SAMSUNG

Vertical Farming Solutions

Market

Capital inflows into vertical/indoor farming is increasing

Bloomberg

Vertical Farming Boom Continues With InFarm Raising $100 Million (Jun. 2019)

The Packer

GV leads $90 million investment in Bowery Farming (Dec. 2018)

Bloomberg

SoftBank Vision Fund Leads $200 Million Bet on Indoor Farms (Jul. 2017)

TC

Billionaires make it rain on Plenty, the indoor farming startup (Jul. 2017)

Image : AeroFarms

Image : Plenty

Image : Infarm

Background

Investment is mainly driven by the following reasons

Demand for fresher, organic, and locally produced food

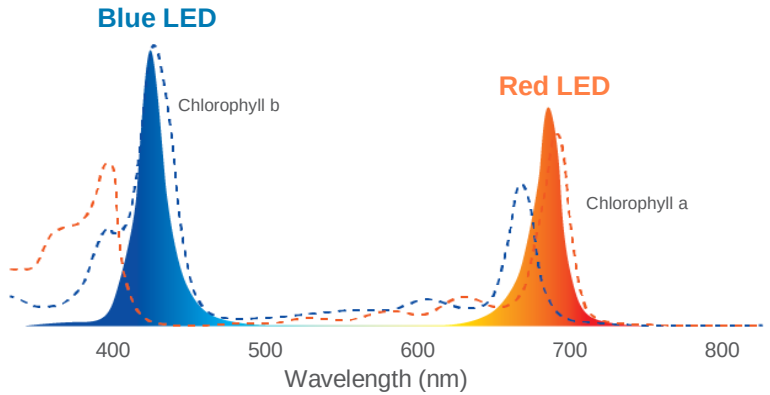
Image : Infarm

Legalization of medical & recreational cannabis

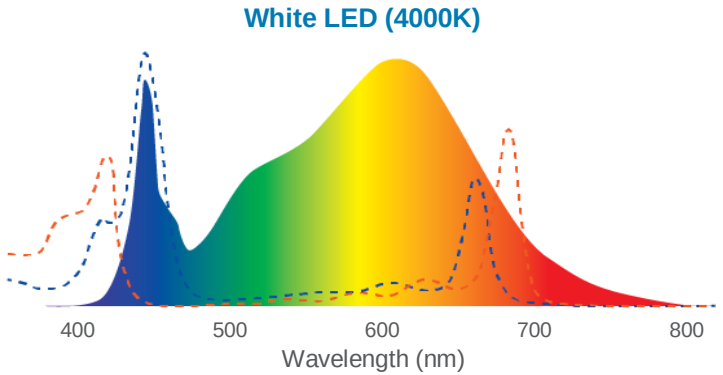
Full Spectrum

LED is the sole source of light and full spectrum is suitable for vertical/indoor farming

Conventional Narrow Spectrum



Full Spectrum



More Favorable Solution

White light enables easier detection of diseases and a pleasant work environment

Narrow Spectrum

Full Spectrum

Key Considerations

There are three key considerations in horticultural lighting

Spectrum	Efficacy	Reliability
Optimized spectrum ensures healthier and balanced plant growth	High PPF/W enables more plant growth with less energy	Horticulture environment requires higher level of reliability and stability

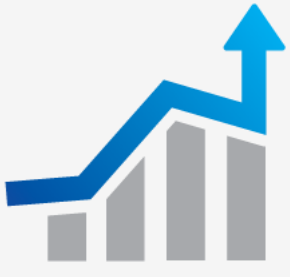
Why Samsung LED

Samsung Horticultural LED line-up is formed with the key considerations in mind

Freedom in Spectrum

Spectrum of infinite possibilities enabling purpose driven plant growth

Industry Leading PPF/W



The highest efficacy increasing yield of crops and saving operation cost

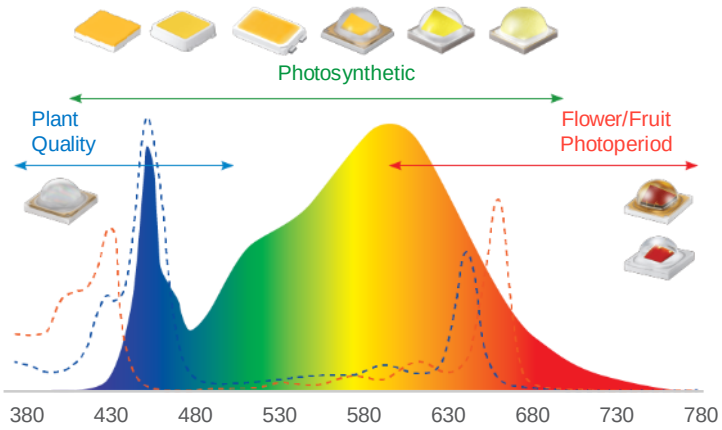
Enhanced Quality

Industry proven reliability under harsh horticulture environment

Spectrum of Infinite Possibilities

A wide selection of LEDs and simulation tool provide freedom of spectrum design

LED Selections



Simulation Tool

Experiment on Full Spectrum

- 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

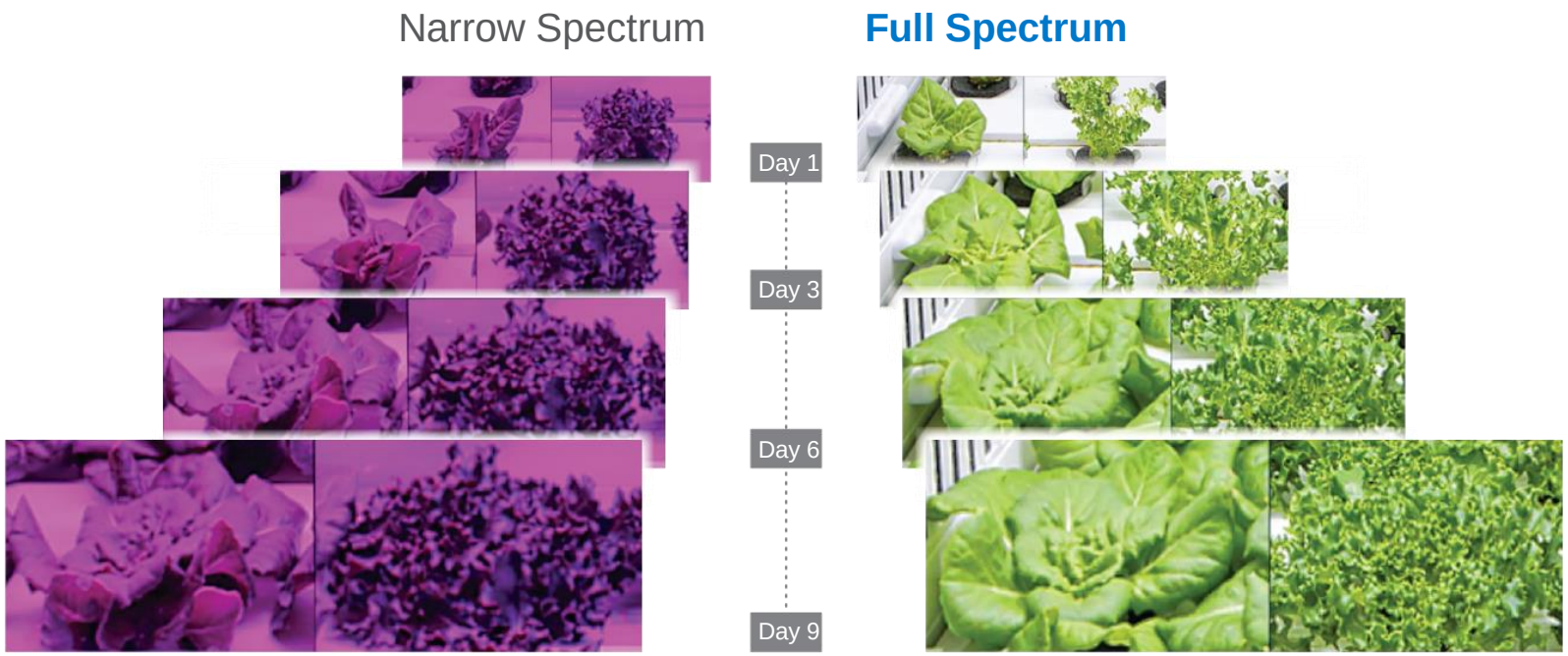
※ Experiment was repeated 3 times with different batches for reproducibility

Narrow Spectrum

Full Spectrum

Experiment on Full Spectrum

10% more fresh weight was obtained from full spectrum

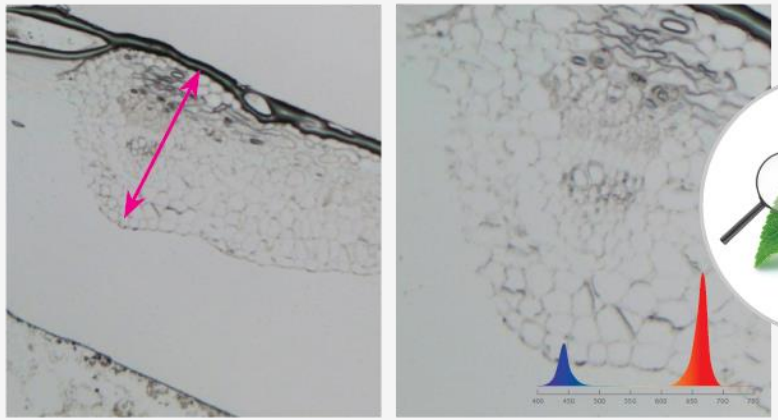


Experiment on Full Spectrum

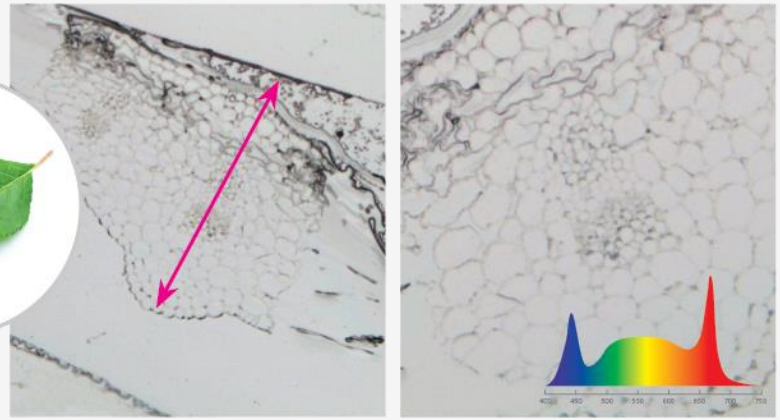
Full spectrum can improve both quantity and quality of plants

- 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 Engineering

Color, taste, and immunity can be optimized with spectrum engineering

Color

Image : Univ. of Guelph

Taste

Image : Plenty

Immunity

Downy mildew

Nighttime Light Treatment

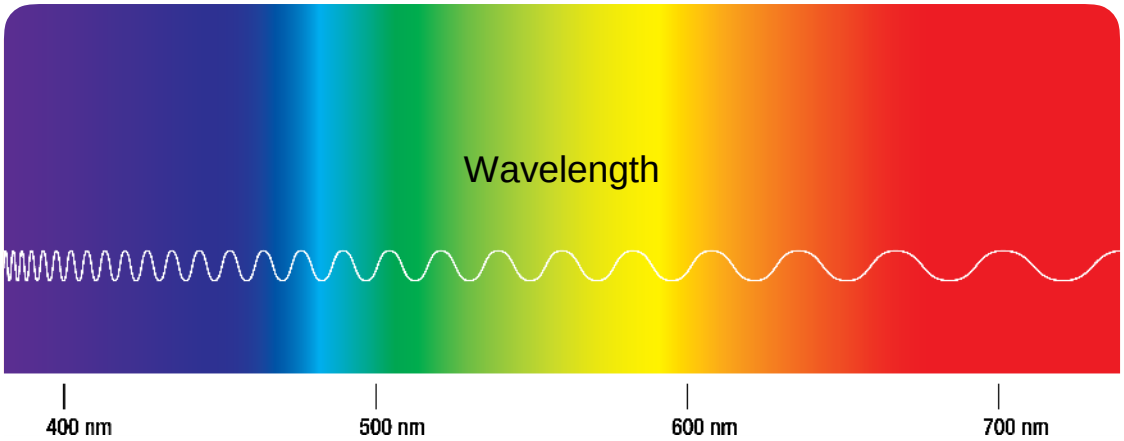
Image : Lighting Research Center

Figure-of-Merits

PAR (Photosynthetically Active Radiation): 400-700nm

PPF (Photosynthetic Photon Flux): Amount of photons in PAR (µmol/s) ↔ lm

PPE (Photosynthetic Photon Efficacy): PPF/Watt efficiency (µmol/J) ↔ lm/W



High Efficacy LED

LED efficacy is key to succeed in horticulture application

→ Samsung provides industry leading high efficacy LEDs

		LM301H	Competitor A	Remark
Form Factor (㎜)		**3.0x3.0**	3.0x3.0	-
25℃ 65mA 5000K CRI80	PPF (μmol/s)	**0.56**	0.51	**+10%**
	PPF/W (μmol/J)	**3.10**	2.86	**+8%**

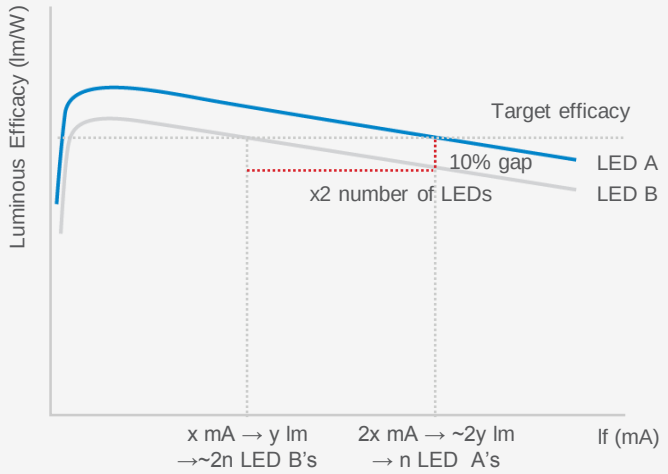
Saving in Lighting System Cost

Initial lighting system cost can be significantly reduced with high efficacy LEDs

- Target PPF > 800 μmol/s
- Target PPE > 2.80 μmol/J

	Company A	**LM301H**
Series x Parallel	17S x 80P	**17S x 37P**
IF (A)	6	**6**
IF/LED (mA)	75	**162**
VF (V)	47.0	**47.8**
Watt (W)	282.0	**286.8**
PPF (μmol/s)	815	**822**
PE (μmol/J)	2.89	**2.87**
Number of LEDs	1360ea.	**629ea.**

54%↓



Saving in Operation Cost

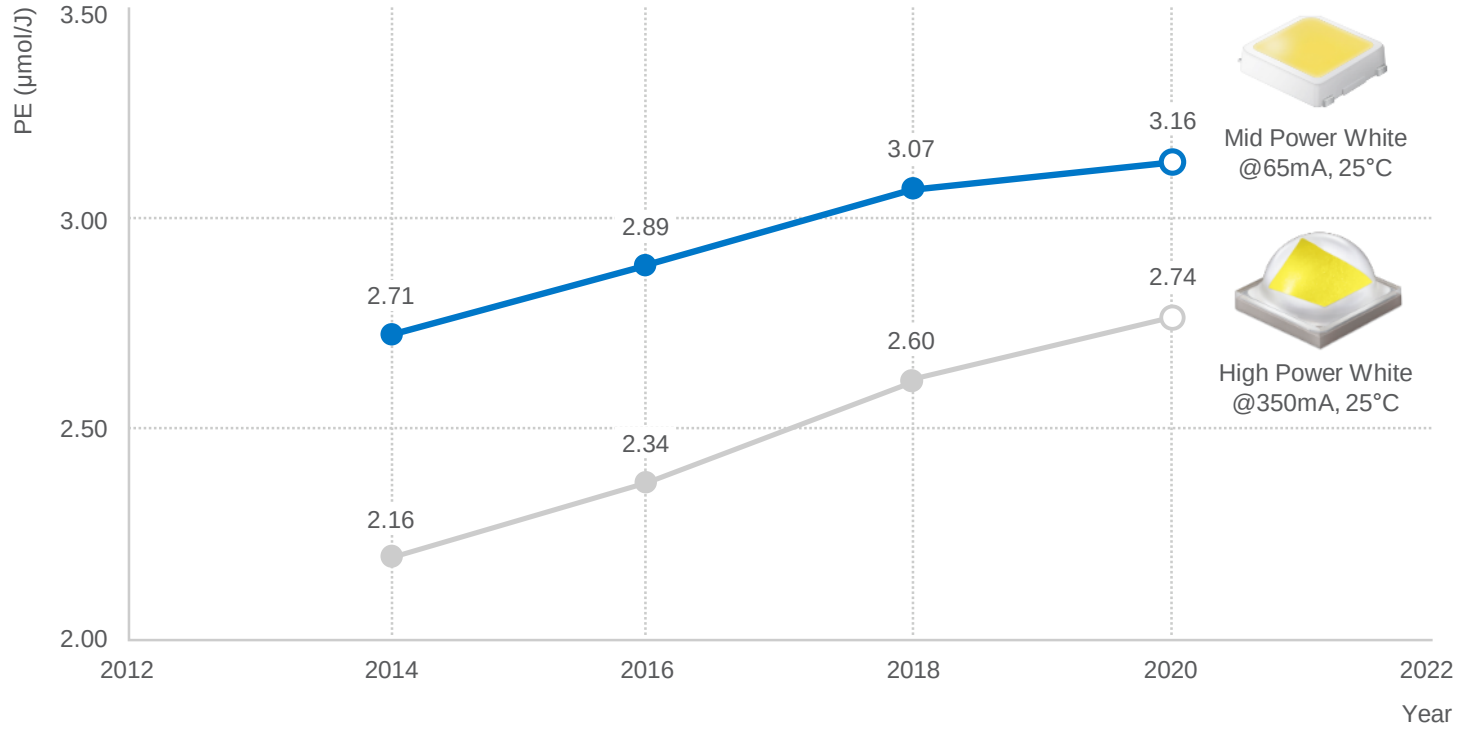
A huge amount of electrical energy can be saved with high efficacy LEDs

FLUENCE

plenty

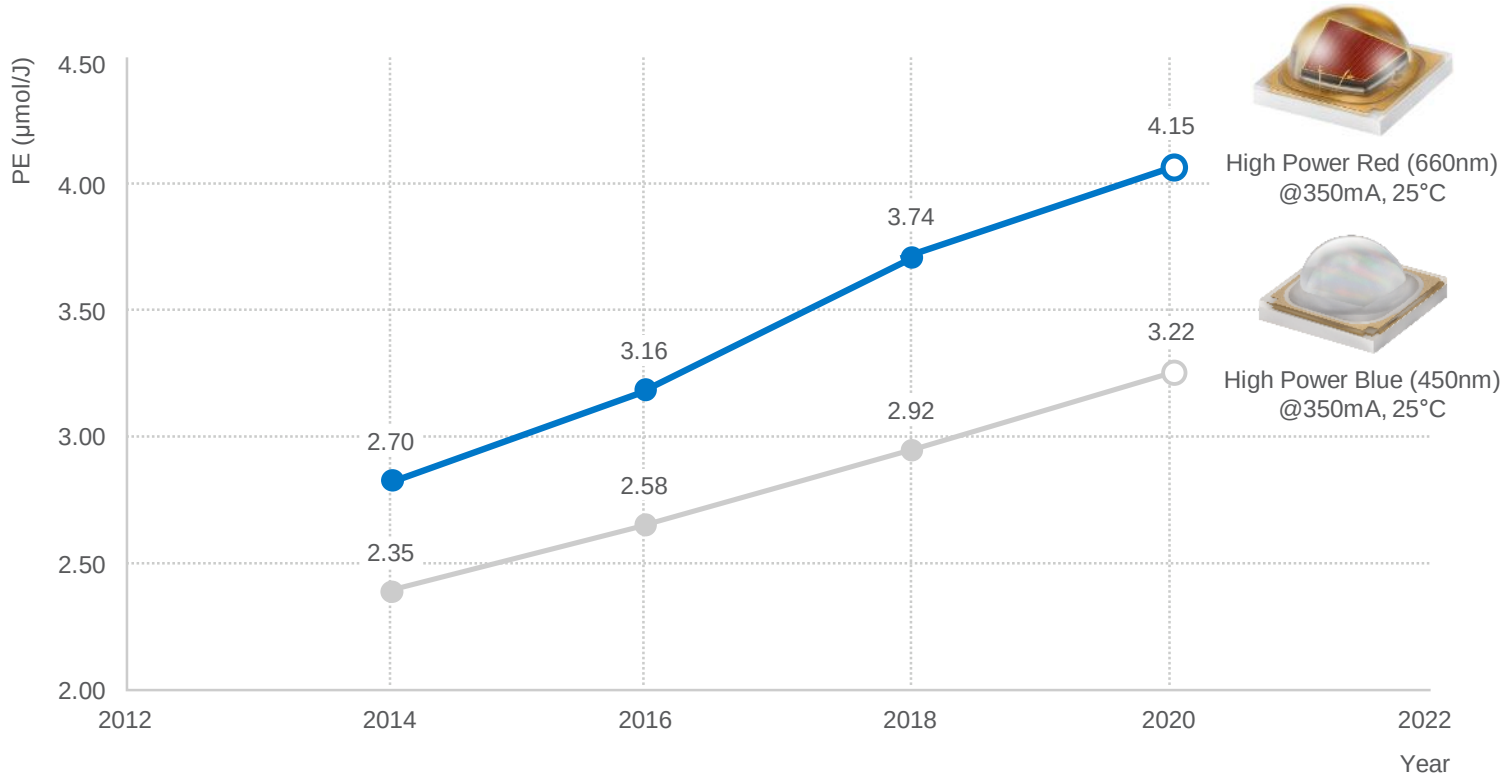
Performance Roadmap – White LED

>3.0μmol/J white-based LED fixtures will be available



Performance Roadmap – Color LED

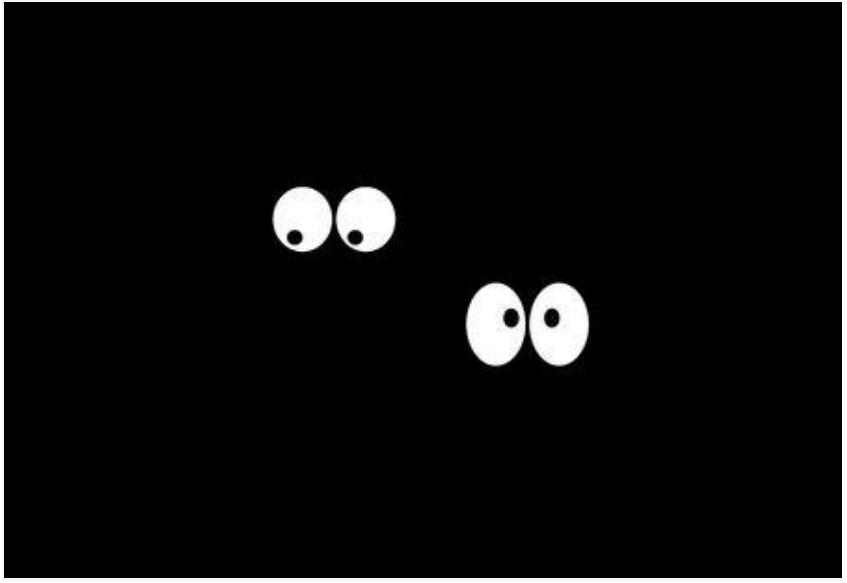
>4.0μmol/J red-based LED fixtures will be available



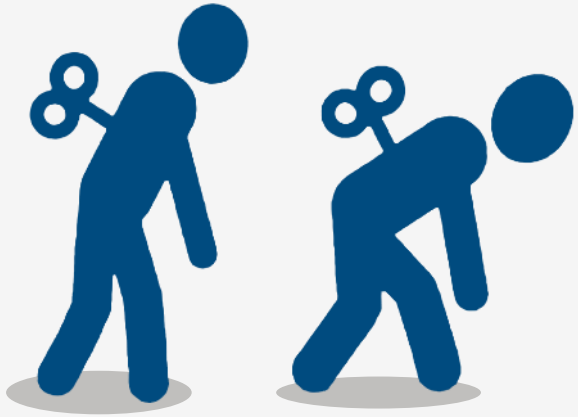
LED Failure Modes

Blackout and performance degradation over time are typical failure modes

Blackout



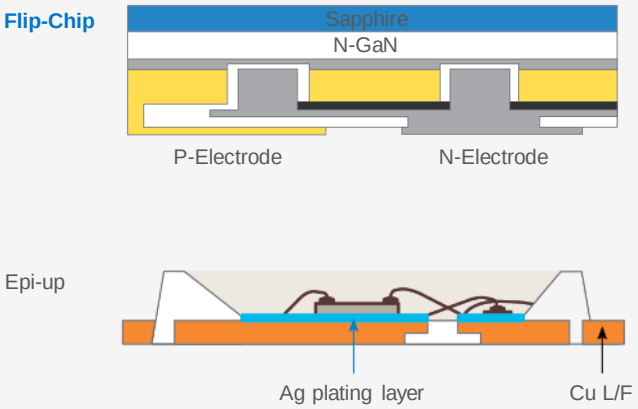
Performance Degradation



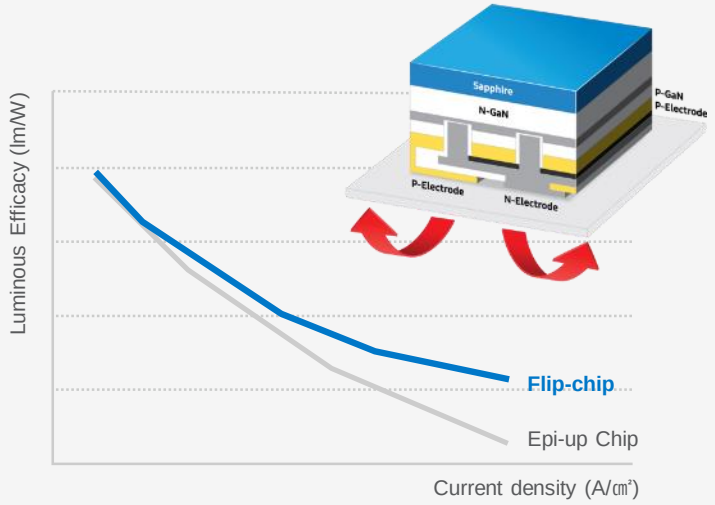
Advanced Flip Chip Structure

Flip-chip LEDs prevent potential wire-open and blackout failure

Wire-free Flip Chip Structure



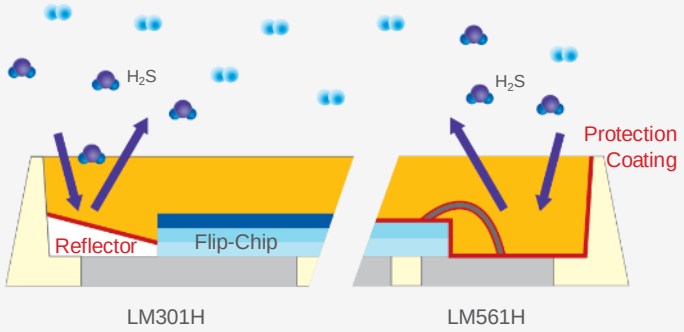
Excellent Heat Management



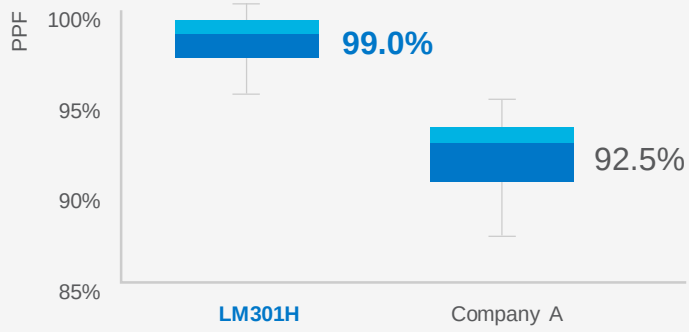
Superior Sulfur Resistance

LEDs with protection schemes are necessary to maintain PPF, Spectrum, etc.

Horticulture LEDs with Protection Schemes



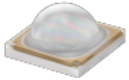
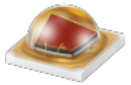
H2S 15ppm, 25°C / 75% humidity for 504hrs



※ IEC Pub.68-2-43

Vertical Farming Solution

- Plants: Lettuce, Herbs, etc.
- LED Lighting Requirements: Efficacy↑, Thermal Management

	White LED			Color LED				
	 LM301H	 LM561H	 LM301H ONE	 LH351H Blue (450nm)	 LH351H Red (630nm)	 LH351H Deep Red (660nm)	 LH351H Deep Red (660nm) V2	 LH351H Far Red (730nm)
PPF (μmol/s)	0.56	0.51	0.49	2.80	1.57	2.32	2.63	*1.96
PPF/W (μmol/J)	3.10	2.84	2.75	2.80	2.14	3.12	3.73	**2.91
Footprint (mm2)	3.0 × 3.0	5.6 × 3.0	3.0 × 3.0	3.5 × 3.5				

*BPF, **BPF/W

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Thank you