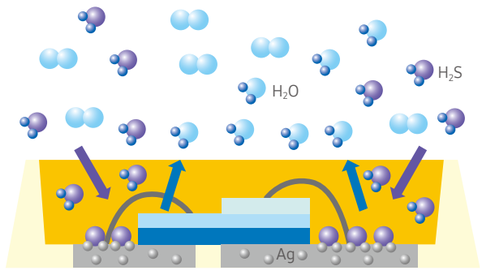
White-based full spectrum LEDs prevent "Purple Sky," a type of light pollution that harms the environment

Narrow Spectrum

Full Spectrum

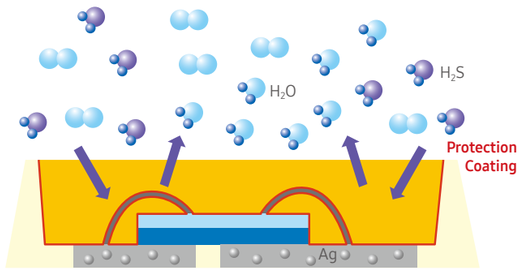
Robust Performance

Superior Device Architecture for Durability



Conventional LED

- Ag in wire or electrodes can be tarnished when exposed to H_2S
- $2Ag + H_2S + 1/2O_2 \rightarrow Ag_2S + H_2O$ (Ag_2S causes PPF degradation)



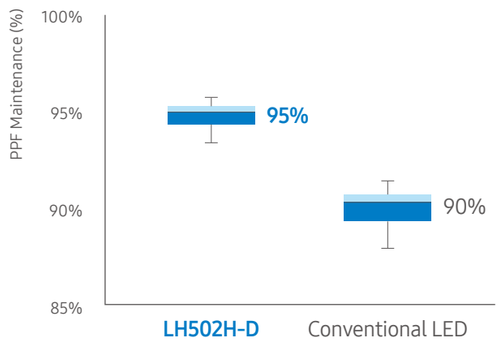
LH502H-D

- LH502H-D: Protection coating to prevent Ag exposure

No Degradation in Horticulture Environment

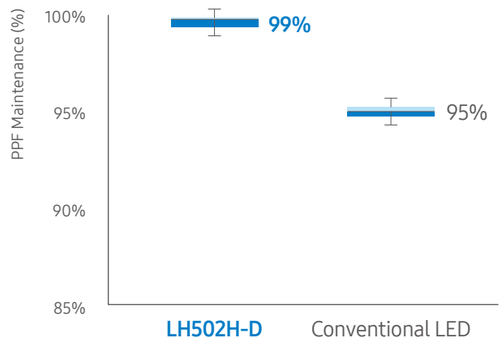
With a protection coating, Samsung's horticulture LEDs can present superior performance maintenance in greenhouse conditions.

Sulfur Resistance Test



@ H2S 15ppm, 25°C, 75% RH, 504hrs

High Temp/Humidity Operating Test



@ 85°C, 85% RH,1000hrs

Maximum Plant Growth at Minimum Cost

Plant-centric Structure Boosting Crop Yield and Lowering Cost for Greenhouse Lighting Solutions

Product Line-up

White Mid Power LEDs

Samsung's mid-power white LEDs deliver the highest efficacy and excellent reliability

LM301H

- Optimized light spectrum for leafy greens
- Anti-sulfurization (with flip-chip technology)

@65mA, 25°C, 5000K, CRI80+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
SL	White	0.54	3.08	3.0 × 3.0

LM301H ONE

- Optimized light spectrum for leafy greens
- Anti-sulfurization (with flip-chip technology)

@65mA, 25°C, 3500K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
S0	White	0.49	2.75	3.0 × 3.0

LM301H EVO

- Plant-centric light spectrum for better growth
- World's best efficacy
- Anti-sulfurization (with flip-chip technology)

@65mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
PR	White	0.56	3.14	3.0 × 3.0

LM301H EVO Mint White

- Plant-centric light spectrum for better growth
- World's best efficacy
- Anti-sulfurization (with flip-chip technology)

@65mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
PM	White	0.57	3.17	3.0 × 3.0

White High Power LEDs

Full line-up of high power white LEDs with industry-proven performance for various horticulture applications

LH241H

- Compact design for small LES module
- Viewing angle: 120°
- Thermal resistance: 2.0K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
R1	White	2.51	2.52	2.4 x 2.4

LH281H

- Compact design for small LES module
- Viewing angle: 120°
- Thermal resistance: 2.0K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
SB	White	2.59	2.65	2.8 x 2.8

Product Line-up

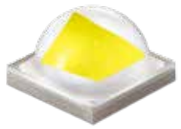
LH351H-B

- Viewing angle: 120°
- Thermal resistance: 4.2K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Q1	White	2.48	2.51	3.5 × 3.5

LH351H-C

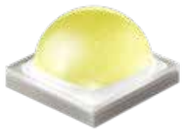


- Viewing angle: 130°
- Thermal resistance: 3.0K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
RB	White	2.56	2.60	3.5 × 3.5

LH351H-D



- Viewing angle: 130°
- Thermal resistance: 2.2K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Y2	White	2.58	2.69	3.5 × 3.5

LH502H-D

- Anti sulfurization
- Viewing angle: 120°C

@180mA, 25°C

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Y2	White	2.84	2.90	5.0 × 5.0

* Subject to change without notice

Color High Power LEDs

Full line-up of high power color LEDs with industry-proven performance for various horticulture applications

LH351H Blue (450nm)

- Viewing angle: 130°
- Thermal resistance: 4.0K/W

@350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Blue	2.80	2.80	3.5 × 3.5

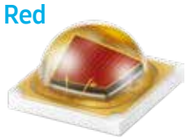
LH351H Red (630nm)

- Viewing angle: 120°
- Thermal resistance: 4.0K/W

@350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Red	1.82	2.41	3.5 × 3.5

LH351H Deep Red (660nm)

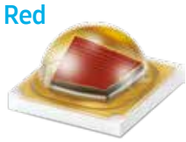


- Viewing angle: 120°
- Thermal resistance: 2.5K/W

@350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	2.4	3.22	3.5 × 3.5

LH351H Deep Red (660nm) V2

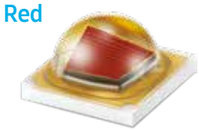


- Viewing angle: 130°
- Thermal resistance: 3.0K/W

@700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.54	3.75	3.5 × 3.5

LH351H Deep Red (660nm) V2+



- Viewing angle: 130°
- Thermal resistance: 3.0K/W

@700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.6	3.8	3.5 × 3.5

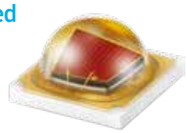
LH351H Deep Red (660nm) V3

- Viewing angle: 130°
- Thermal resistance: 3.0K/W

@700mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm²)
Deep Red	5.65	3.9	3.5 × 3.5

LH351H Far Red (730nm)



- Viewing angle: 120°
- Thermal resistance: 3.9K/W

@350mA, 25°C

Color	* BPF (μmol/s)	* BPF/W (μmol/J)	Footprint (mm²)
Far Red	2.07	3.1	3.5 × 3.5

* Biologically-active Photon Flux

Module

Customized designs are also available per customer request

Horticulture LED Module Gen2

Color	PPF (μmol/s)	PPF/W (μmol/J)	Luminous Flux (lm)	Watt (W)	Vf (V)	IF (mA)	Efficacy (lm/W)	Tp (°C)
White + Red	154.2	3.06	8,960	50.4	42	1,200	178	25

* Subject to change without notice