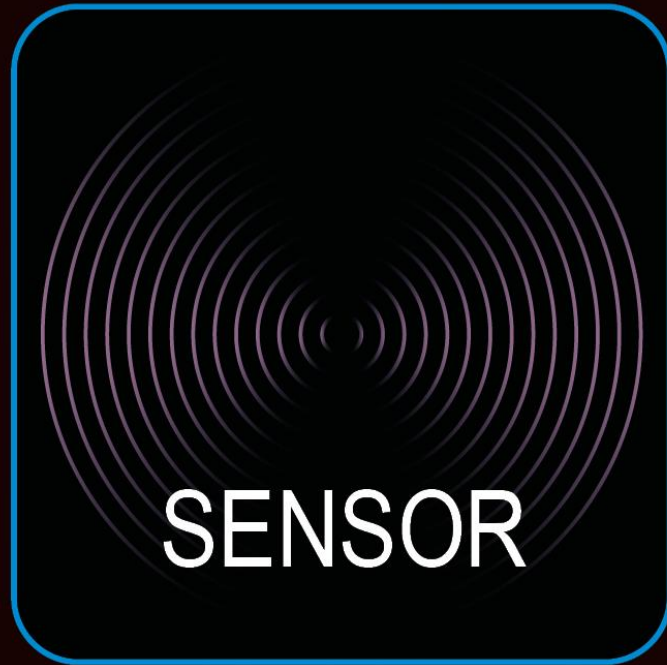


# RUTRONIK TECHTALK MEETS



08.06. - 10.06.2021 | **ONLINE**

UVC LEDs AND MORE! For water, air and surface disinfection

Dr. Olga Stroh-Vasenev  
Sales Account Manager Business Unit Active Components



# UVC LEDs and More! For Water, Air And Surface Disinfection

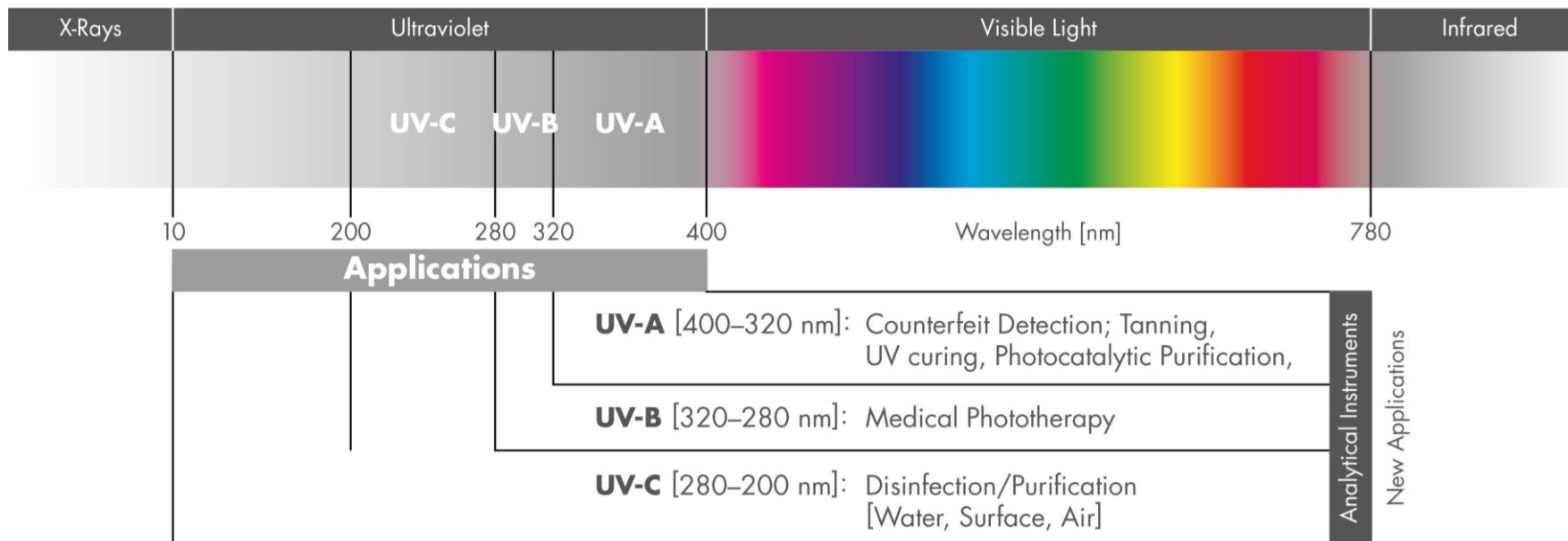
RUTRONIK TECHTALK MEETS – UV LIGHT 202

Dr. Olga Stroh-Vasenev  
June 9, 2021

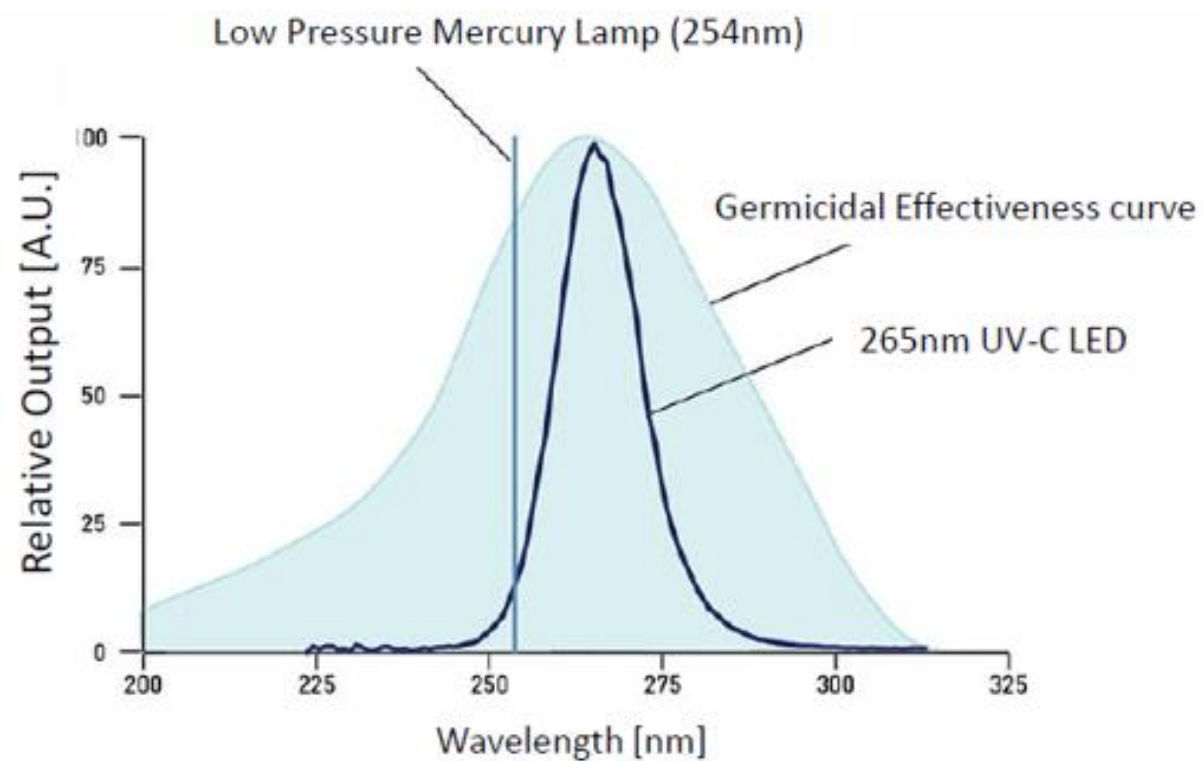
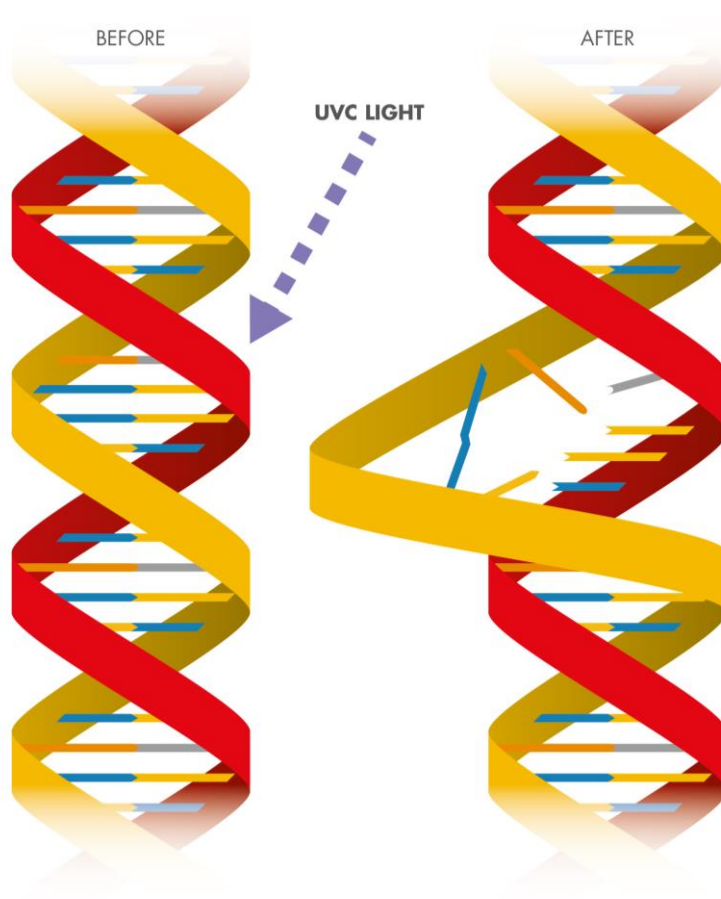


Source: Bolb Inc. / © istock.com/pavlinec


# Electromagnetic Spectrum



# UVC Disinfection Mechanism

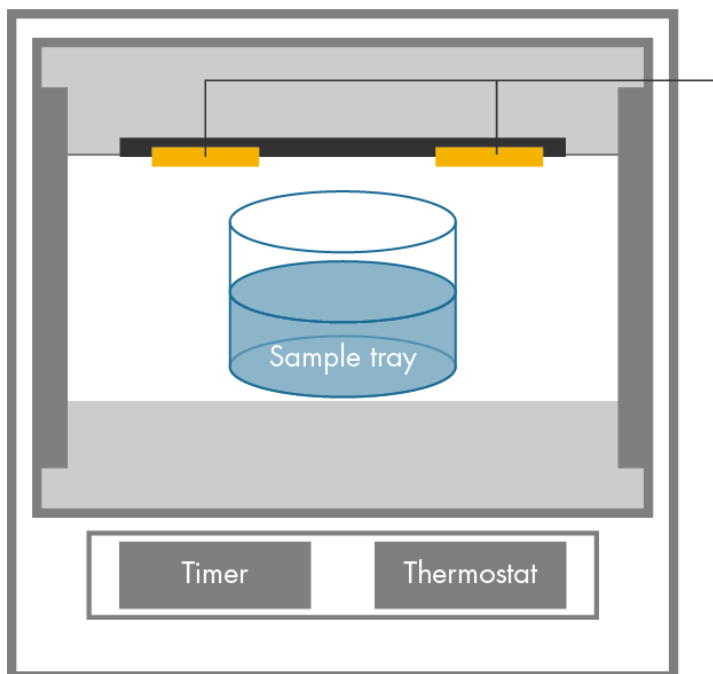


# Sterilization Test

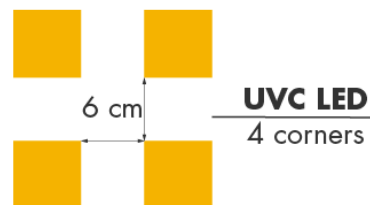
Number of Cell		Log CFU/g (Log CFU/ml)		
1,000,000	$10^6$	6		1 log reduction (90%)
100,000	$10^5$	5		2 log reduction (99%)
10,000	$10^4$	4		3 log reduction (99.9%)
1,000	$10^3$	3		4 log reduction (99.99%)
100	$10^2$	2		5 log reduction (99.999%)
10	$10^1$	1		

UVC LED

# Sterilization Performance by UV Dose



Module Composition:  
10mW UVC PKG 4 pcs.  
Wavelength: 274nm  
Temperature: 25 °C  
Distance: 4 cm

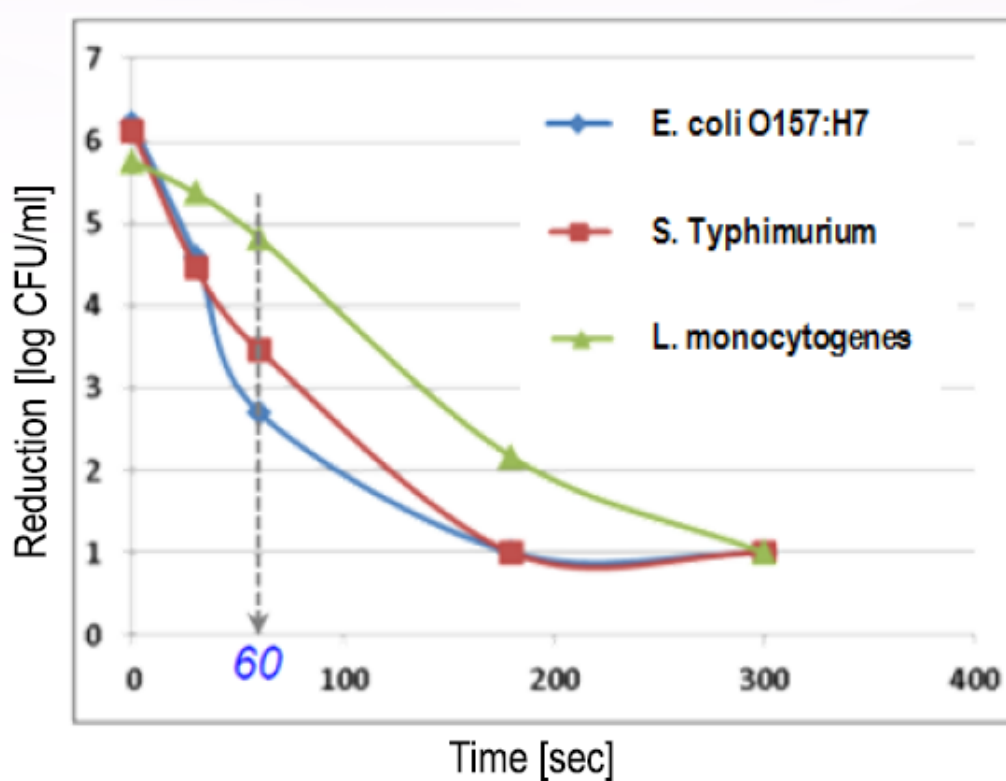


Microorganism	UV Dose (mJ/cm <sup>2</sup> )					
	0	0.2	0.5	1	2	3
<i>E. coli</i> O157:H7	6.72±0.28	5.18±0.42 (97.12%)	2.87±0.23 (99.99%)	1.69±0.27 (>99.99%)	1.07±0.12 (>99.99%)	<1 (>99.99%)
<i>S. Typhimurium</i>	6.71±0.17	5.09±0.15 (98.09%)	3.75±0.32 (99.88%)	2.14±0.60 (>99.99%)	1.30±0.30 (>99.99%)	<1 (>99.99%)
<i>L. monocytogenes</i>	5.29±0.11	4.84±0.22 (64.52%)	3.76±0.28 (97.05%)	1.97±0.20 (99.95%)	<1 (>99.99%)	<1 (>99.99%)

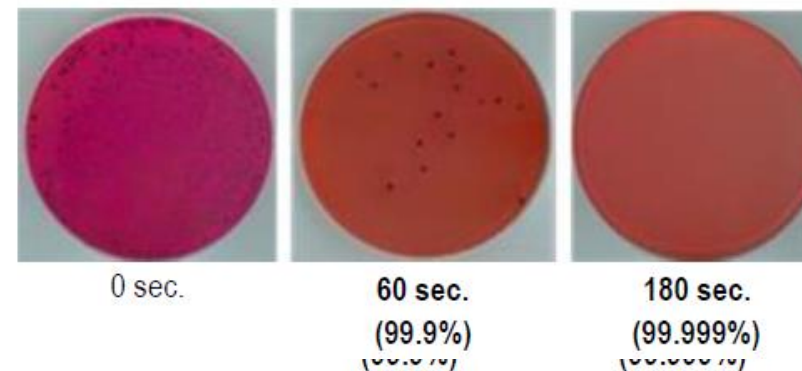
278nm UV-LED (SPL ID : D2218\_4in1). Treated at room temp, 4.5 cm distance between sample and LED. Data represent mean population (log<sub>10</sub>CFU/ml) of three replicates ± standard deviations.

# Output Power Comparison

Surface: 99,9% @60sec. (2mW UV-C LED)



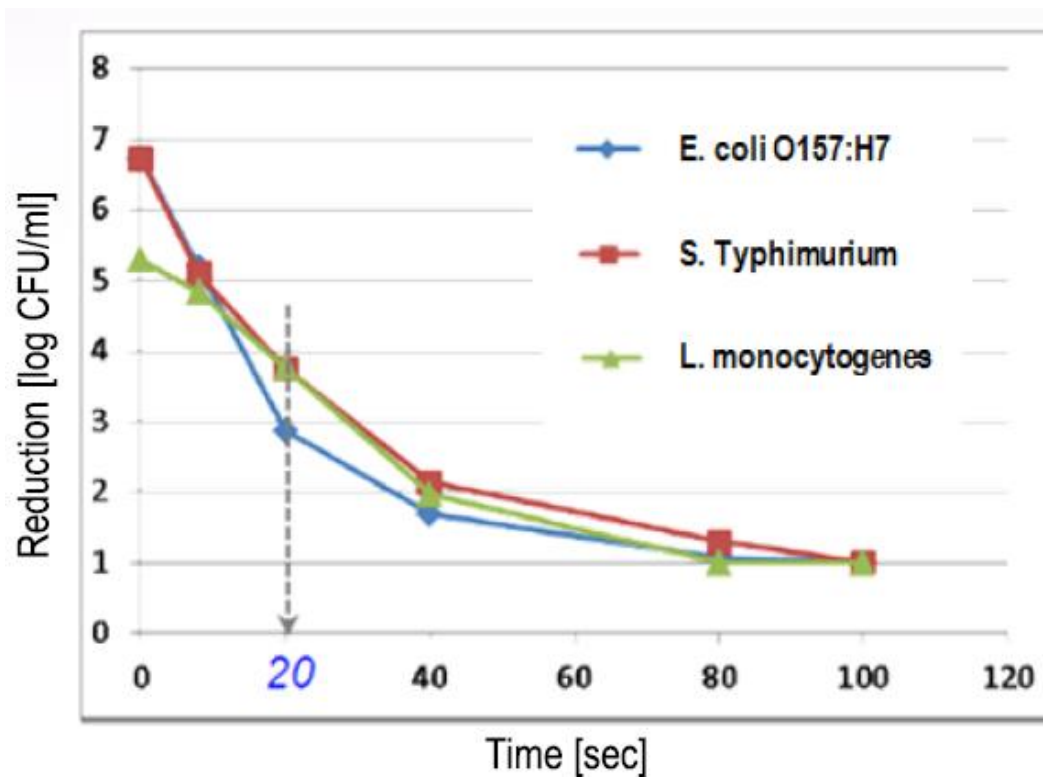
*S. Typhimurium*





# Output Power Comparison

Water 10mL: 99,9% @20sec. (10mW UV-C LED)



S. Typhimurium



0 sec.



20 sec.  
(99.9%)

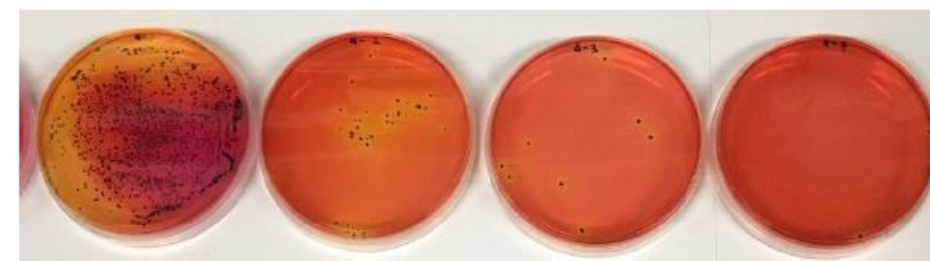
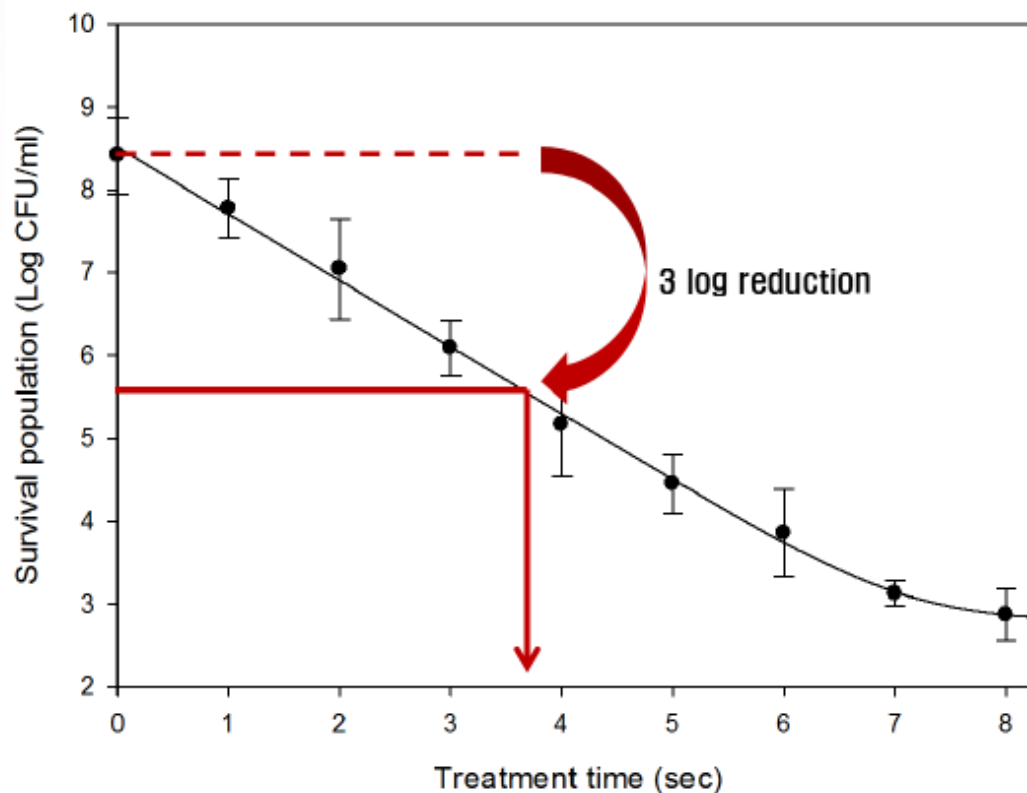


100 sec.  
(99.999%)



# Output Power Comparison

Surface: 99,9% @3.4sec. (100mW UV-C LED)



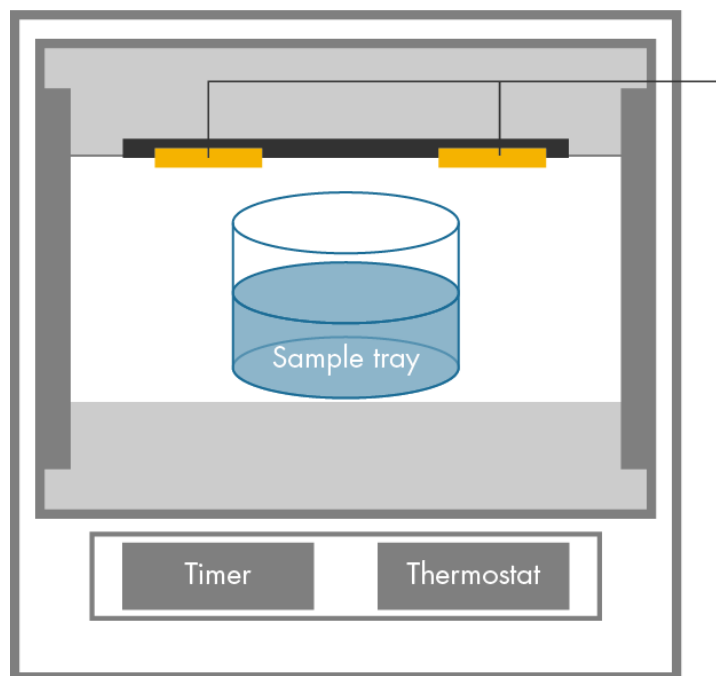
1 sec.      2 sec.      3 sec. (99.9%)      4 sec. (99.9%)



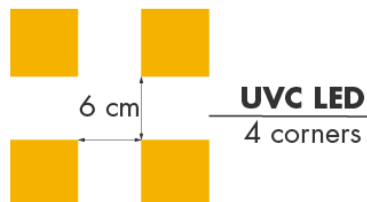
5 sec. (99.99%)      6 sec.      7 sec. (99.999%)      8 sec.

UVC LED

# Sterilization Performance for Mold



Module Composition:  
10mW UVC PKG 4 pcs.  
Wavelength: 274nm  
Temperature: 25 °C  
Distance: 4 cm



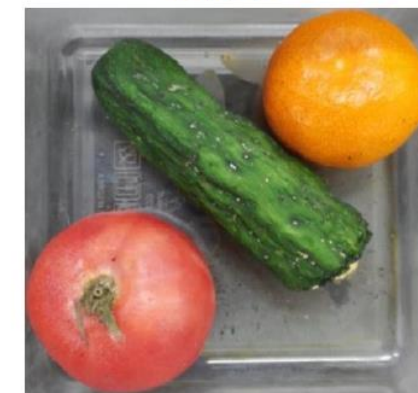
Control



UV Lamp



UV LED



※ 12 days passed



Mold developed



Shrinkage  
Decolorization

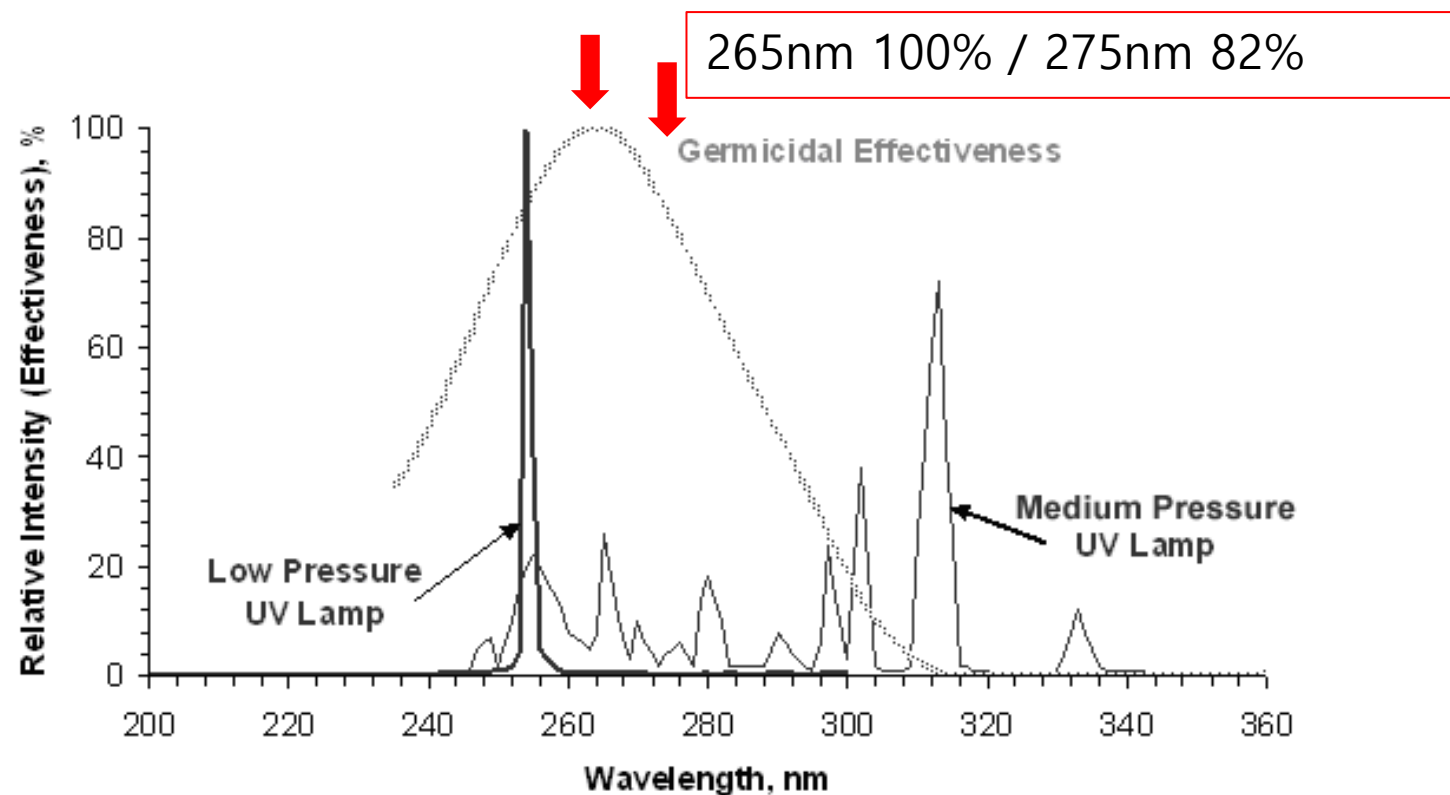


Fresh

UVC LED

## 265nm UVC LEDs

- Germicidal curve by wavelength



Source: Photon Wave

## 265nm UVC LEDs



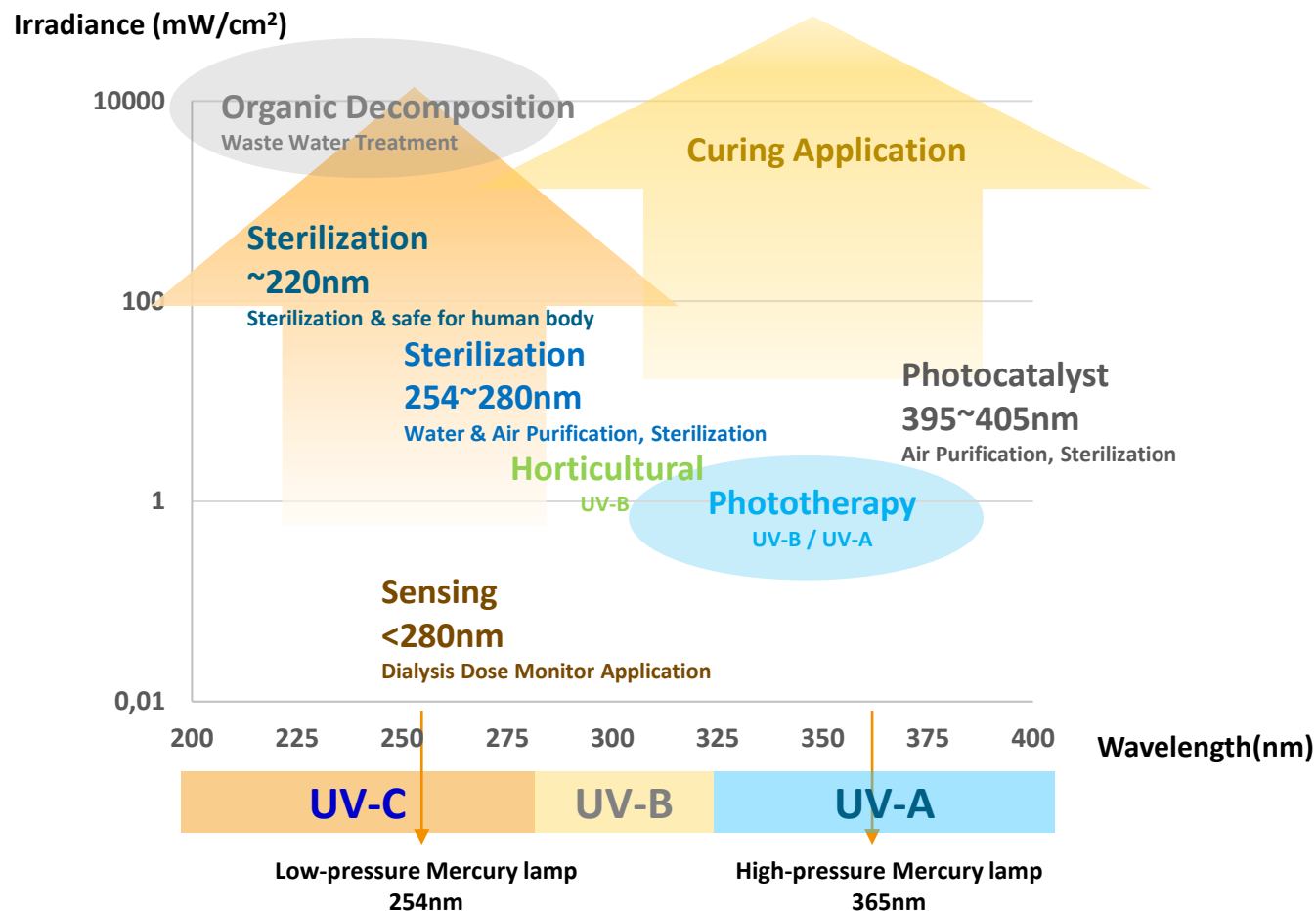
- Disinfection comparison by wavelength

	E Coil		Salmonella		Listeria	
Dose(mJ/cm2)	265nm	275nm	265nm	275nm	265nm	275nm
0.2	>99.99 %	>99.96%	98.88%	98.26%	94.11%	79.11%
0.5	>99.99 %	>99.99 %	>99.99 %	>99.99 %	>99.99 %	99.89%
0.7	>99.99 %	>99.99 %	>99.99 %	>99.99 %	>99.99 %	>99.99 %

Source: Photon Wave

# UV Wavelength vs Application

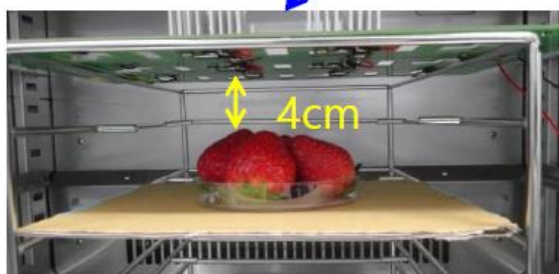
PHOTON WAVE



Source: Photon Wave

# Extended Fresh Life of Food by UVC

UV LED



• After 14 days Mold

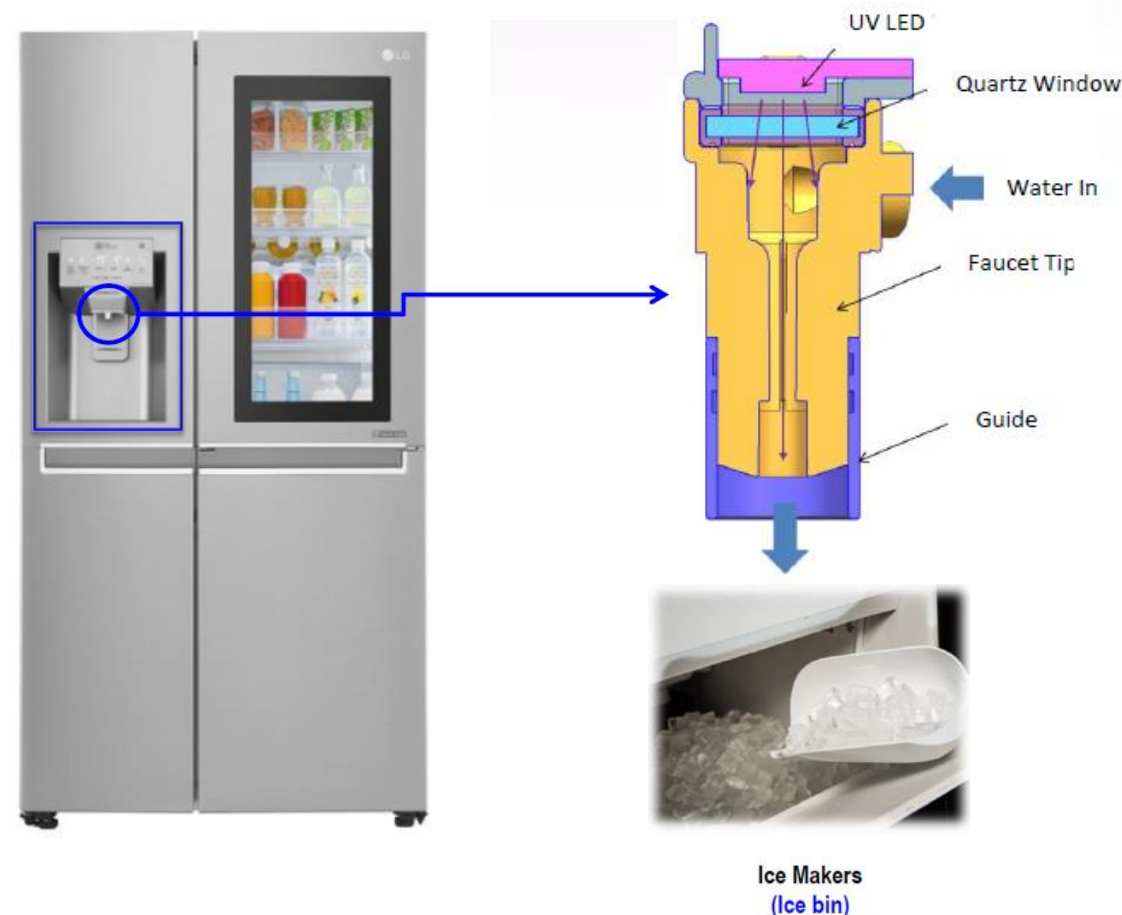


UVC (100mW)



## Sterilization in a Fridge: Faucet Tip and Ice Maker

- Sterilization of faucet tip easily contaminated
- Enable to sterilize a narrow space
- Log3-4 sterilization within few minutes with UVC irradiation
- Auto mode: e.g. every hour for few min.
- Manual mode: sterilize by pressing UV button





## Water Tank

- Protects germs reformation
- Revitalizes purifies stored water
- Energy saving: power Consumption is very low

Water quality control



Water Softeners



Vacuum Cleaners  
(Dust canister)



Dish Washers  
(Washing cabinet)



Washers  
(Detergent Storage)



Coffee Makers  
(Water Storage)

## Disinfection Lighting in a Car

- Partial sterilization on human-touched part
  - Break/Accelerator (30cm)
  - Door Handle (4cm)
  - Gear Stick (15cm)



Source: ©istock.com/Henrik5000

# Sense of Urgency has Increased for UV-C Disinfection Solutions



Pre-CoViD-19

Nice-to-Have becomes MUST-Have



Medical



Water



Agri/Food



Automotive



Water



Surfaces



Offices



Schools



Hospitals



Transportation



Hospitality

UVC LED

Source: Bolb Inc.



# Disinfections Solutions in Surface Spot Treatment



Handheld  
Reference Design  
featuring 5x5 Array

Against **human coronavirus (H229E ssRNA virus)\***:

20cm away, covering 20cm dia. circle: **2 seconds, 99.995%** inactivation  
1 meter away, covering 1 meter dia. circle: **60 seconds, 99.995%** inactivation

Against **MRSA\*\***

1 meter away, covering 1 meter dia. circle: **60 seconds, 99.999%** inactivation



UVC LED

\*Test report by ALG USA and Guangzhou Institute of Microbiology March-May 2020

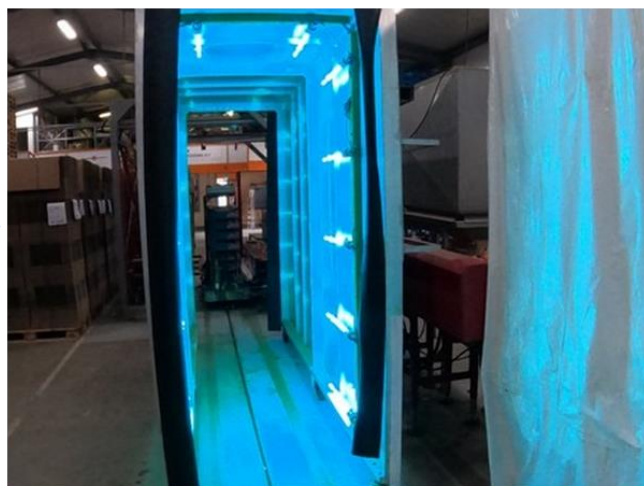
\*\*Test report by Analytical Lab Group, USA, January 2020 ;

Source: Bolb Inc.

# Disinfections Solutions in Hospital Environments



Decontamination of Healthcare Workers and Police  
In “surge tents” for Coronavirus isolation/treatment



Source: Bolb Inc.

UVC LED



# Disinfections Solutions in PPE



N95 Mask Container with BOLB 2x2 Arrays Achieve **99.9996% Kill Against SARS2**



Two BOLB customers had demonstrated high inactivation efficacy against SARS 2 virus on porous N95 surface




**INFORME DE RESULTADOS**


Fecha de emisión: 2020-08-14 UBMF- actividad UV95/2020

**Estudio de eficacia de dispositivo de irradiación ultravioleta para desinfección de mascarillas N95 contra SARS-CoV-2 y HSV-1 en ensayo in vitro**

INFORME TÉCNICO

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**INFORME DE RESULTADOS**


Fecha de emisión: 2020-08-14 UBMF- actividad UV95/2020

muestra	Log <sub>10</sub> virus sin tratar con UV	Log <sub>10</sub> virus tratado con UV	Reducción en Log <sub>10</sub>	Porcentaje de reducción
Mascarilla +UV	4.5	0.5	5.5	99.9996%

**Conclusiones:** El dispositivo denominado UV95 para irradiación de mascarillas N95 marca 3M con luz UV diseñado por la empresa Simpla Automated Health, tuvo la capacidad de eliminar por completo los virus de herpes simple HSV-1 y coronavirus pandémico humano SARS-CoV-2 causante de COVID-19, esto mediante los ensayos realizados en el CIATEJ en donde al someter a la luz UV por 10 minutos, mascarillas infectadas con títulos de 10<sup>4</sup> para ambos virus, no se observó CPE en los cultivos celulares post-infección, en donde los controles positivos para ambos virus mostraron infección en las mismas condiciones, pero sin la luz UV.

Elaboró



Darwin Elizondo Quiroga  
Investigador Titular C  
Biotecnología Médica y Farmacéutica  
Correo electrónico [delizondo@ciatej.mx](mailto:delizondo@ciatej.mx)

Revisó



Abel Gutiérrez Ortega  
Dirección de Unidad  
Biotecnología Médica y Farmacéutica  
Correo electrónico [aortega@ciatej.mx](mailto:aortega@ciatej.mx)

Source: Bolb Inc.

# Bolb's New Air Treatment Reference Design



Achieves **99.96%** Kill At **3000 LPM** flow rate in a **single pass**  
Standard 5x5 Module 2.5 Watt Optical Power 42W Electrical Power  
Against Aerosolized *Staph aureus*



GUANG ZHOU INSTITUTE OF MICROBIOLOGY CO., LTD.

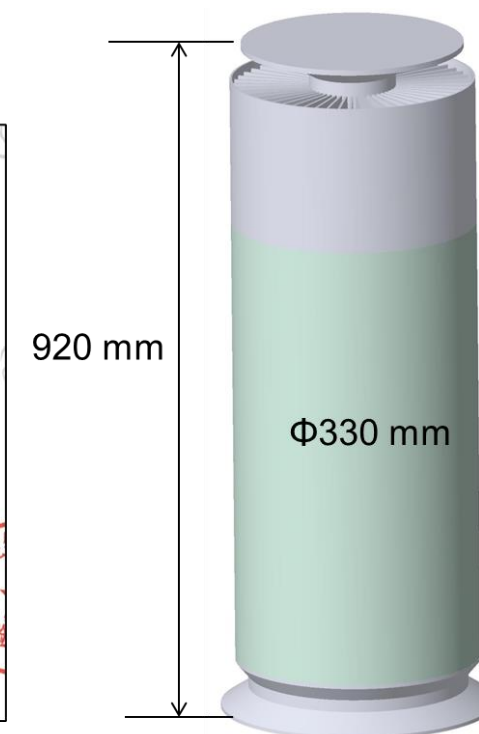
TEST REPORT

Date Received: Mar. 15, 2021  
Date Analyzed: Mar. 18, 2021

Test result summary

Number of Sample	Items of Analysis	Machine running state	Unit	Result
KJ20210569-1	Cleaning Efficiency (Staphylococcus aureus)	Second grade wind speed + UV lamp off	%	54.67
		Second grade wind speed + UV lamp on	%	99.29
		Third grade wind speed + UV lamp off	%	59.43
		Third grade wind speed + UV lamp on	%	99.87
		Rapid grade wind speed + UV lamp off	%	73.81
		Rapid grade wind speed + UV lamp on	%	99.96

\*\*\*To be continued\*\*\*



Source: Bolb Inc.



# Bolb's UVC LED – Exceptional Technology at 275nm



UVC LED

May 2020



Typical single emitter  
100 mW @ 250mA 6.5V  
6060 SMD  
L70 5,000 hours from Time 0  
at case temp of 38 °C

December 2021



Typical single emitter  
160 mW @ 350mA 7V  
6060 SMD  
L70 7,000 hours from Time 0  
at case temp of 38 °C

Level 2  
Modules

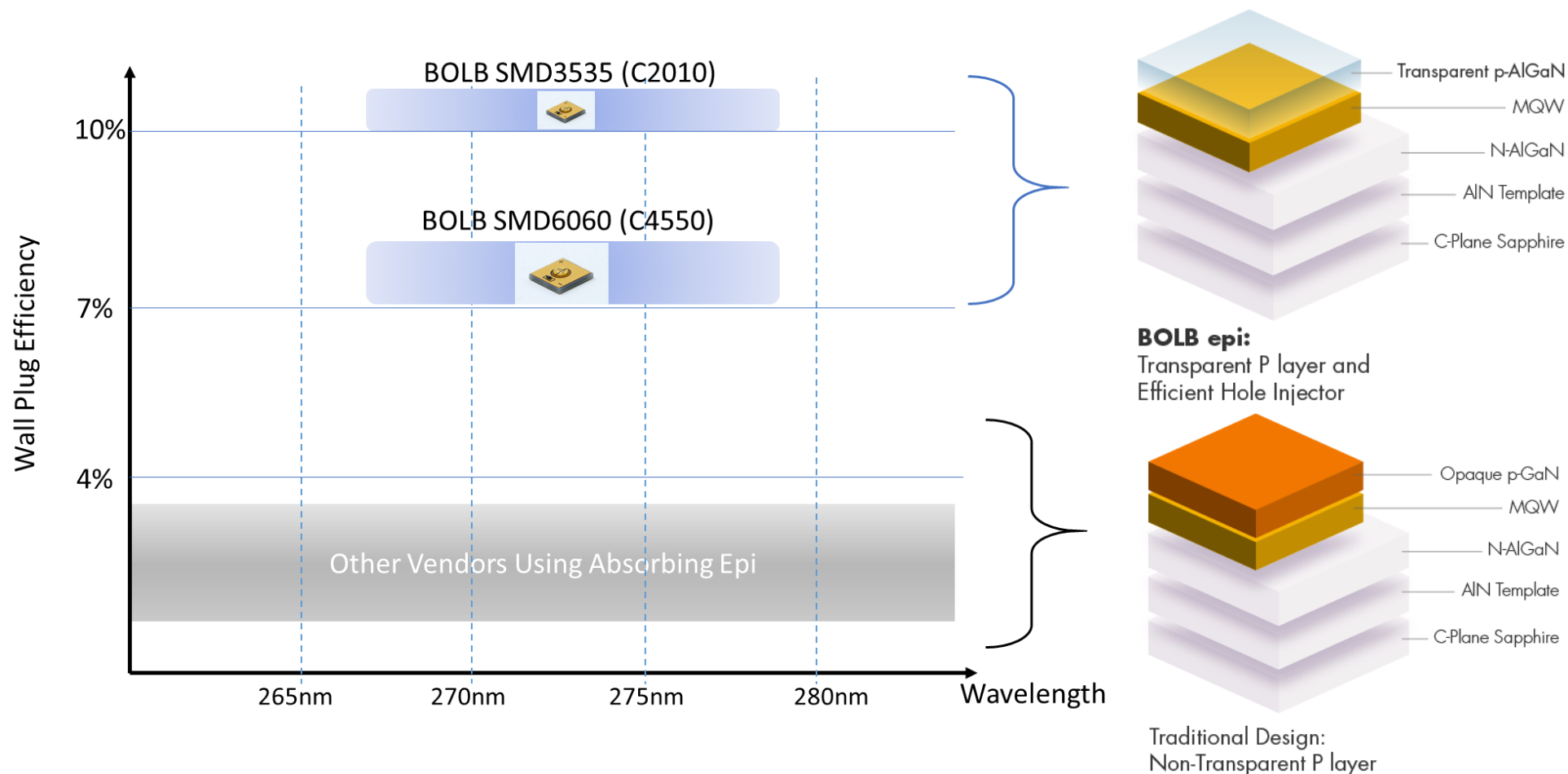


Task-specific Modules  
Maximum differentiation

$$WPE = 0.100 \text{ W} / (0.25 \text{ A} * 6.5 \text{ V}) = 6.15\%$$

Source: Bolb Inc.

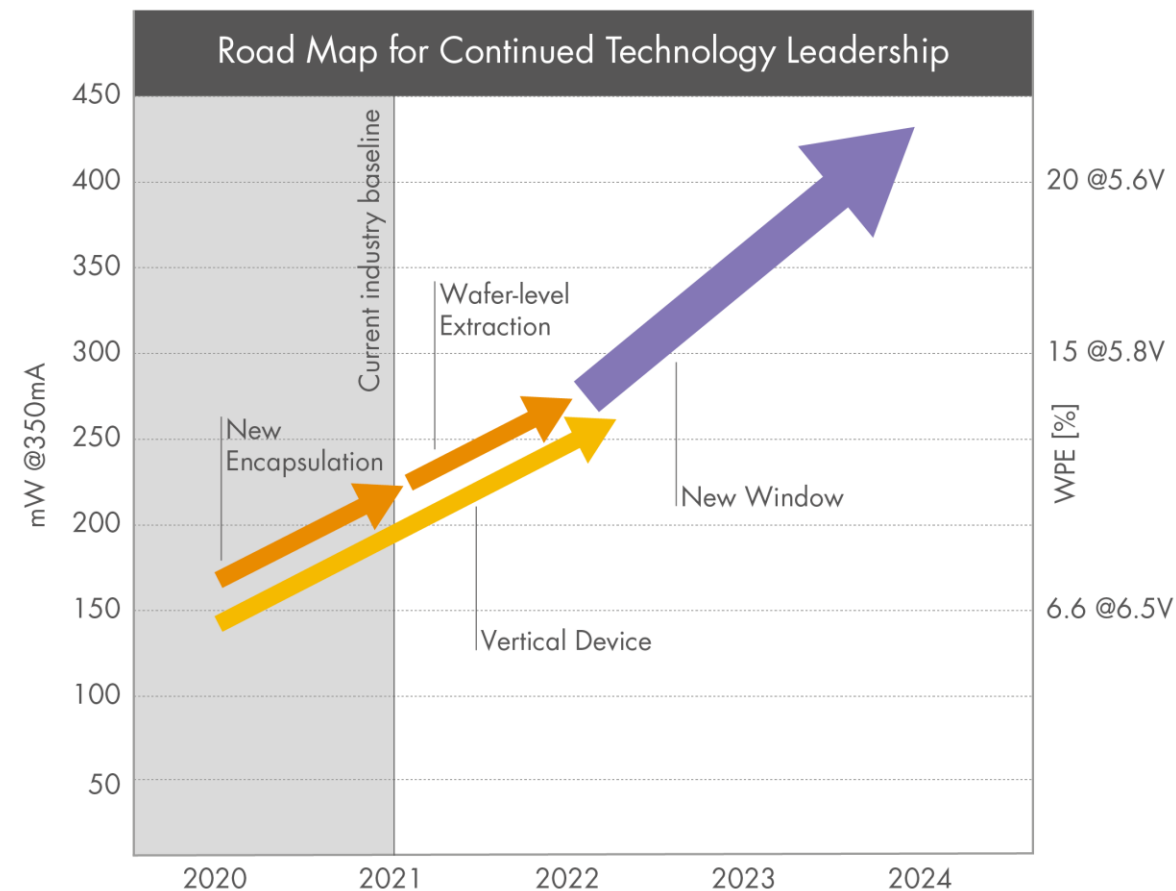
# Technology Leadership / 2-3x Increased Efficiency



Source: Bolb Inc.

## Development Progress

- Technical development and production improvement will reflect in a €/mW ration  $< 0.10\text{€/mW}$

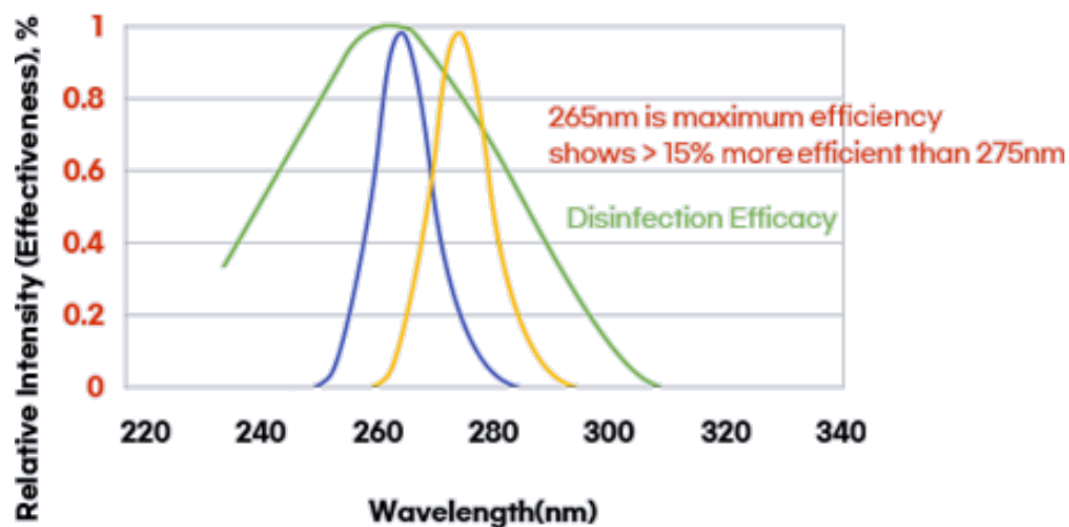


Source: Bolb Inc.

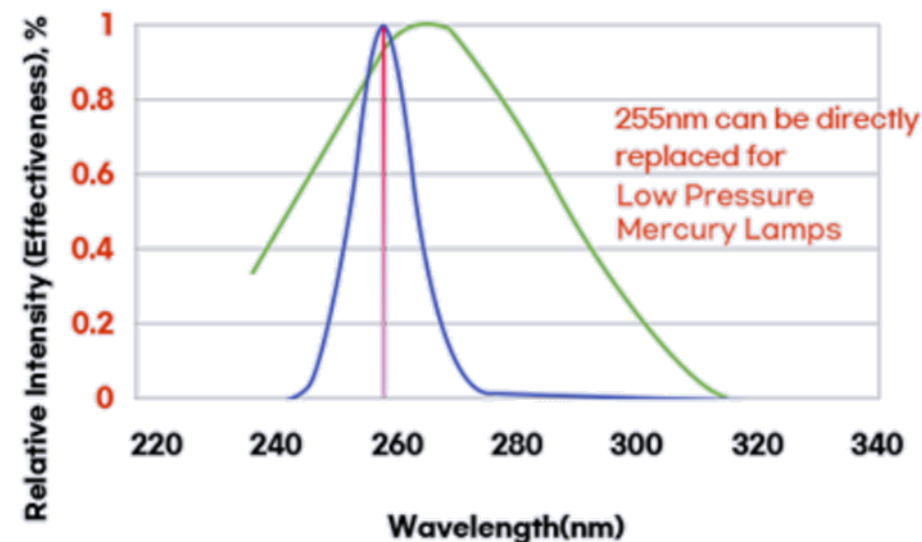
# Sterilization Efficacy



Disinfection efficacy curve(E.Coli) and  
265nm Vs. 275nm UVC LED spectrum comparison



Low pressure mercury lamp peak  
Vs. 255nm UVC LED spectrum





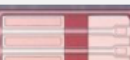


Source: Photon Wave

# Photon Wave

## Variaty in Wavelengths and Chip Sizes



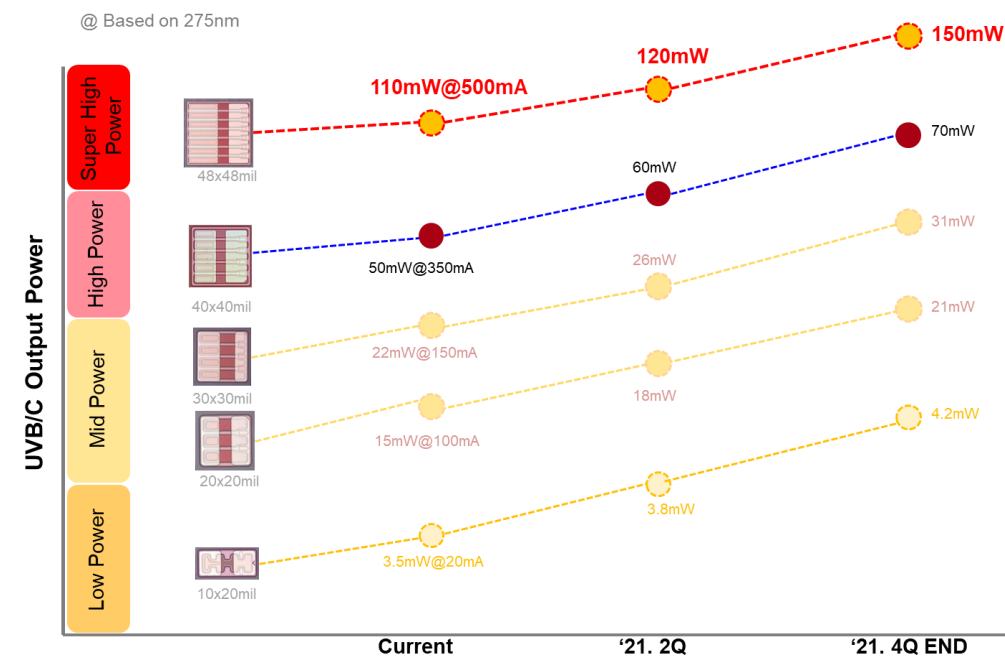
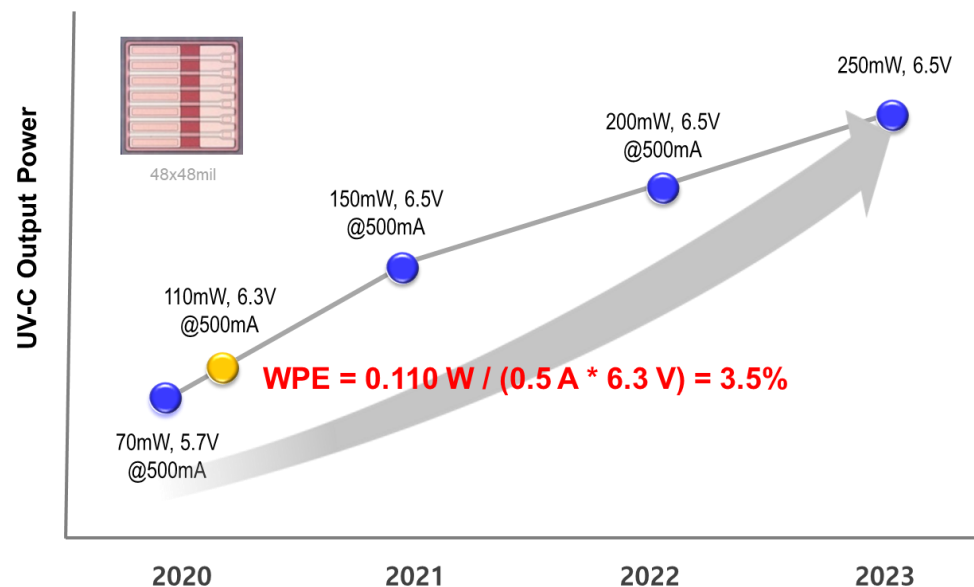
Products		Size	Typical Spec					
			Current	255nm	265nm	275nm	295nm	308nm
CHIP		10 x 20 mil <sup>2</sup>	20mA	3.2mW, 5.8V	3.5mW, 5.7V	3.5mW, 5.6V	3.3mW, 5.7V	3.3mW, 5.7V
		20 x 20 mil <sup>2</sup>	100mA	15mW, 5.8V	15mW, 5.8V	15mW, 5.7V	15mW, 5.7V	15mW, 5.7V
		30 x 30 mil <sup>2</sup>	150mA	20mW, 5.7V	22mW, 5.7V	22mW, 5.6V	21mW, 5.7V	21mW, 5.7V
		40 x 40 mil <sup>2</sup>	350mA	45mW, 5.7V	50mW, 5.7V	50mW, 5.5V	50mW, 5.7V	50mW, 5.7V
		48 x 48 mil <sup>2</sup>	500mA	70mW, 6.3V	105mW, 6.3V	110mW, 6.2V	110mW, 6.2V	110mW, 6.2V

Source: Photon Wave

# UV-C Product Roadmap 2021~2023



- PhotonWave is a performance **leading company** among UV-C LED industry (@ **Single Chip**)



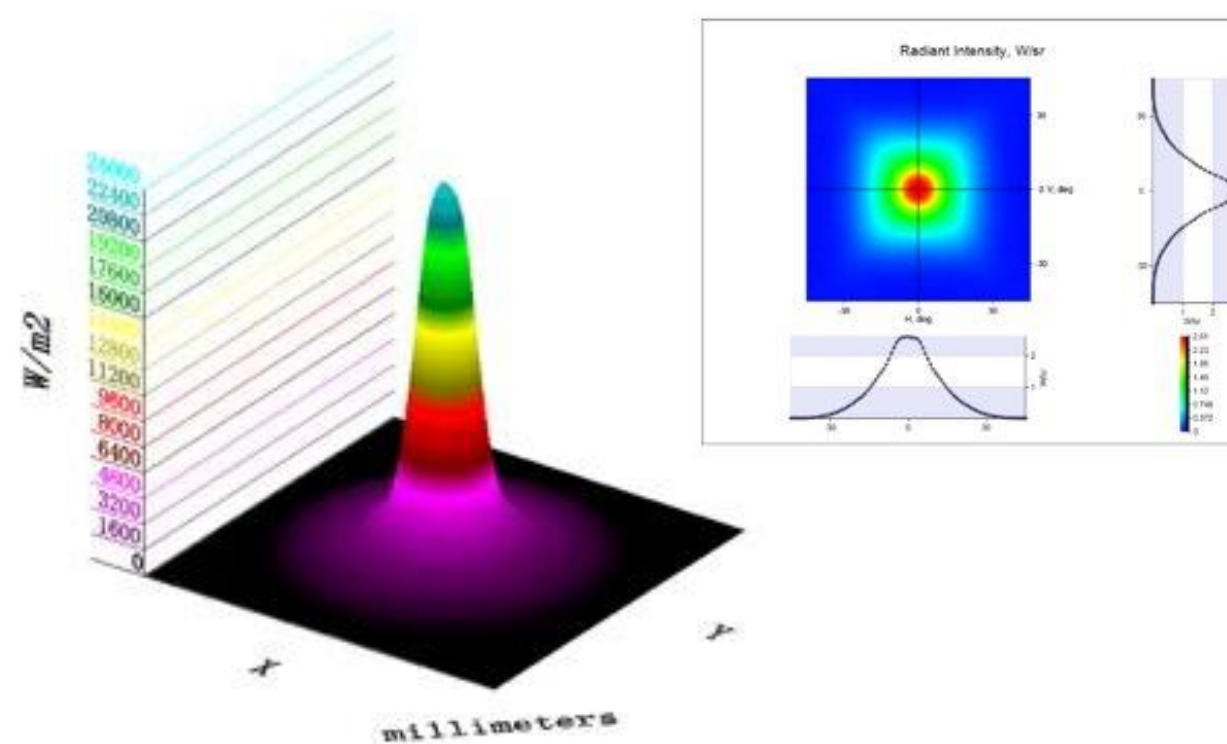
Source: Photon Wave

# Water Treatment



- Demonstration: Single UVC LED Point-of-Discharge / Faucet Hospital Water Treatment Reactor

UVC LED



Source: Bolb Inc.

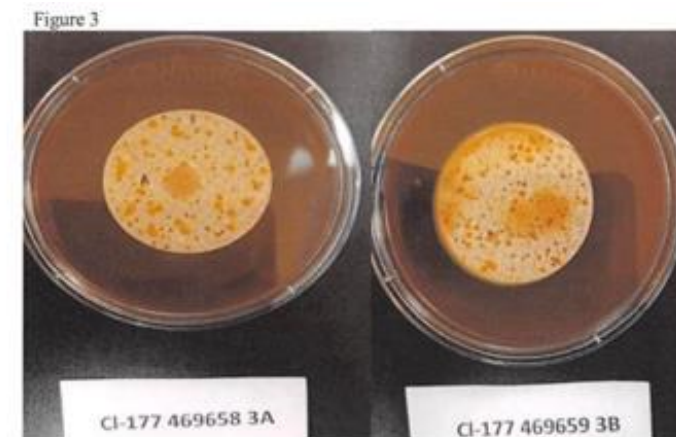


# Validation Test Results

## Bolb's Demo Water Treatment Reactor Tests

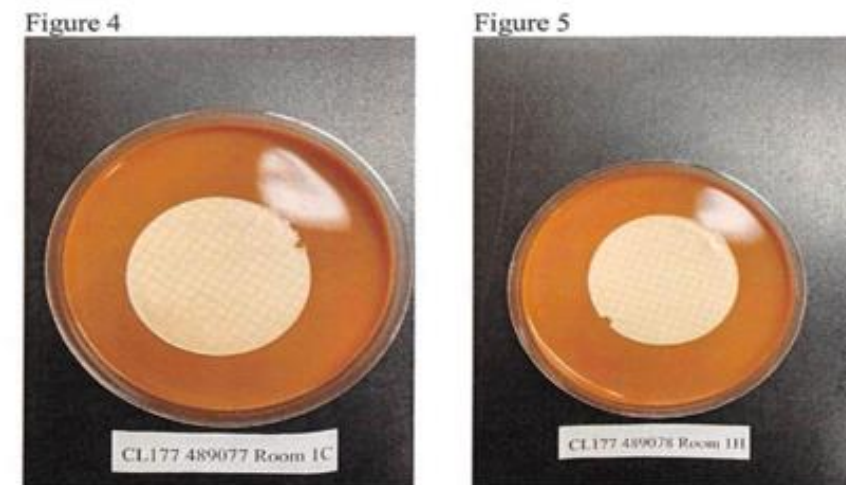
Flow	Rate	E. Coli Reduction Rate
LPM	GPM	
1.5	0.40	> 99.999%
5	1.32	99.999%
15	3.96	99.75%
20	5.28	97.52%

Before



Rev. 1 Added counts CFU/mL to sample 469654-469657

After

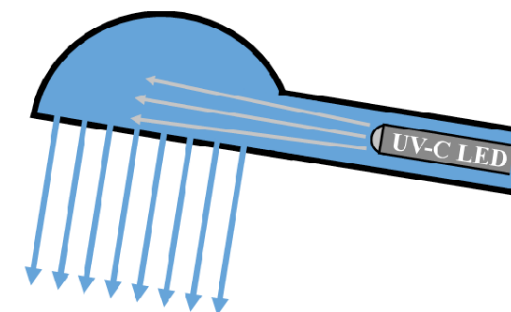


Rev 1 – Update summary and added Figures 4 and 5.

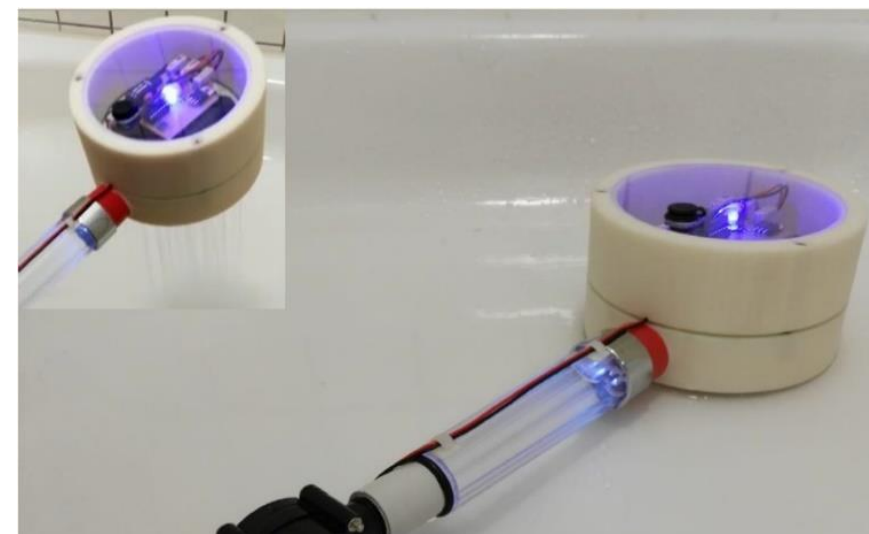
Source: Bolb Inc.

## Single 100 mW LED in a Shower Head

- 254 nm UVC hg lamp source – Legionella rubrilucens 90% reduction with 1.1 mJ/cm<sup>2</sup>
- Using single 100 mW LED dependent on angle of emission distribution
- 0.01 sec required for 90% reduction
- 0.03 sec for 99.9% reduction
- Driven by water flow turbine



Scheme of a UV-C LED within a Shower Head

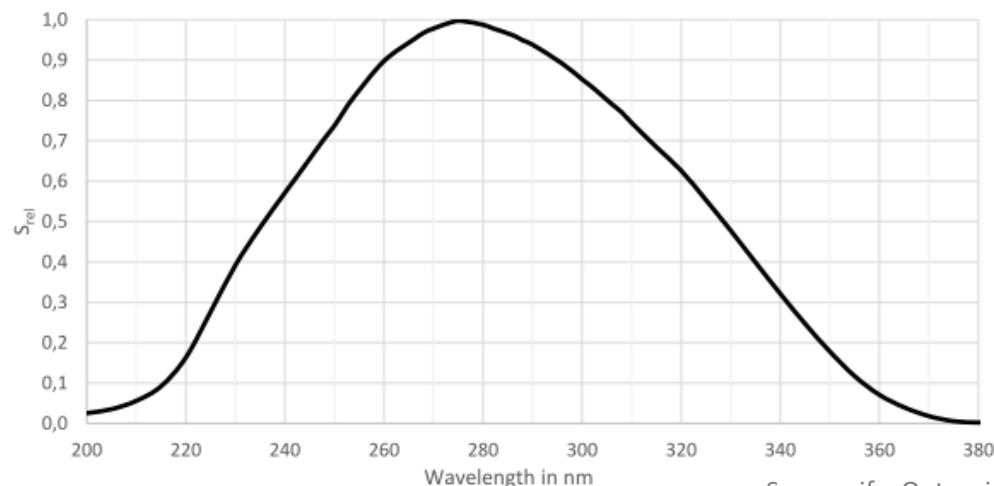


Source: Martin Hessling, Ph.D., Professor,  
Institute of Medical Engineering and Mechatronics, Ulm University of Applied Sciences

# Sensors for UVC Radiation Monitoring

- **DVGW – W294** regulates the UVC radiation monitoring in drinking water treatment
- Used in municipal water treatment systems (e.g. Jena) – hard UVC radiation with Hg lamps – DVGW compliant
- Sensor usable also for POU and POE devices

Relative Spectral Responsivity  $S_{rel}$ :



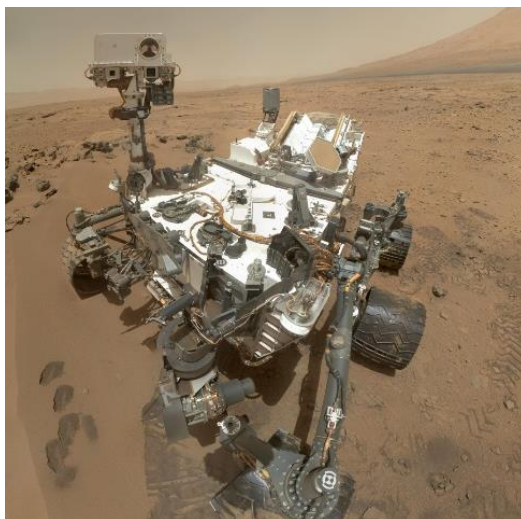
Source: ifw Optronics



# UV Sensors Application – Beyond Disinfection

- NASA Curiosity Photodiodes
- SiC Photodiodes: Extremely robust
- Expertise and high technological know-how

Curiosity Rover



19.02.2017



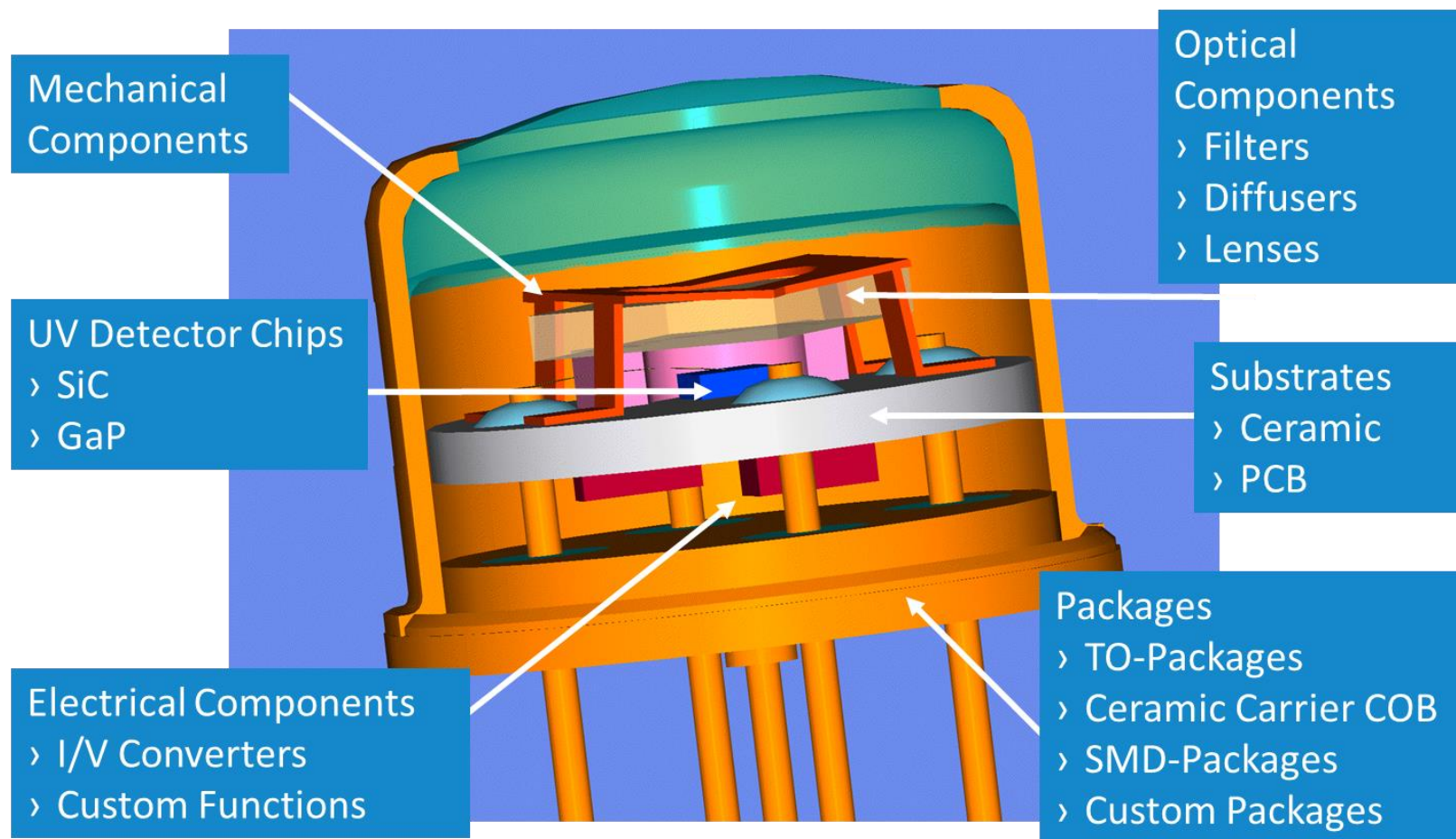
Source: Images courtesy of JPL/Caltech



# ifw optronics GmbH

## Radiation-Hard Assembly Tech.

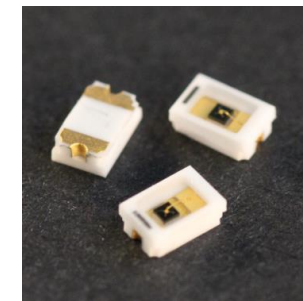
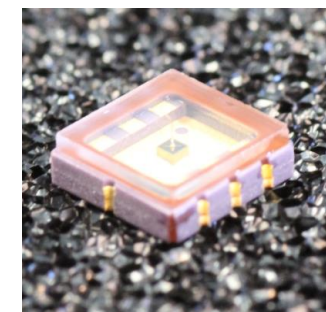
ifw optronics



Source: ifw Optronics

# Assembly Technology – Products

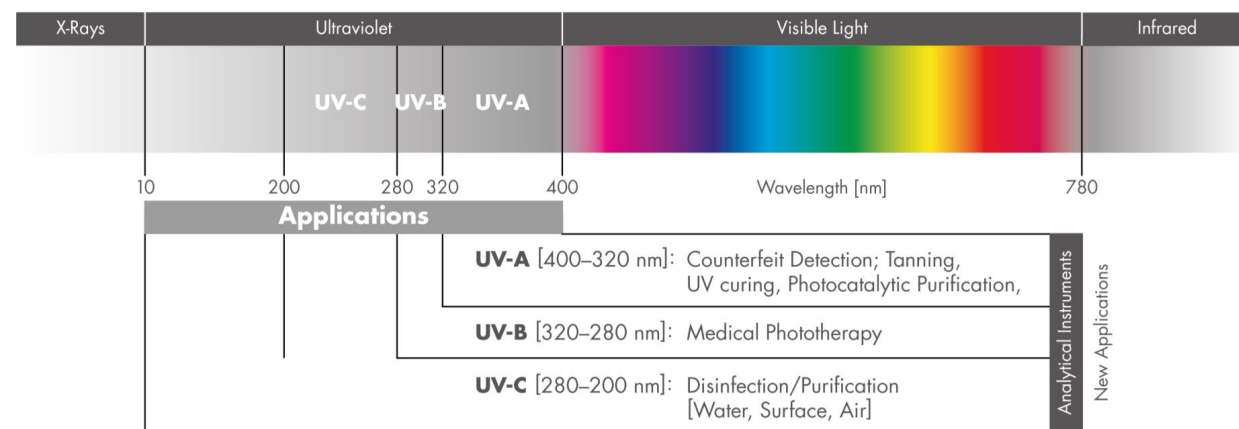
- State of the Art:
  - UV-sensors in hermetic TO-package
  - Used adhesives: conductive epoxy for chip bonding
- SMD photodiode assembly (in development)
- SiC sensors in ceramic SMD package with hermetic seal
  - Sealing
  - Window-encapsulation
  - Reflow-Solderable
  - Smaller packages possible
- SiC sensor modules
  - Tricky material combinations: stainless steel, quartz, ceramic



Source: ifw Optronics

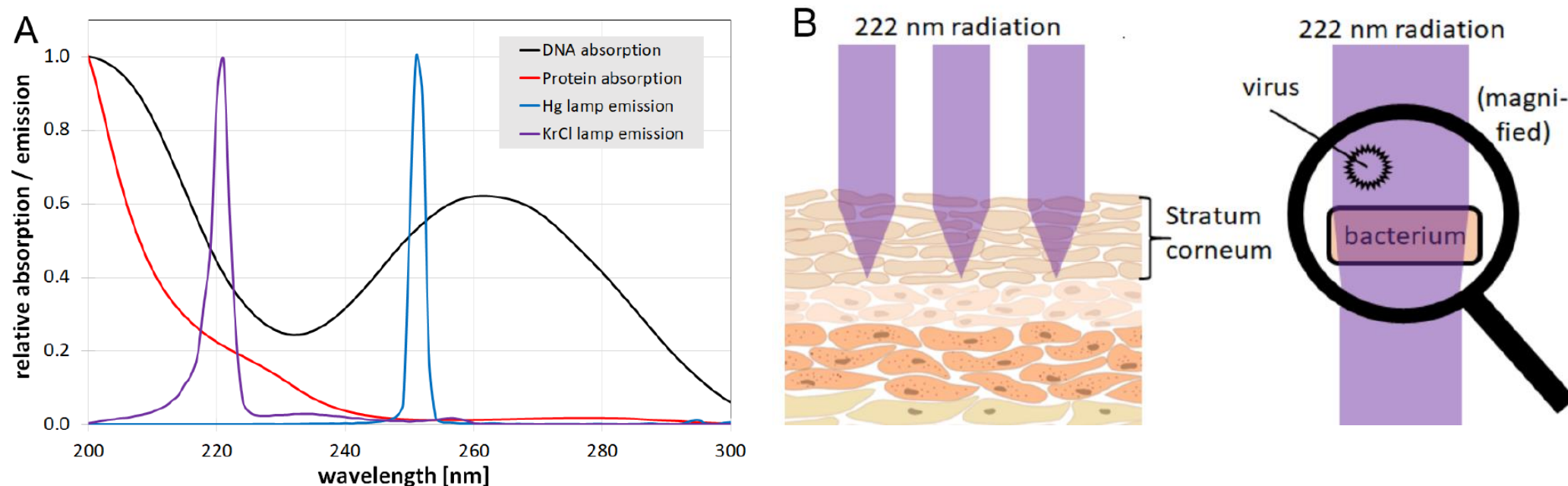
# Challenges in UVC Filter Design

- UVC light in range of 207-222nm has been found to efficiently kill bacteria and viruses without causing damage to human cells
- Penetration of UV light is harmlessly absorbed by the outer layer of dead skin
- UV light lamps emit longer wavelengths that are damaging to human skin and need to be blocked





# Mechanism of Far-UVC Disinfection

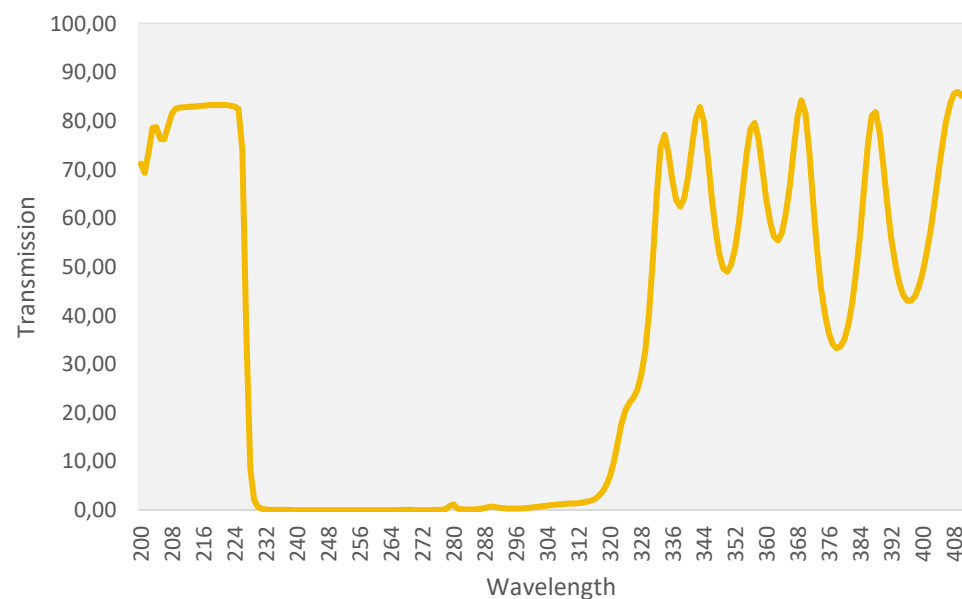


**Figure 1:** A: Absorption spectra of DNA and proteins, with emission spectra of a KrCl excimer and a low-pressure mercury lamp (Hg lamp); B: Scheme of far-UVC propagation in skin and pathogens

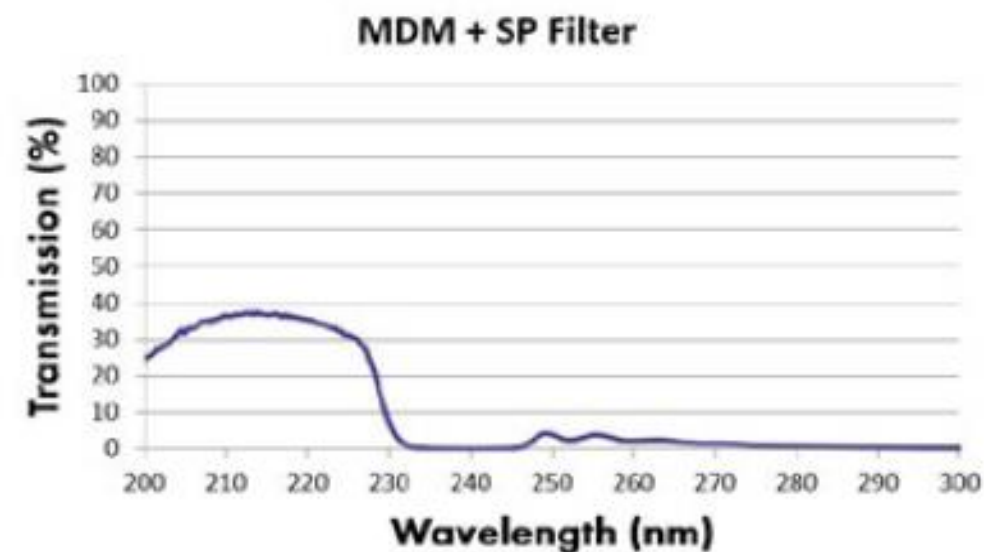
# Laser Components UV Filter Design Options

- Most coating materials do not transmit well and can be damaged due to absorption and scatter
- Special coating materials are required

UV Shortpass Design with extended blocking range



Metallic coating with Shortpass combination

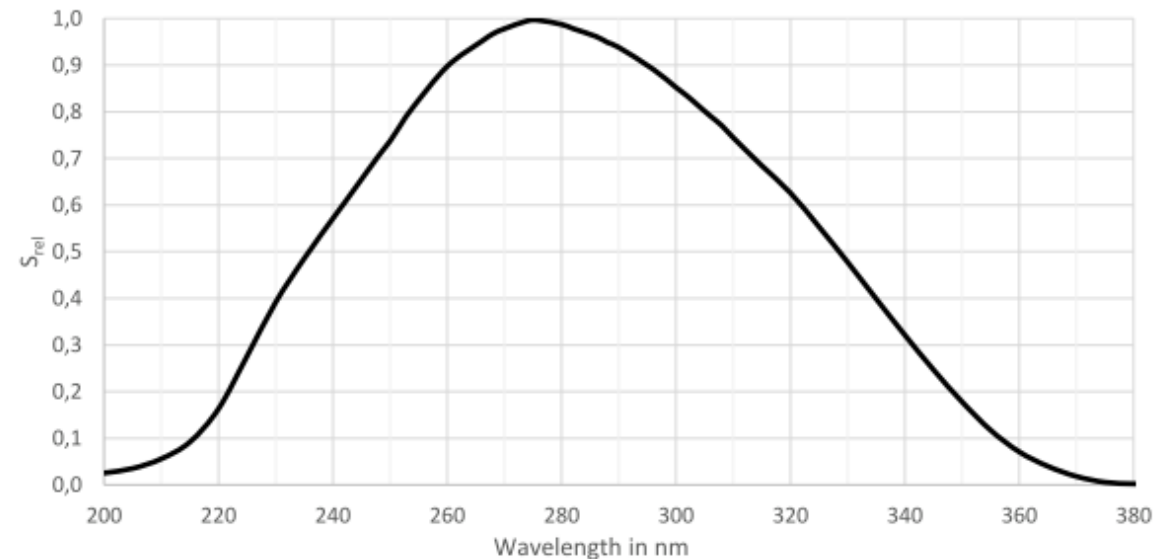


# Sensing and Monitoring in Far-UVC

- SiC detectors of ifw Optronics are suitable for Far-UVC detection
- Peak sensitivity at 272nm 0.18A/W
- At 230nm 40% -> 0.072A/W is enough for typical intensities at this region



Relative Spectral Responsivity  $S_{rel}$ :



Source: ifw Optronics

# Your Contact

"We are specialized in  
**challenging demands** and  
apparently **impossible inquiries!**"

LASER COMPONENTS GmbH

**Dr. Olga Stroh-Vasenev**

[o.stroh-vasenev@lasercomponents.com](mailto:o.stroh-vasenev@lasercomponents.com)

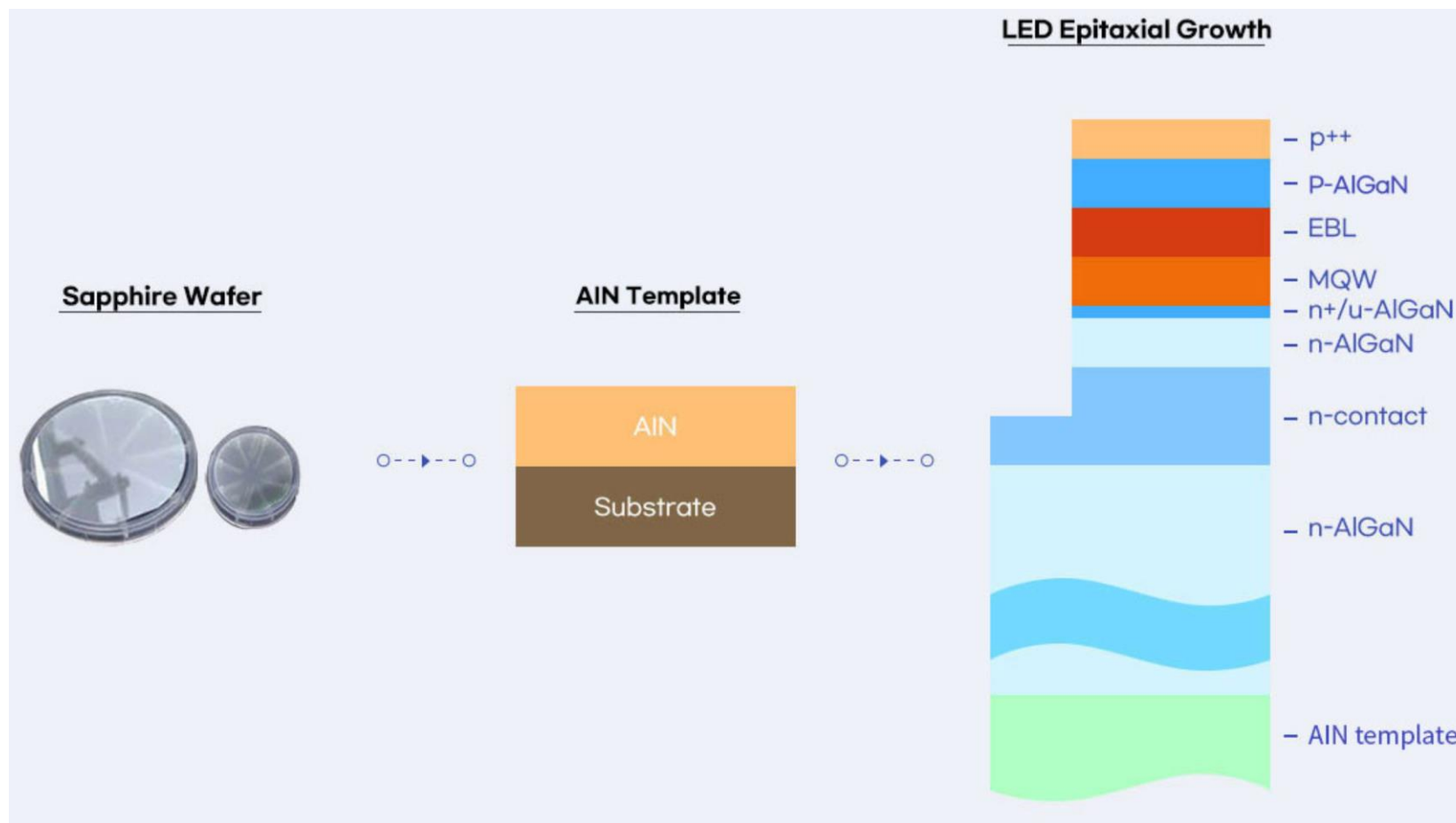
+49 (0)8142 2864-763



# Photon Wave – Technology, UVC & UVB 255-308nm

**P**WAVE

UVC & UVB



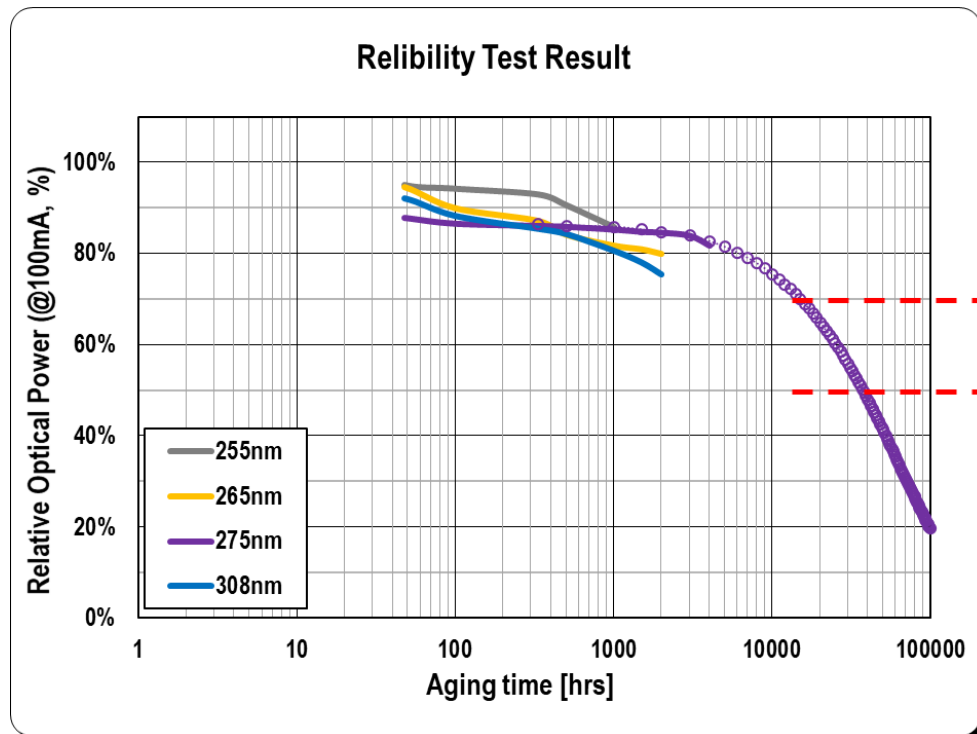
Source: Photon Wave



## 20mil Reliability



- PCD-10-V1 [IF=100mA, T<sub>j</sub>=43.3°C, T<sub>a</sub>=25°C, w/ heat sink]



Size	WP	Expected Life Time		VF	
		L70	L50	0 hrs	4000 hrs
20 mil	275 nm	14,000 hrs	38,000 hrs	5.76 V	5.95 V

-- L70

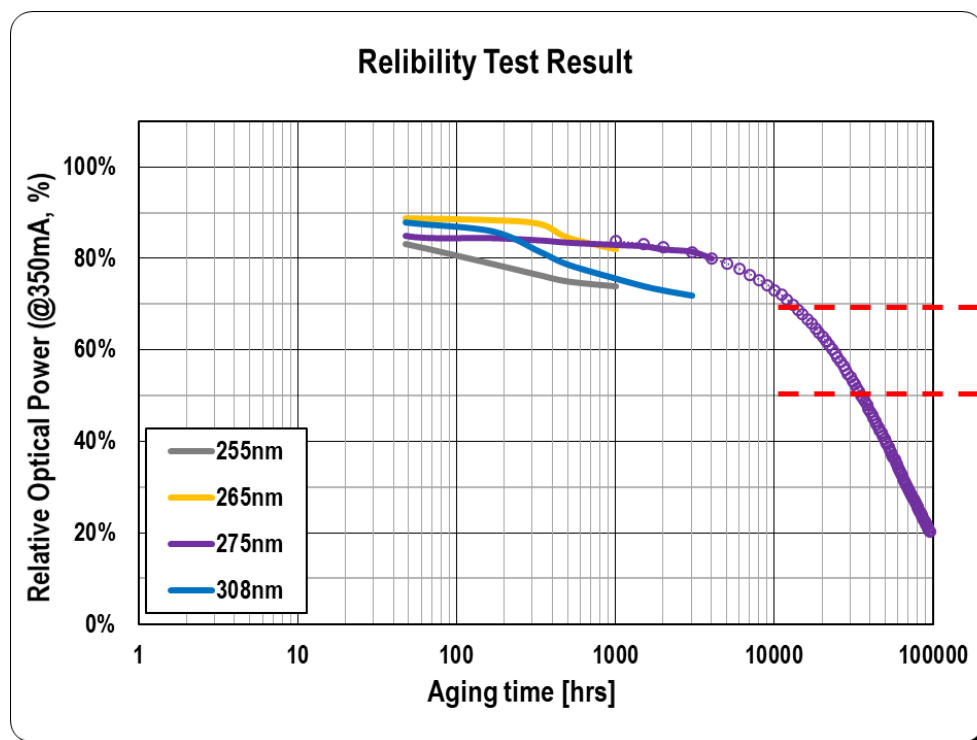
-- L50

Source: Photon Wave

## 40mil reliability



- PCD-35-V2 [IF=350mA, T<sub>j</sub>=47.9°C, T<sub>a</sub>=25°C, w/ heat sink]



Size	WP	Expected Life Time		VF	
		L70	L50	0 hrs	4000 hrs
40 mil	275 nm	13,000 hrs	36,000 hrs	5.91 V	6.14 V

L70

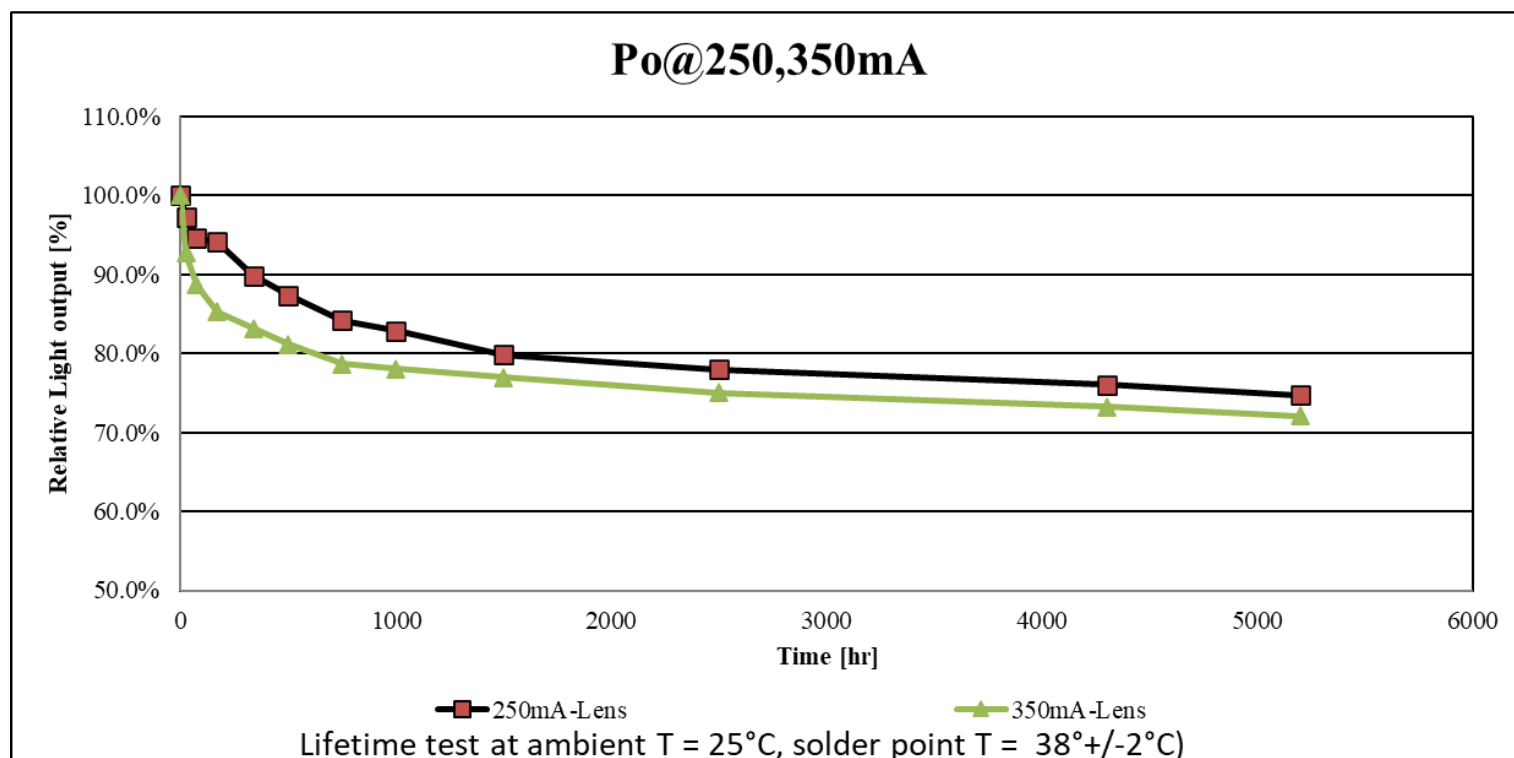
L50

Source: Photon Wave

# Real World Lifetime Measured and Documented



25°C Ambient Lifetime Test



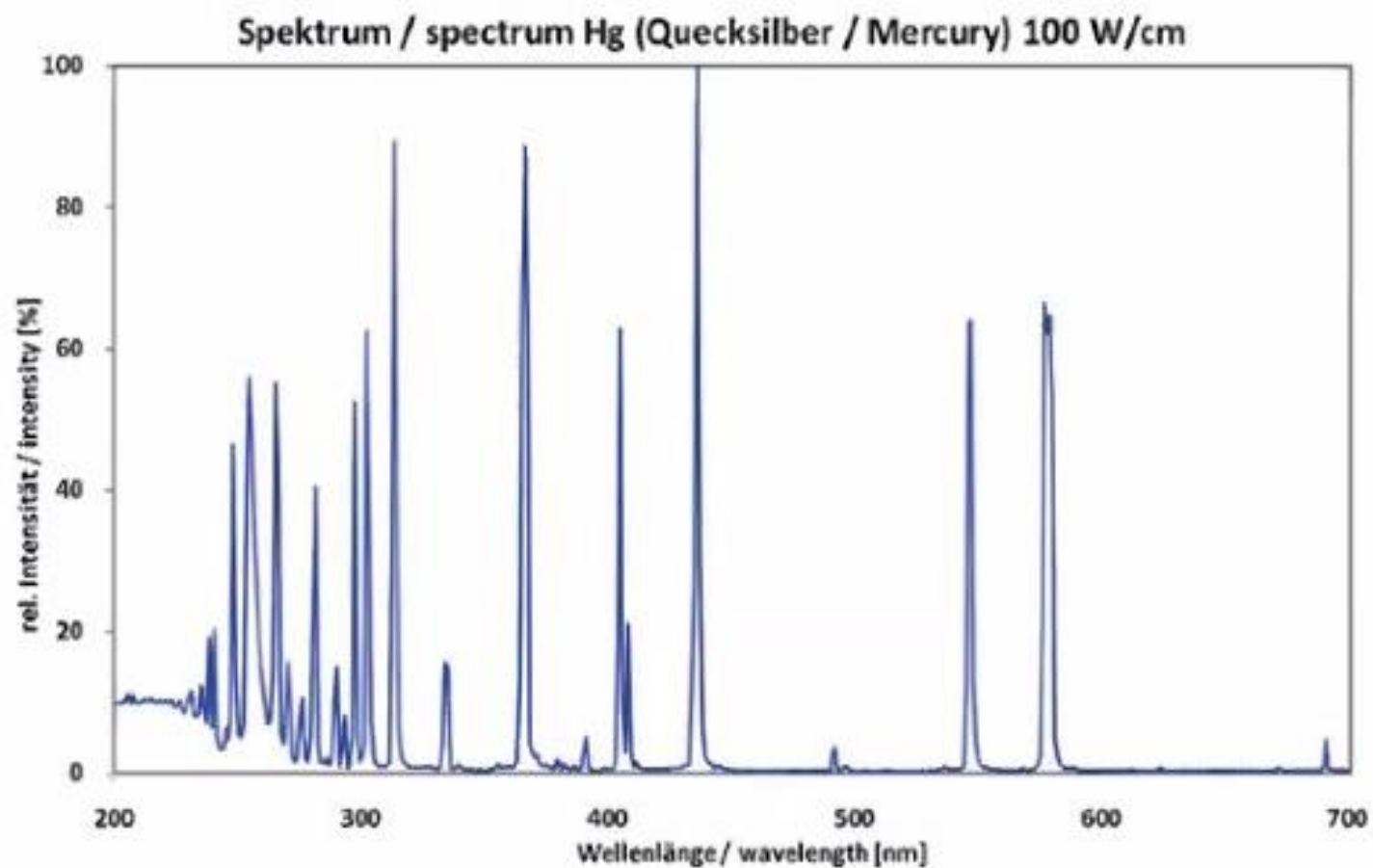
Solder point temperature = 38±2°C

Average performance 90-110mW packaged @ 250mA

Vf change ≤+0.3V after 4,000 hr

Source: Bolb Inc.

# Mercury Spectrum 100 W/cm



Source: Jingke Printing Equipment Co., Ltd