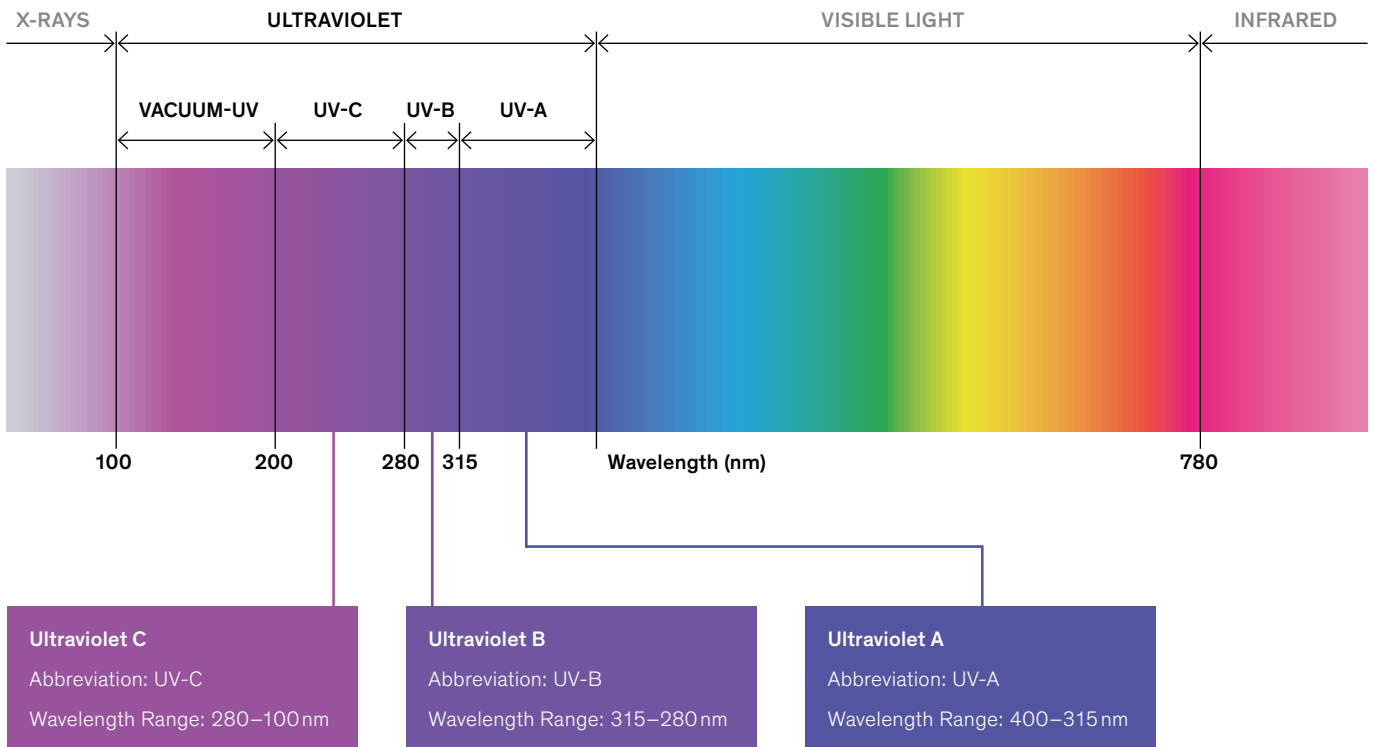


The UV market has seen tremendous growth over the past several years. This is not only the result of technological advances in the manufacturing of solid-state UV devices, but the ever-increasing demand for environmentally friendly methods of producing UV light which is currently dominated by mercury lamps.



Electromagnetic Radiation Spectrum

- > Ultraviolet light occurs between the visible and x-ray spectrums
- > The Ultraviolet wavelength range is specified as 100 to 400 nm; however, many optoelectronic companies also consider wavelengths as high as 430 nm to be in the UV range
- > Ultraviolet light gets its name due to the “violet” color it produces in the visible portion of the spectrum although much of the output of UV light is not visible to the human eye



UV light for LEDs can be broken down into 3 areas. These are classified as UV-A, UV-B and UV-C.



Upper UV-A LEDs (390–420 nm range)

Have been available since years and have been traditionally used in applications such as counterfeit detection or validation (Currency, Driver's license, Documents etc.) and Forensics (Crime scene investigations). The power output requirements for these applications are very low and these are by far the cheapest UV LEDs.

Middle UV-A LEDs: (350–390 nm)

Component area has seen the greatest growth over the past several years. The majority of are for UV curing of both commercial and industrial materials such as adhesives, coatings, and inks. LEDs offer significant advantages over traditional curing technologies such as mercury or fluorescent due to increased efficiency, lower cost of ownership and system miniaturization. The trend to utilizing LEDs for curing is increasing and the rapid advances in manufacturing as well as increasing volumes are steadily driving down prices.

Lower UVA-B and UVB (300–350 nm)

Are the most recent introduction to the marketplace. These devices offer the potential to be used in a variety of applications including UV curing, biomedical, DNA analysis and various types of sensing.

UVC ranges (approximately 250–280 nm)

Benefited from improved UV-C LED technology, more and more manufacturers showcase UV-C LED products. UV-C LED can be utilized in food preservation, air purification and water disinfection markets, holding huge market demand potential. Users can easily install UV-C LED products onto existing home appliances and take advantage of the technology.

There is significant overlap in all 3 of the UV spectral ranges; therefore, one must consider not only what is best for the application, but also what is the most cost-effective solution, since the lower in wavelength, typically the higher the LED cost.

UVA

UVA spectrum is the safest of the three various spectra of UV light, although high exposure has been linked to skin cancer in humans as well as other potential issues such as accelerating skin aging. LEDs are highly directional with very narrow viewing angles. Looking directly into a UV LED can be harmful to the eyes.

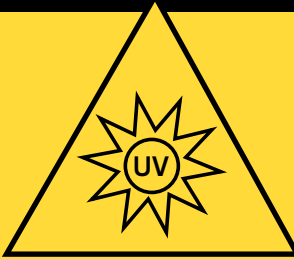
Application	Product	Wavelength
Curing	3D Printing	385–405 nm
Curing	Adhesive	365 nm
Curing	Exposure	385–405 nm
Curing	Nail Curing	405 nm
Deodorizing	Air Purifying System	365 nm
Deodorizing	Refrigerator	365 nm

UVC/UVB

These LED lamps should always be shielded and never be viewable to the naked eye even though it may appear that little or no light is emanating from the device. Exposure to these wavelengths may cause skin cancer and temporary or permanent vision loss or impairment. All UV devices should have warning labels similar to the label shown here

Application	Product	Wavelength
Sterilization	Surface Disinfection	275 nm
Sterilization	Air Purifier	275 nm
Sterilization	Water Purifier	275 nm
Sterilization	Ice Maker	275 nm
Medical	Skin Care	310–340 nm
Horticulture	Plant Growth	285–325 nm

CAUTION!



1. LEDs emit very strong UV radiation during operation.
2. Don't look directly into the LED light when in operation as UV radiation can harm your eyes.
3. To prevent even inadequate exposure, wear protective eyewear.
4. If LEDs are embedded in devices, please indicate warning labels against the UV LED used.
5. Avoid prolonged exposure to skin or other tissue during operation.
6. Keep out of reach of children.
7. Take appropriate precautions around pets and other living organisms to avoid UV exposure.
8. Specifications and dimension are subject to change without notice.



Industrial stainless steel container with UV radiation markings.

Focus Application: Disinfection (UV-C)

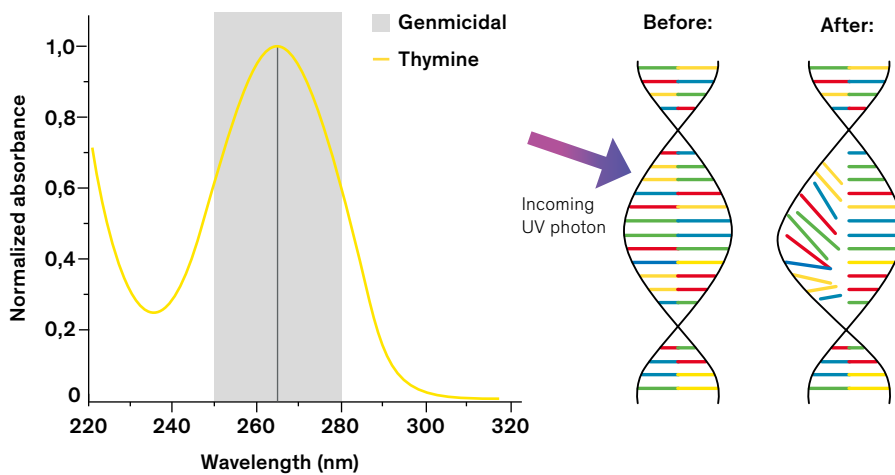
UVC – DNA Absorbance Wavelength

- > 275 nm UVC LED has the same sterilization effect as 254 nm by tube
- > When exposing microorganisms to UVC light (254–280 nm), the light penetrates through their cell walls and disrupts the structure of their DNA molecules, prohibiting reproduction
- > Because UV disinfection does not rely on chemicals or filtration materials, it can be used effectively and safely
- > UV-C sterilization has several advantages like rapidity, thoroughness, non-pollution, easy operation and low use and maintenance costs, which is the most advanced, effective, and economical disinfection



Industrial installation for UV water purification

UVC Absorbance of DNA



Sterilization Principles

	UV-C	Chlorine	Ozone
Disinfection Methods	Physical	Chemical	Chemical
Capital Investment	Low	Low	High
Operation Costs	Low	Medium	High
Maintenance Charges	Low	Medium	High
Disinfection Effects	Very Good	Good	Unstable
Harmfulness to Humans	Very Low	Medium	High
Residual Toxic Substances	No	Yes	Yes
Change to Water and Air	No	Yes	Yes

Benefits of UV-C vs. Chemical Disinfection

- > Use of UV over chemical disinfection is recognized in several legislative directives across the world, including the European Drinking Water Directive
- > Benefits of UV-C over chlorine disinfection include:
 - > No disinfection by-products or toxins
 - > No volatile organic compound (VOC) or toxic air emissions
 - > Does not require storage of hazardous material
 - > Requires minimal space for equipment and contact chamber
 - > Does not affect the smell or taste or the minerals in the water
 - > Deactivation of chlorine-resistant microorganisms such as Cryptosporidium and Giardia
 - > No corrosion effects



Industrial stainless steel container with UV radiation markings.

World Health Organization Approved Irradiation Energy

World Health Organization (WHO) Required UV Dosage*

- > Bacteria: Sterilizing effect reaching 99%: 7 mJ/cm²
- > Virus: Sterilizing effect reaching 99%: 59 mJ/cm²
- > Disinfection performance is a function of the UV dose
- > Microorganisms do not respond to UV light in the same way

*Dosage = Energy = Irradiance (mW/cm²) * Time (sec) = mJ/cm²

UV dosage

- > When exposing micro-organisms will die or lose its viability under adequate dose of UV in a certain time
- > In line with the standards on disinfection and sterilization technology, each kind of microorganism has its own specific dosage of UV-C, the dosage is equal to the product of irradiation intensity and exposure time

Lethal Dose of UV-C on Various Bacteria and Viruses Microorganism

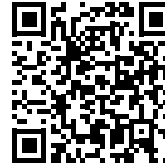
Scientific Name	Type of Microorganism	Disease	Lethal Dose of UV (μWSec/cm ²)
Bacillus subtilis	Bacterium	–	22,000
Bacteriophage	Virus	–	6,600
Coxsackie virus	Virus	Intestinal Infection	6,300
Shigella spores	Bacterium	Bacillary Dysentery	4,200
Escherichia coli	Bacterium	Food Poisoning	6,600
Fecal coliform	Bacterium	Intestinal Infection	6,600
Hepatitis A virus	Virus	Hepatitis	8,000
Influenza virus	Virus	Influenza	6,600
Legionella pneumophila	Bacterium	Legionellosis	12,300
Salmonella typhi	Bacterium	Typhoid Fever	7,000
Staphylococcus aureus	Bacterium	Food Poisoning, Toxic Shock Syndrome, etc.	6,600
Streptococcus spores	Bacterium	Throat Infection	3,800

Disinfection, Studies and Research papers

Airborne SARS-CoV-2 Is Rapidly Inactivated by Simulated Sunlight

“This study examined effect of simulated sunlight, relative humidity, and suspension matrix on stability of SARS-CoV-2 in aerosols.”

Published By: Oxford University Press



The potential virucidal effects of UV-C irradiation on SARS-CoV-2

“UV-C irradiation is highly effective in inactivating and inhibiting SARS-CoV-2 replication.”

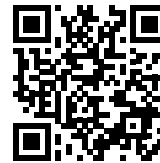
Published By: Medrxiv.org



Inactivation of Viruses on Surfaces by Ultraviolet Germicidal Irradiation

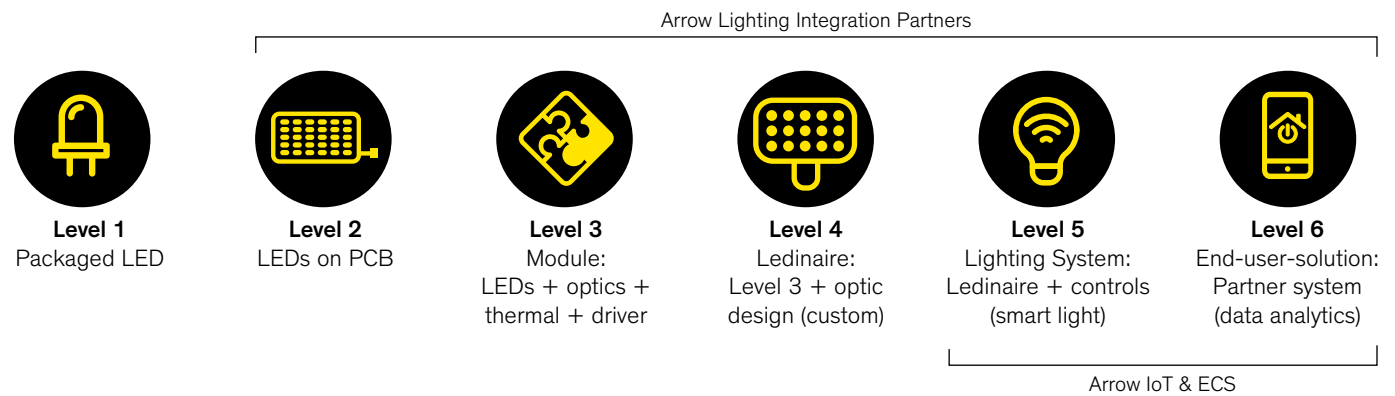
“Ultraviolet germicidal irradiation (UV-C) is considered a promising method to inactivate viruses.”

Published By: National Science Council, China

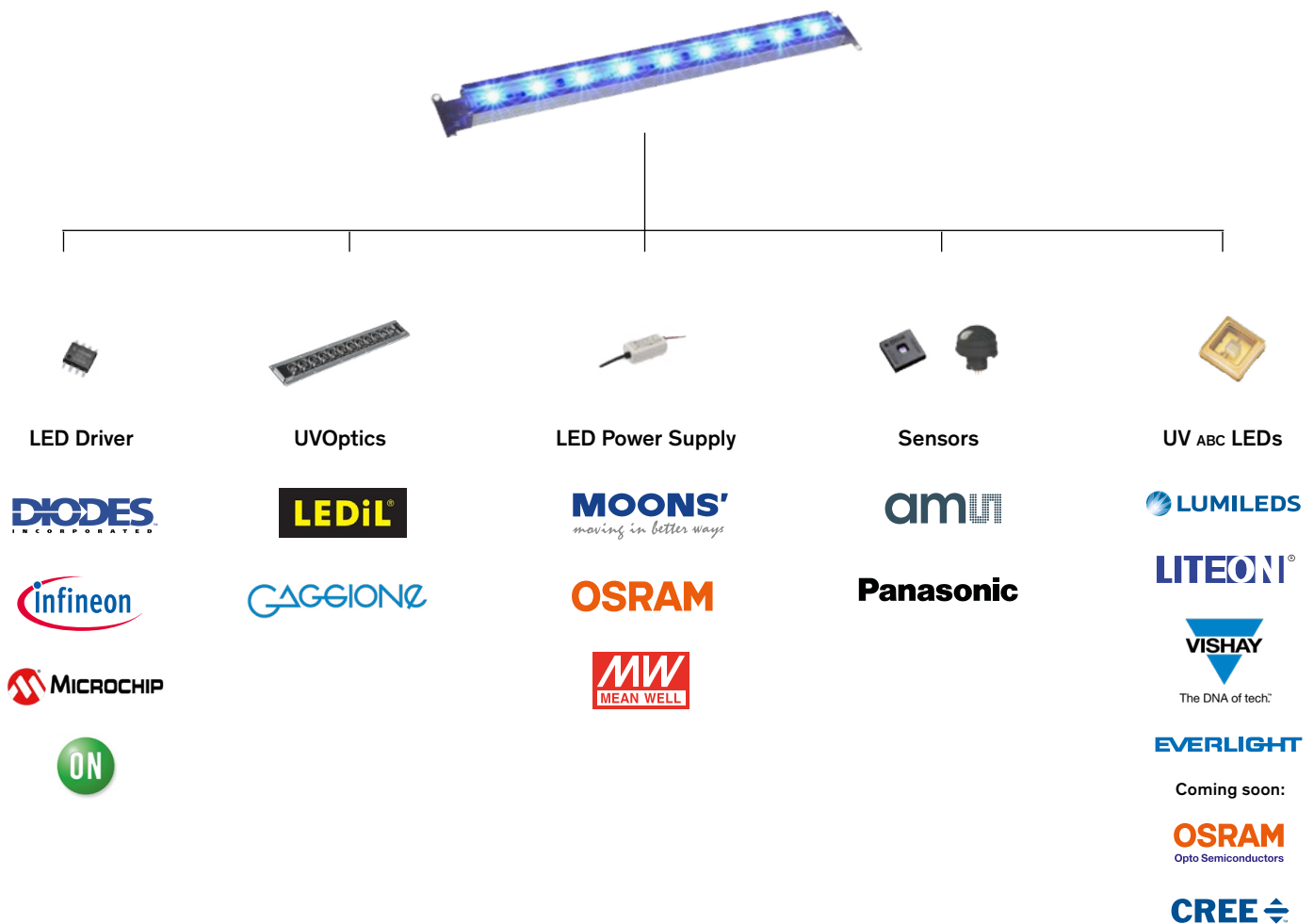


Arrow Integrated Lighting Projects

Each application has an unique requirement. Having the right products on the shelves is nearly impossible or time consuming and very expensive. Since 2018 Arrow offers customers the possibility to order customized solutions developed and/or manufactured through a network of integration partners.

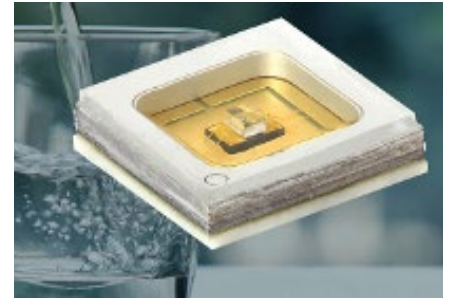


Arrow Lighting Kit v.2



UV LED vs Traditional CCFL Light Sources

- > Conventional systems using mercury lamps operate at 254 nm (UVC) with ~35% eff
- > UV LEDs do not contain toxic mercury often found in CCFLs lamps. They are much smaller and more durable than CCFLs and are more resistant to vibration and impact, resulting in less product breakage and reduced waste and maintenance expense as well. 254 nm is not the peak absorption wavelength of bacteria and viruses, but is a convenient line of mercury
- > It was expected that the peak of 260 to 265 nm would be the most effective wavelength range for disinfection
- > However, due to the absorption of water, a wavelength range of 275 to 280 nm proved to be the most effective for microbial disinfection in tap water and deionized water

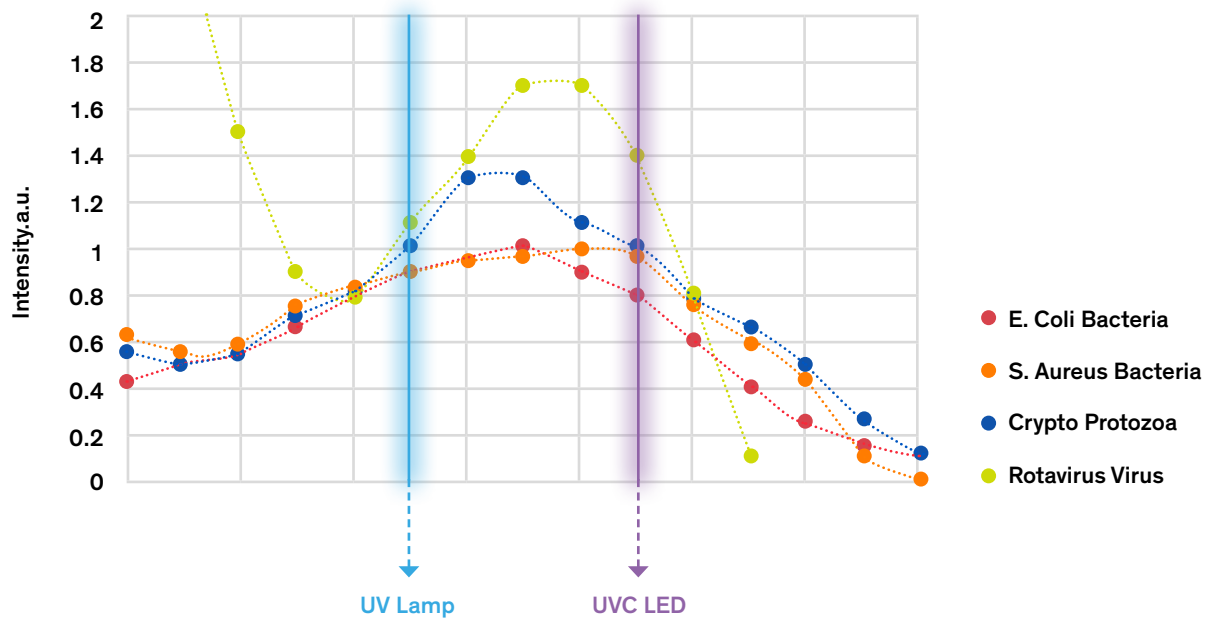


Item	UV LED	UV Lamp
Technology	New, Light, Simple, Compact	Old, Bulk, Heavy, Complex
Lifetime	10,000~50,000 hours	2,000~10,000 hours
Energy consumption	Low	High
Warm-up time	Zero	Slow
Environmental Friendliness	No mercury, no Ozone	Mercury used, Ozone generation
Heat Generation	Low	High
Emission Wavelength	Single UV Band, Customizable	Multiple Peaks
Heavy Metals	None	Mercury (20~200 mg)





	DUV-LED	Mercury Lamp
Wavelengths	Monochromatic and selectable (Application-and energy-optimized selections possible)	Broad (MP) or monochromatic (LP) (In some cases inefficient filter solutions necessary)
Forward Voltage	5~7V (DV driving, low voltage, simple, safe)	100~Several 10,000V (AC driving, high voltage, complex, risky)
Size	mm, order (Small, light, robust, easy design)	Dozens mm to meter order (Bulky, radial, fragile)
Radiant Heat	None (Heat can be removed by thermal management, no heat radiation to the object)	High (Uncontrolled IR and heat emission to surface resp. to the object)
Warm-up Time	None (Instant ON/OFF)	Up to several minuted (Requires mechanical shutters)
Lifetime	Over 10,000 hours	3,000~5,000 hours
Environmental Burden	Safe (Mercury free, sustainable, RoHS and REACH compliant)	Critical (contains mercury, fragile)

- > The UVC LED 275nm disinfection efficiency is similar to 253nm tube as shown in below diagram
- > UVC LEDs with 275nm and equivalent radiant power as the tube can be used for disinfection

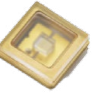
Spectral Sensitivity referenced to 254 nm radiation



























UV-C Product Families

Manufacturer	Package	Family	Class	Dimension (mm)	Angle (°)	Wavelength Typ (nm)	Ref Voltage Typ (V)	Radiant Power Typ (mW)	Foward Current (mA)	I max (mA)
LITEON		LTPL-G35UVC275GS	UVC	3.45×3.45×1.78	120	275	5,7	2,7	20	50
LITEON		LTPL-G35UV275GC-E	UVC	3.45×3.45×1.78	120	277	6,5	10	100	150
LITEON		LTPL-G35UV275GR-E	UVC	3.45×3.45×1.78	120	277	6,7	21	180	200
LITEON		LTPL-G35UVC275GM	UVC	3.45×3.45×1.78	120	275	6,2	34	250	300
LITEON		LTPL-G35UVC275GZ	UVC	3.45×3.45×1.78	120	275	6,2	47	350	500
LITEON		LTPL-G35UVC275GH	UVC	3.45×3.45×1.78	120	275	6,7	72	600	700
VISHAY		VLMU35CL20-275-120	UVC	3.45 × 3.45 × 1.8	120	275	6,8	2,5	20	30
VISHAY		VLMU35CB20-275-120	UVC	3.45 × 3.45 × 1.8	120	275	6,3	10	100	150
VISHAY		VLMU35CT20-275-120	UVC	3.45 × 3.45 × 1.8	120	275	6	19	150	200
EVERLIGHT		ELUC3535NUB-P7085Q05075020-S21Q	UVC	3.5×3.5×1.3	120	275	5,75	2	20	40
EVERLIGHT		ELUC3535NUB-P7085Q15070100-S22Q	UVC	3.5×3.5×1.1	120	275	6	10	100	150

UV-B Product Families

Manufacturer	Package	Family	Class	Dimension (mm)	Angle (°)	Wavelength Typ (nm)	Ref Voltage Typ (V)	Radiant Power Typ (mW)	Foward Current (mA)	I max (mA)
LITEON		LTPL-G35UVB308GM	UVB	3.45×3.45×1.78	120	308	5,7	24	200	250
LITEON		LTPL-G35UVB308GH	UVB	3.45×3.45×1.78	120	308	5,5	45	350	600

UV-A Product Families

Manufacturer	Package	Family	Class	Dimension (mm)	Angle (°)	Wavelength Typ (nm)	Ref Voltage Typ (V)	Radiant Power Typ (mW)	Foward Current (mA)	I max (mA)
VISHAY		VLMU3500...60	UVA	3.5×3.5×2.9	60	385, 395, 405	3,4	780	500	700
VISHAY		VLMU3500...120	UVA	3.5×3.5×2.9	120	385, 395, 405	3,4	780	500	700
VISHAY		VLMU3500...130	UVA	3.5×3.5×2.9	130	385, 395, 405	3,4	780	500	700
VISHAY		VLMU3511...130	UVA	3.5×3.5×2.1	130	365	3,6	1000	600	700
VISHAY		VLMU3520...120	UVA	3.5×3.5×2.9	120	385, 395, 405	3,4	1000	500	1200
VISHAY		VLMU3520...60	UVA	3.5×3.5×2.9	60	385, 395, 405	3,4	1000	500	1200
VISHAY		VLMU1610...135	UVA	1.6×1.6×1.4	135	365	3,4	23	20	60
LITEON		LTPL-C034UVExxx	UVA	3.45×3.45×2.13	130	365, 385, 395, 405, 430	3,7	630	350	500
LITEON		LTPL-C034UVGxxx	UVA	3.45×3.45×2.13	130	365, 385, 395, 405, 430	3,6	1380	700	1000
LITEON		LTPL-C16FUVMxxx	UVA	1.6×1.6×1.38	135	365, 375, 385, 395, 405	3,5	19	20	40
LUMILEDS		LUXEON UV FC1	UVA	1.0×1.0	140	385, 395, 405, 415	3,1	750	500	1000
LUMILEDS		LUXEON UV FC2	UVA	2.0×2.0	140	385, 395, 405, 415	3,1	1200	1000	2000
LUMILEDS		LUXEON UV U1	UVA	1.7×1.3	140	385, 395, 405, 415	3,1	650	500	1000
LUMILEDS		LUXEON UV U2	UVA	2.12×1.72	138	385, 395, 405, 415	3,1	1300	1000	2000
KINGBRIGHT		KTDS3534UVxxxB	UVA	3.45×3.45	120	365, 395, 405	3,4	800	500	700
KINGBRIGHT		KTS2012UVxxx	UVA	2.0×1.2	150	365, 385	3,3	16	20	30
EVERLIGHT		ELUA20160GB-x..x-VA1M	UVA	2.0×1.6	120	365, 385, 395, 405	3,5	25	20	20
EVERLIGHT		ELUA20160GB-x..x-V21M	UVA	2.0×1.6	120	365, 385, 395, 405	3,5	70	60	100
EVERLIGHT		ELUA20160GB-x..x-VD1M	UVA	2.0×1.6	120	365, 385, 395, 405	3,5	600	500	700
EVERLIGHT		ELUA3020LUB-x..x-VA1D	UVA	3.0×2.0	120	365, 385, 395, 405	3,5	30	20	30
EVERLIGHT		ELUA2835TG0-x..x-VA1D(CM)	UVA	2.8×3.5	120	365, 395	3,5	250	150	
EVERLIGHT		ELUA35350GB-x..x-V31M	UVA	3.5×3.5	120	365	3,5	400	250	350
EVERLIGHT		ELUA35350GB-x..x-VD1M	UVA	3.5×3.5	120	365, 385, 395, 405	3,5	1200	500	700
EVERLIGHT		ELUA35350G5-x..x-VD1M	UVA	3.5×3.5	50	365, 385, 395, 405	3,5	1200	500	700

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