

**SAMSUNG**

Specialty Lighting

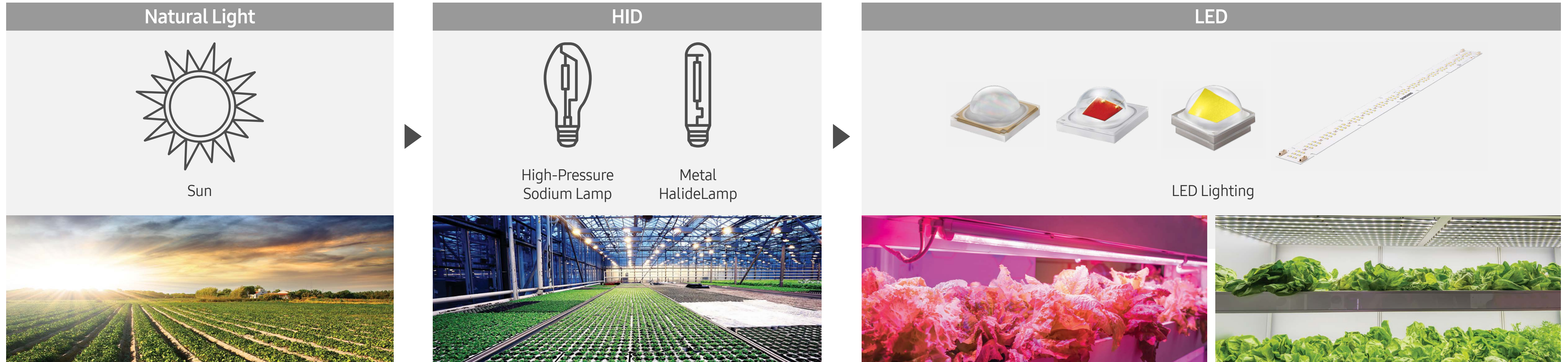
# Horticulture Lighting Solutions

2020 H2 v1

# Horticulture Lighting Trends

## Evolution of Horticulture Lighting

LEDs help production yield of crops and reduce the total cost of ownership of lighting system



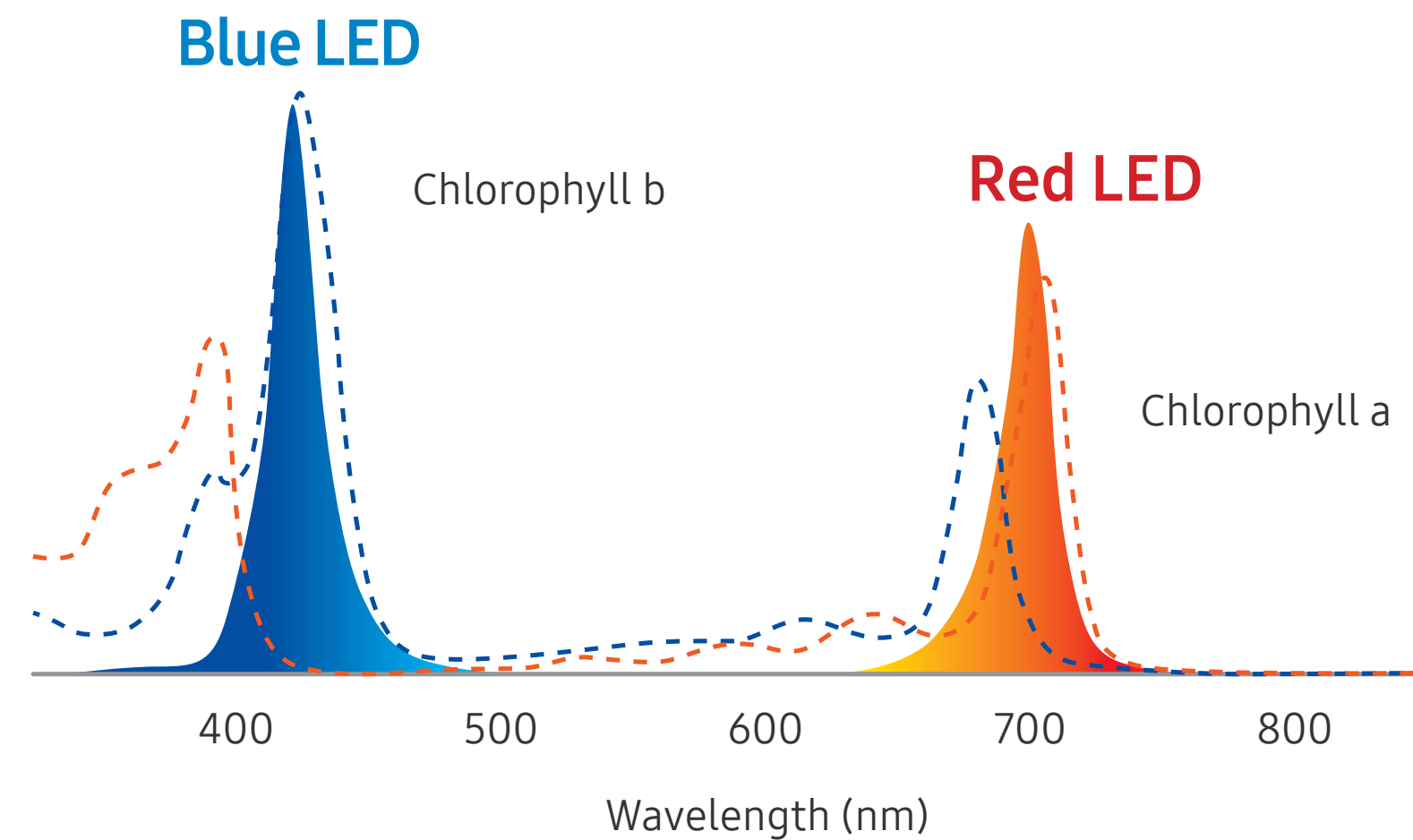
	Fluorescent	MH	HPS	<b>LED</b>
Efficacy ( $\mu\text{mol}/\text{J}$ )	1.0	1.4	1.8	<b>&gt; 2.5</b>
Heat	Low	High	High	<b>Low</b>
Lifetime (hrs)	< 20,000	< 20,000	< 30,000	<b>&gt; 50,000</b>
Warm-up Time	Short	Long	Long	<b>Short</b>
Design Flexibility	Low	Low	Low	<b>High</b>
Spectrum Controllability	Low	Low	Low	<b>High</b>

# Horticulture Lighting Trends

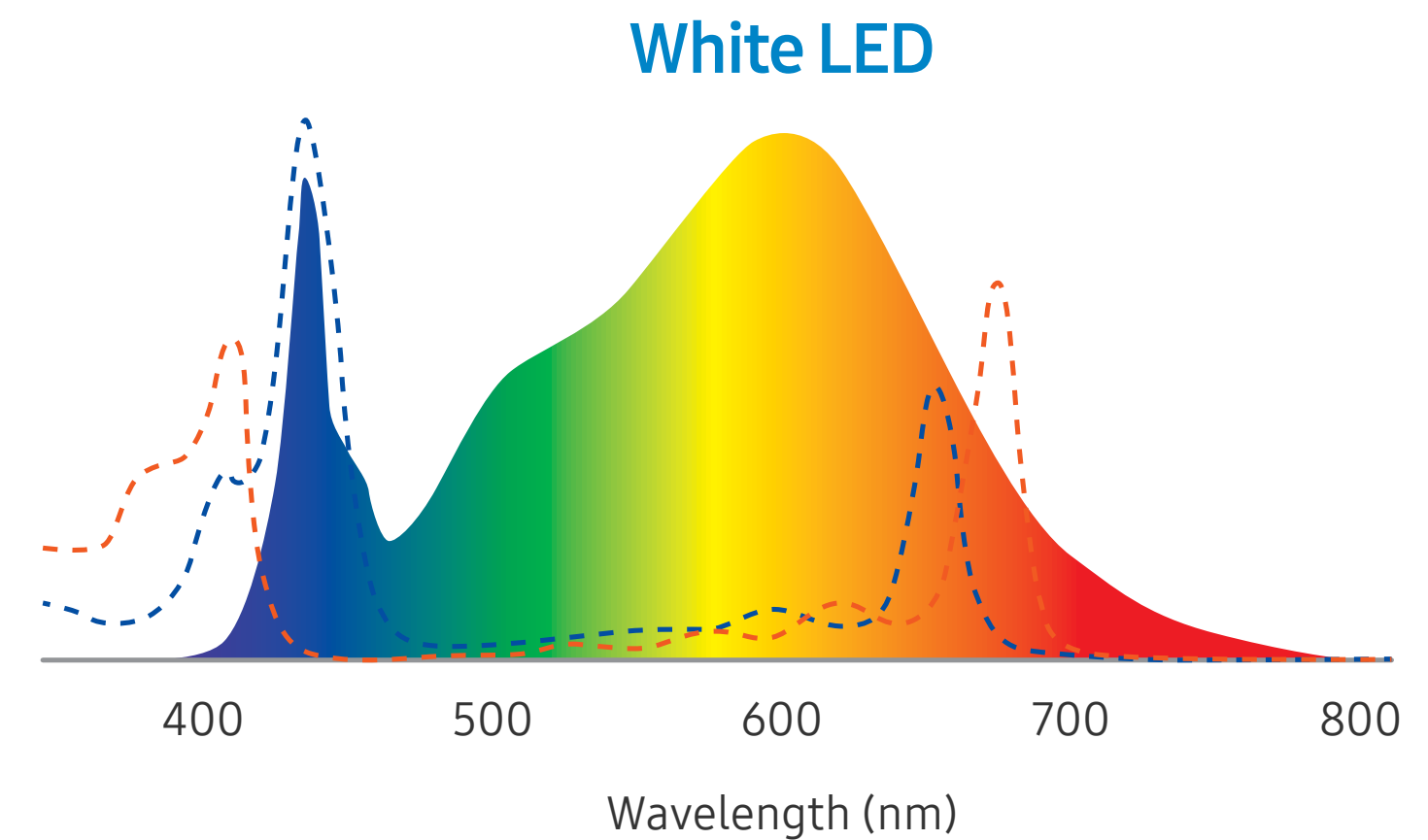
## Full Spectrum LED

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

### Conventional Narrow Spectrum

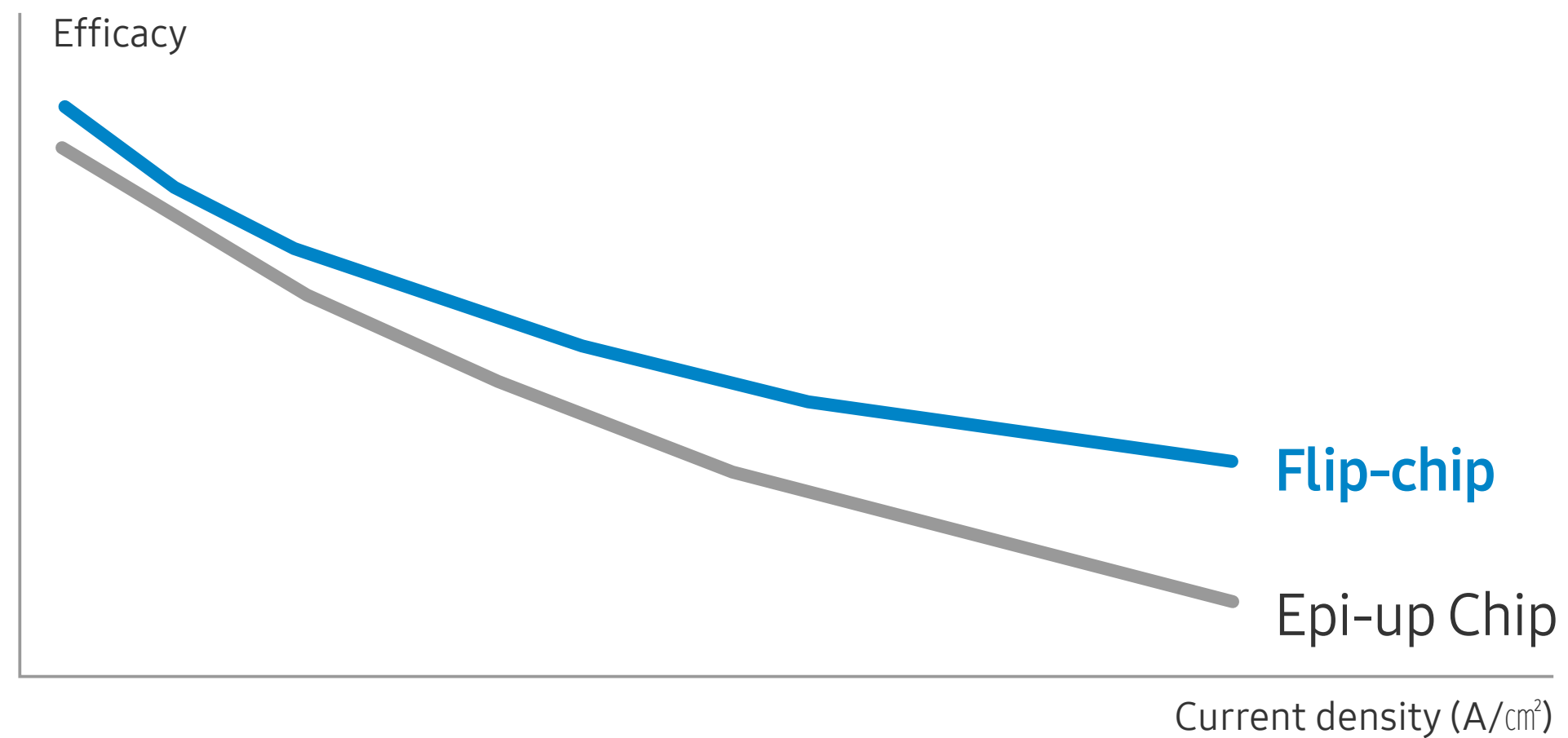
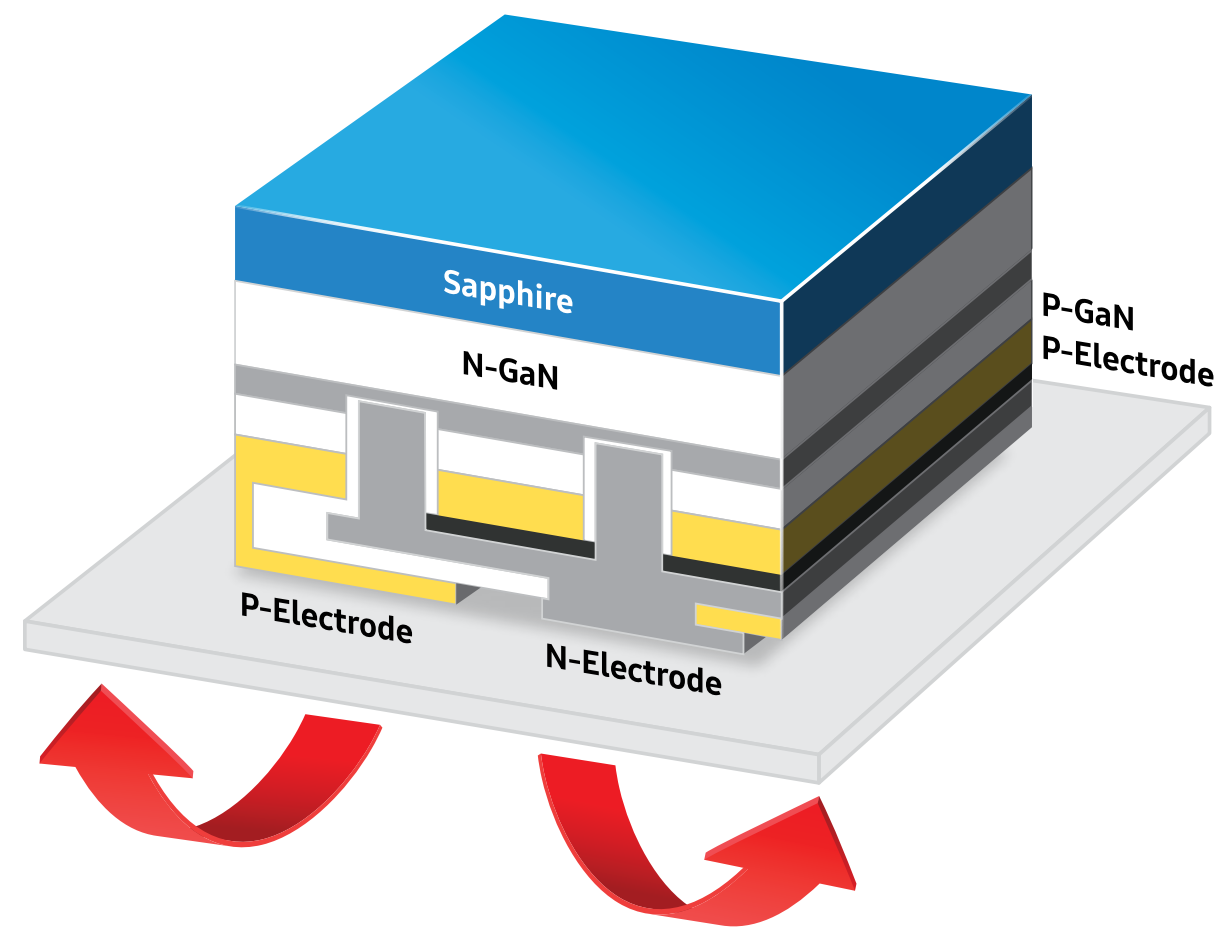


### Full Spectrum



## Excellent Heat Management

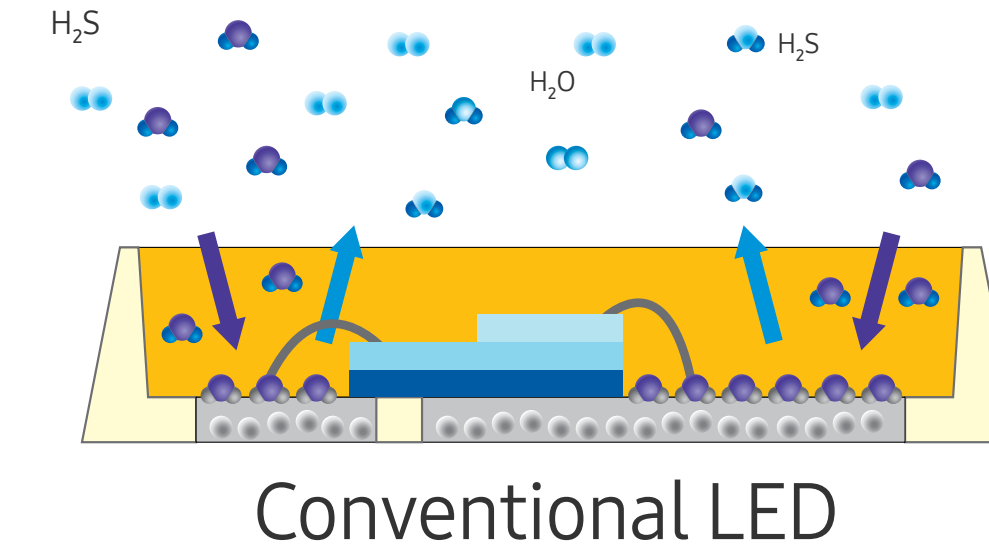
### Flip-chip



## Superior Sulfur Resistance

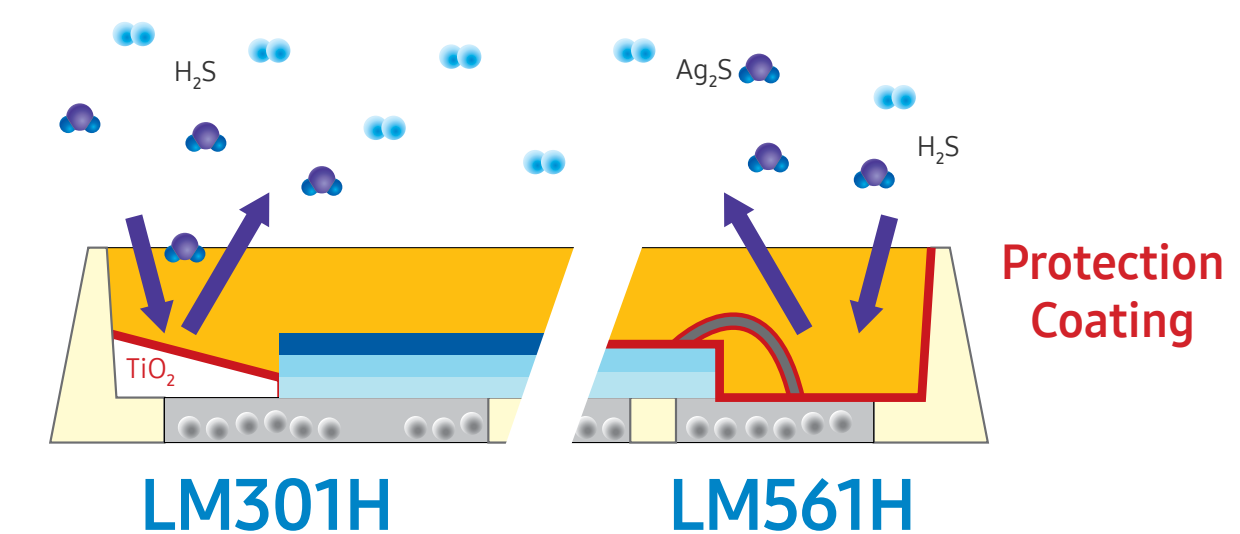
### Conventional Lead Frame Package

- Ag in wire or electrodes can be tarnished when exposed to H<sub>2</sub>S
- $2\text{Ag} + \text{H}_2\text{S} + 1/2\text{O}_2 \rightarrow \text{Ag}_2\text{S} + \text{H}_2\text{O}$  (Ag<sub>2</sub>S causes PPF degradation)



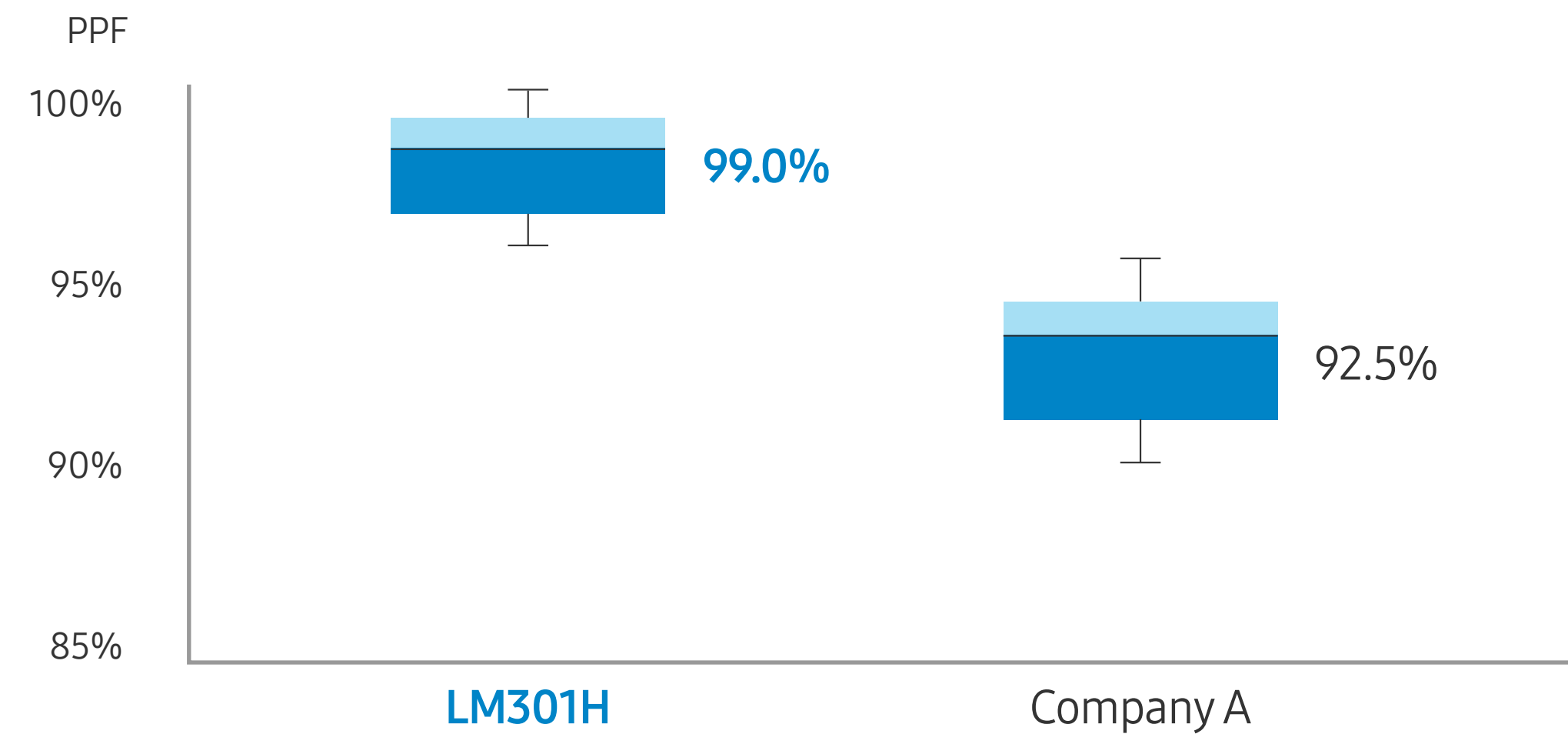
### Samsung Horticulture Package

- LM301H: Flip-chip with no wire
- LM561H, LH351H: Protection coating to prevent Ag exposure



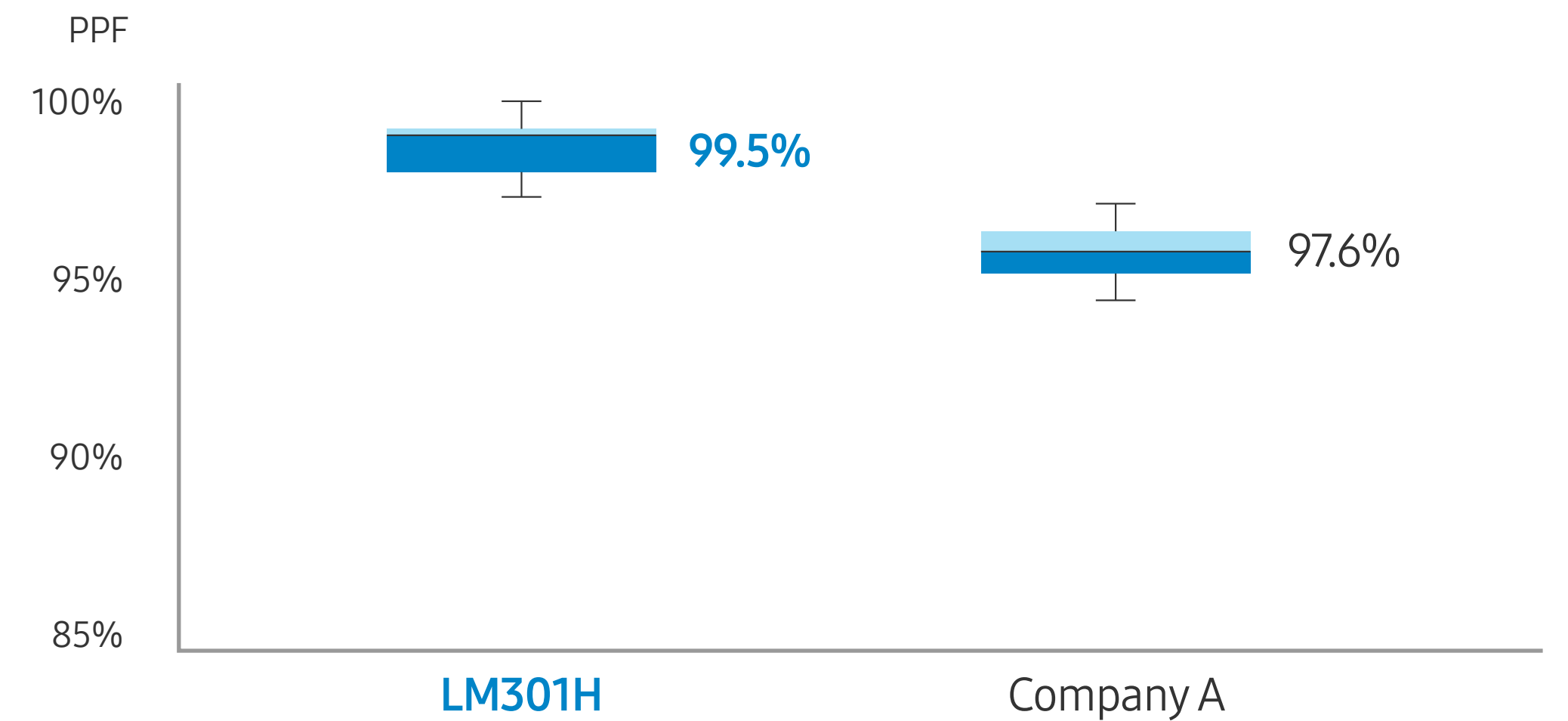
## No Degradation in Horticulture Environment

### Sulfur Resistance Test



H<sub>2</sub>S 15ppm, 25°C / 75% humidity for 504hrs  
\* IEC Pub.68-2-43

### High Temp/Humidity Operation Test

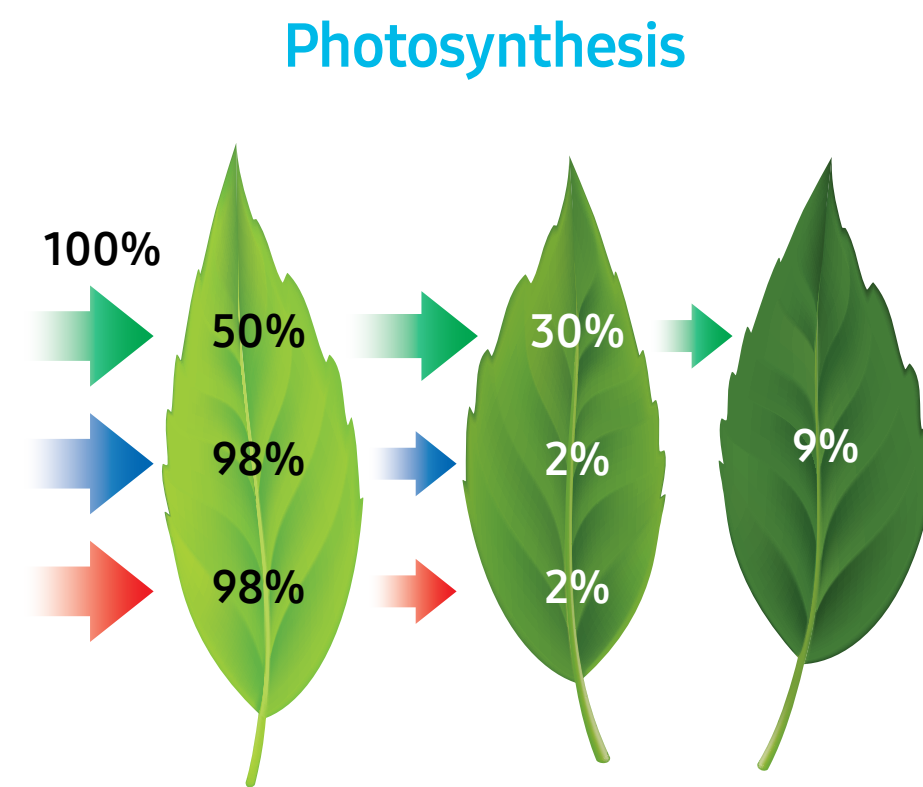


Operation in 85°C / 85% humidity for 1,000hrs

## High Efficacy LEDs for More Efficient Plant Growth

	Mid Power White <small>65mA 25°C CRI80+ 5000K</small>			High Power Red <small>350mA 25°C</small>		
	SAMSUNG LM301H	Company A	Remark	SAMSUNG LH351H Red	Company B	Remark
Form Factor (mm <sup>2</sup> )	3.0 x 3.0	3.0 x 3.0	-	3.5 x 3.5	3.0 x 3.0	-
PPF (μmol/s)	0.56	0.51	<b>+10%</b>	2.63	2.62	-
PPF/W (μmol/J)	3.10	2.86	<b>+8%</b>	3.73	3.72	-

## Better for Photosynthesis, Anti-disease, and Nutrition



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



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



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

# Performance

## Spectrum Comparison Experiment

PLAY VIDEO ▶

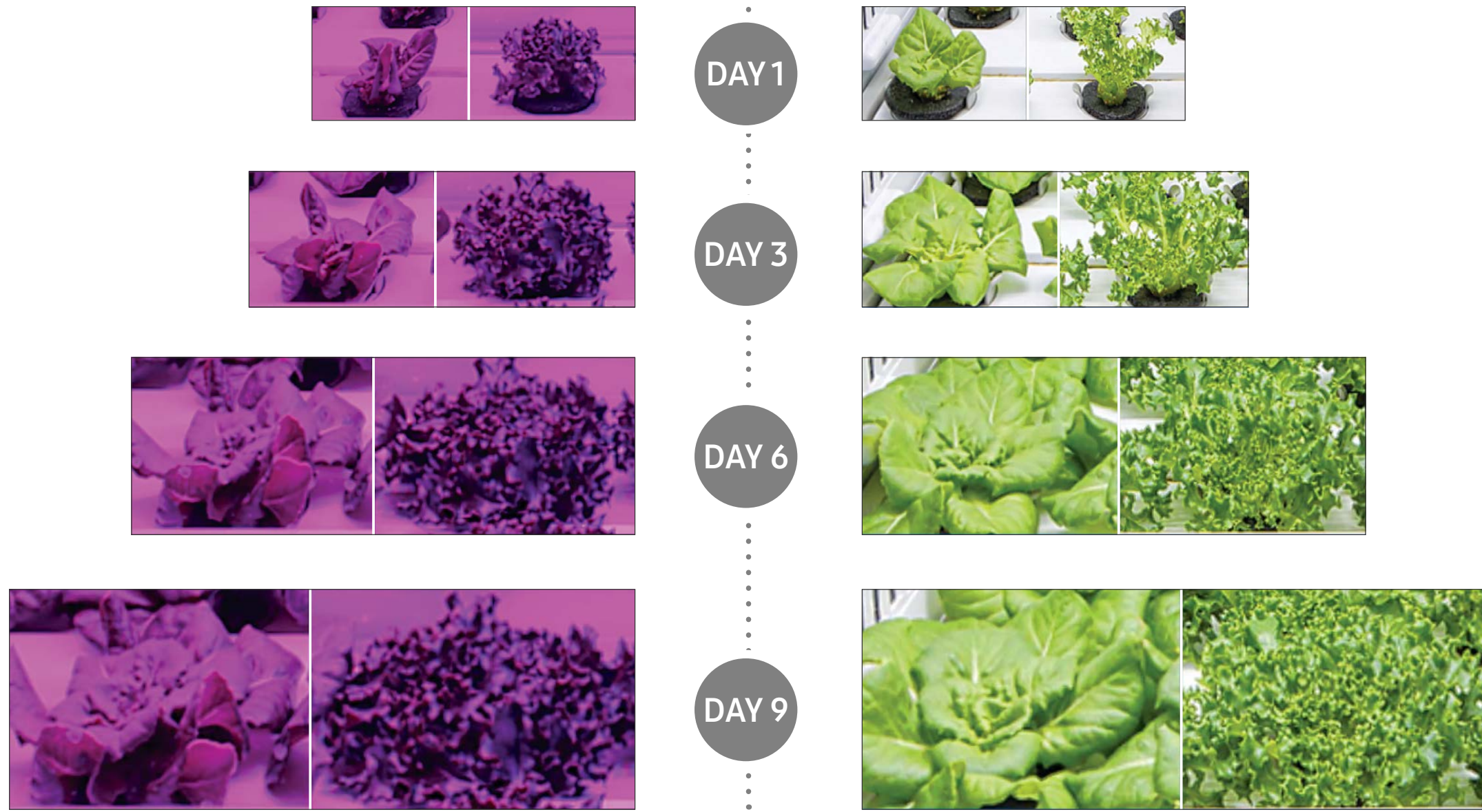


- Plants: Butterhead Lettuce, Oak Leaf
- Environment: 24°C, RH 70%, On/Off=16/8hrs, Hydroponic
- Test Period: 10 days
- Variable: Light spectrum (narrow vs. full) with same PPF

### Narrow Spectrum

### Full Spectrum

DAY 1  
DAY 3  
DAY 6  
DAY 9



※ Experiment was repeated 3 times with different batches for reproducibility

## Healthier Growth Under Full Spectrum

- Cross-sections of the leaves under narrow spectrum vs. full spectrum were compared
- Thicker leaf and well-formed structures (xylem, phloem, etc) were obtained from full spectrum

### Narrow Spectrum



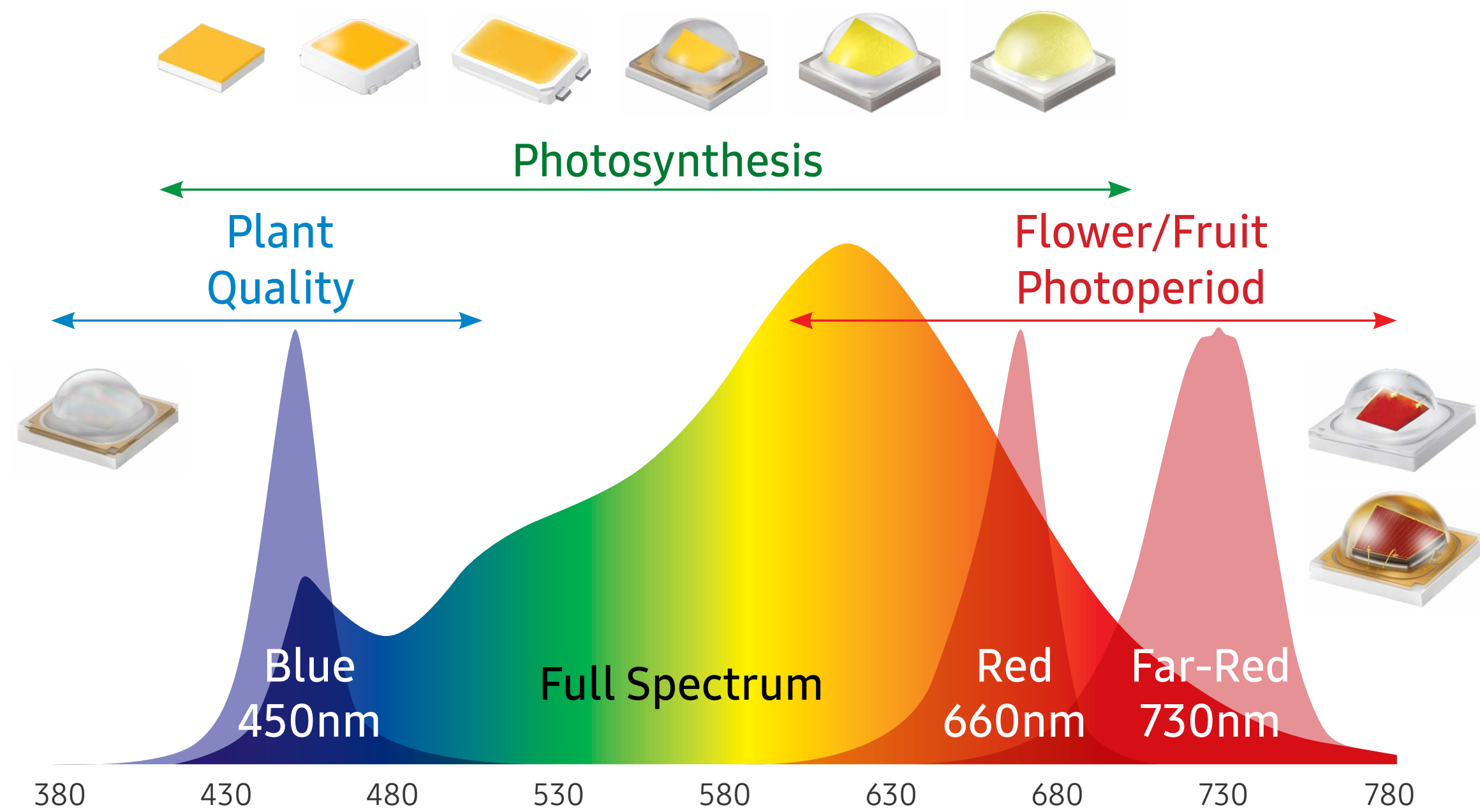
### Full Spectrum



※ Acknowledgement: Prof. Chun at Seoul National Univ.

## Spectrum of Infinite Possibilities

A wide range of LED selections from mid to high power, and white to monochromatic color LEDs



## Spectrum Simulation Tool to Support Customer Design



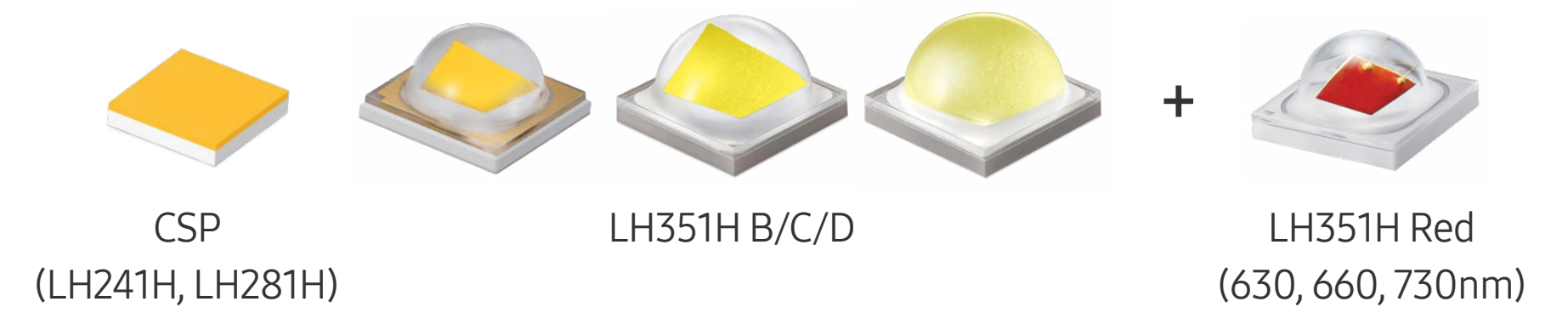


## Vertical/Indoor Farming



\* Crop: Lettuce, Herb → Short Size, Short Life Cycle

## Greenhouse Farming



\* Crop: Tomato, Pepper, Cucumber → Tall Size

# Product Line-up

## White Mid Power LEDs

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

### LM301H



- World's best efficacy
- Anti-sulfurization (with flip-chip technology)

@65mA, 25°C, 5000K, CRI80+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
SL	White	0.56	3.1	3.0 × 3.0

### LM301H ONE



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

@65mA, 25°C, 3400K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
S0	White	0.49	2.75	3.0 × 3.0

### LM561H



- Balanced performance/cost
- Anti-sulfurization (with protection coating)

@65mA, 25°C, 5000K, CRI80+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
S6	White	0.51	2.84	5.6 × 3.0

# Product Line-up

## 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 (mm <sup>2</sup> )
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+

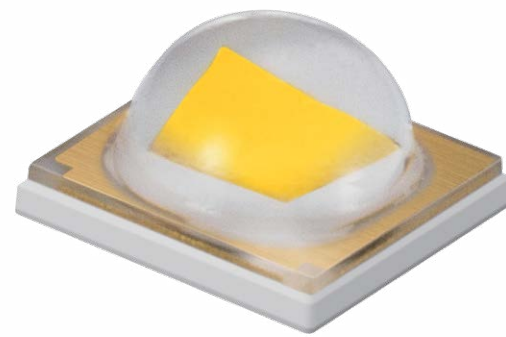
Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
SB	White	2.59	2.65	2.8 x 2.8

# Product Line-up

## White High Power LEDs

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

### LH351H-B

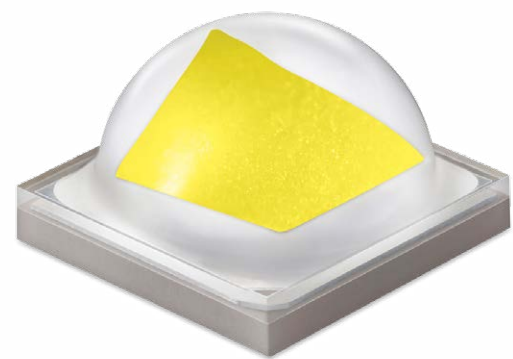


- Viewing angle: 120°
- Thermal resistance: 4.2K/W

@350mA, 25°C, 5000K, CRI70+

Rank	Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
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 (mm <sup>2</sup> )
RB	White	2.56	2.6	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 (mm <sup>2</sup> )
Y2	White	2.58	2.69	3.5 × 3.5

# Product Line-up

## 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 (mm <sup>2</sup> )
Blue	2.8	2.8	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 (mm <sup>2</sup> )
Red	1.57	2.14	3.5 × 3.5

# Product Line-up

## Color High Power LEDs

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

### LH351H Deep Red (660nm)

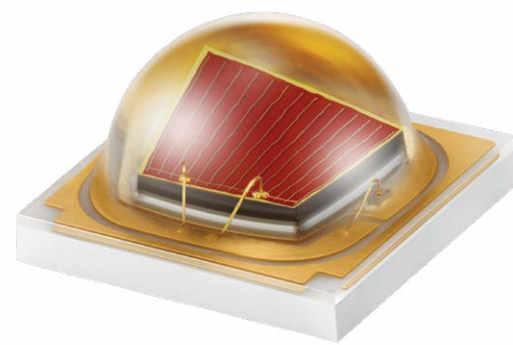


- Viewing angle: 120°
- Thermal resistance: 2.5K/W

@350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
Deep Red	2.32	3.12	3.5 × 3.5
Deep Red	2.4	3.11	3.5 × 3.5

### LH351H Deep Red (660nm) V2



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

@350mA, 25°C

Color	PPF (μmol/s)	PPF/W (μmol/J)	Footprint (mm <sup>2</sup> )
Deep Red	2.63	3.73	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 (mm <sup>2</sup> )
Far Red	1.96	2.91	3.5 × 3.5
Far Red	2.07	3.1	3.5 × 3.5

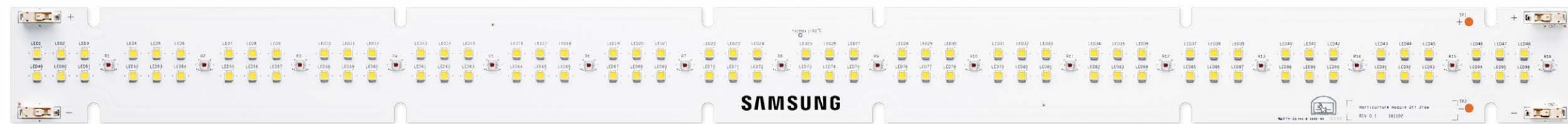
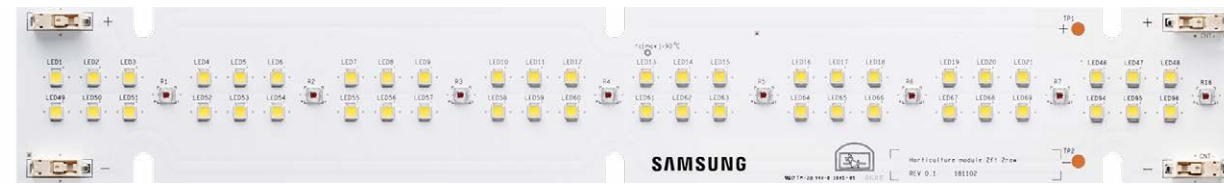
\* Biologically-active Photon Flux

# Product Line-up

## I Module

Customized designs are also available per customer request

### Horticulture LED Module



※ Conformal coating is optional

Item	LED type	CCT	Flux	Efficacy	PPF	PPF/W	If	Vf	Watt	Tp
Unit	-	K	lm	lm/W	μmol/s	μmol/J	mA	V	W	°C
1ft	White + Red	5390	4110	159	70.9	2.74	1200	21.5	25.8	25
2ft		5390	8220	159	141.8	2.74	1200	43.1	51.7	25