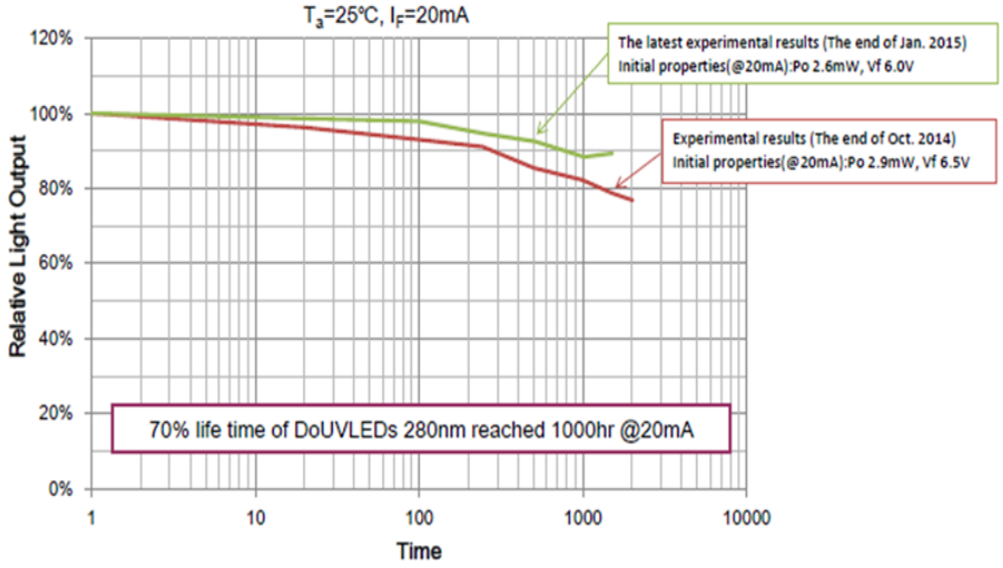
Higher Power, Longer Lifetime UV-C LED Breakthrough Technology Enables New Design Criteria

***February 2015,* Marubeni-OPTO™ *Santa Clara, CA*:** Beyond the UV-A region lie deeper Ultraviolet wavelengths that hold a high level of promise for the overall growth of UV LEDs. Traditional AlInGaN LEDs have reached down into the UV-A band for some time. This zone, centered around 395nm λP, required no significant changes to basic production techniques or technologies and is primarily responsible for the growth of the UV LED sector to date. Driven primarily by UV Curing applications, as well as by UV Sensing, Tanning, Medical, Lithography, Blacklight, Currency Validation and Photo-catalysis applications, UV-A LEDs have had significant market success. Now, this year UV LEDs will genuinely enter into a new emerging second growth phase as true UV-B and UV-C LEDs enter the market in greater magnitude: "The UV LED business is therefore expected to grow from ~$90M in 2014 to ~$520M in 2019," says Yole Développement the France-based UV market research firm. UV-B (280-315nm λP) and UV-C (200-280nm λP) are now no longer a novelty, due to higher levels of intensities and correspondingly longer lifetimes which enable new product designs and applications.

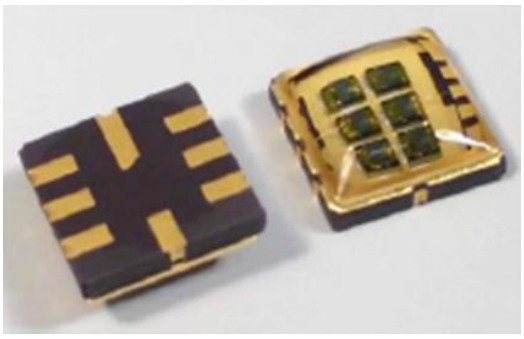
Dowa, a multibillion dollar Japanese headquartered company established in 1884 with over 4,500 employees worldwide, has now developed UV-B and UV-C LEDs with longer lifetimes and higher power densities than previously known. Dowa offers these LEDs in the 265, 280, 310, 325 and 340nm λP wavelengths in a variety of packages including SMDs, Metal-Case Headers and bare Flip-Chip Die Mounted on individual sub-mounts. These devices round-out the UV region for LEDs adding additional Medical Phototherapy and Diagnostics applications; DNA and Protein Analysis Equipment, Pharmaceutical and Chemical Analysis uses, Machine Vision, Sensing, Inspection and the Disinfection of water, air and surfaces, to the market.

Dowa, with patented new technology, has been able to create this new quaternary compound semiconductor emission region with long lifetimes as well as high optical output. For example, L70 lifetimes are now realized at 280nm λP wavelengths for devices having 10,000 hours of operation. This breakthrough enables corresponding application designs. Dowa utilizes advanced metal-organic chemical vapor deposition (MOCVD) reactors to grow AlInGaN Multiple Quantum Well (MQW) epitaxial wafers, fabricate them into die formats including flip-chip, and packages these devices selling them in discrete components or as multiple-up modules to user specifications. This new technology is based on low-cost silicon substrates which are used in this focused epitaxial wafer process. With this advance in technology, users should compare with other manufacturers data or with traditional technologies, as Dowa products have a significant edge in terms of lifetime and intensities.



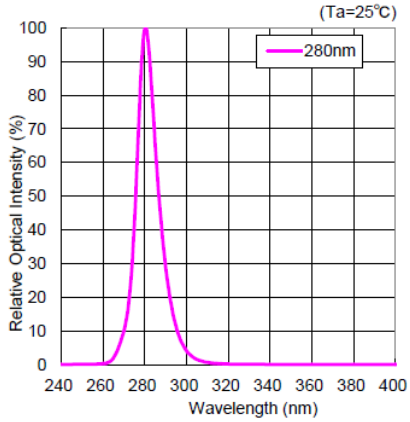
For example, take the feld of High-performance liquid chromatography (HPLC) used in analytic chemistry, the traditional source technlogy is the deuterium lamp, with a lifetime rated at approximately 1000 hours (L50) for most types. This timespan decreases dramitically due to "working around" the lamps inherent use difficulties. For example, the practice of leaving the lamp on continuously will tend to decrease its useful life by about 3-fold, based on an eight-hour workday. Additionally, it should be noted that turning the lamp on and off during the day for breaks, etc., is difficult and will also shorten lamp lifetime and will be less productive as the lamp needs to warm up for 30 minutes to stabilize. Users of this

type of lamp also note that any physical shock to the instrument or detector module, such as occurs while loading and unloading, when the lamp is hot, can damage or break the lamp filament as at approximately 2700°K operation, the tungsten filament is almost liquid when the lamp is on. It is also noted to always allow the lamp to cool down before turning it back on. Powering on a hot lamp may negatively impact the structural integrity of the filament and also lessen lifetime. And deterium lamps can cost from $300 to $1000 each to replace.

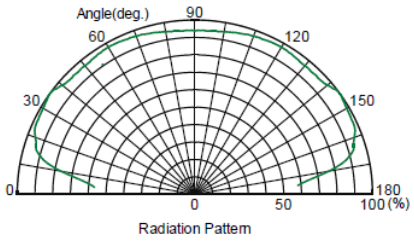


Correspondingly, not only do UV LEDs now provide longer lifetimes than traditional sources, they also benefit the user with all of the traditional properties of LEDs in general. For example they are much more volumetricaly efficienct in terms of size and weight. They are rugged and immune to the physical shocks that can destroy traditional lamps and they have instant on/off speeds with no warm-up or cool-down cycles that rob work time, which lend themselves to full digital control. Their highly narrow band and consistent emission characteristics of UV LEDs is also of significant benefit. Traditional deterium lamps produce emissions extending from 112 to 900nm, although its continuous spectrum is only from 180 to 370nm, only specific wavelengths are useful for HPLC analysis of a compound. The balance of light is filtered out in the chain-of-optics to avoid interference in the detection process. Now, designers can eliminate and simplfy their optical designs by eliminating elements such as filters or gratings as well with narrow-band UV LEDs, such as the Dowa DF8VG SMD.

Spectrum



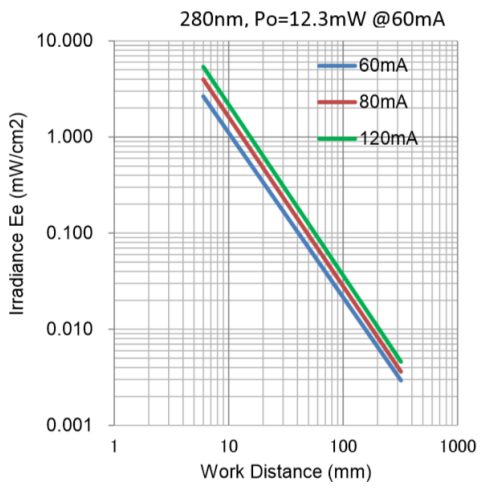
Radiation Pattern



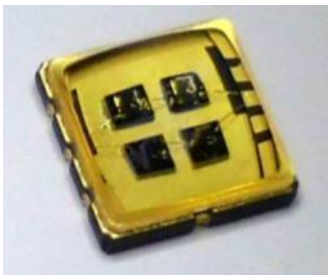
With Dowa's 280nm λP wavelength UV-C LED, the DF8VG, not only do you obtain higher emission characteristics, but also its narrow-band emission irradience and broad 180 half angle radiation pattern, are ideal for HPLCs. This high-temp co-fired ceramic surface mount device (SMD) measures only 4.7mm square with a height of 2.1mm, yet emits at a typical drive current of 60mA 15mW with a maximum drive of 120mA. This 6-die package, can also be driven at 80mA, 100 and 120mA for higher irradience. You can choose, via digital controls, the performance level you need and outperform deuterium lamps at this wavelength. The Dowa DF8VG emission output is also highly stable in its distribution pattern. In HPLC flucuations in source output, even over short periods of time, can impair measurements and leave lower concentrations of compounds undetected. Although high-end deuterium lamps are touted as highly stable, and at a higher cost premium, the Dowa DF8VG by comparrison rivals or exceeds such devices.

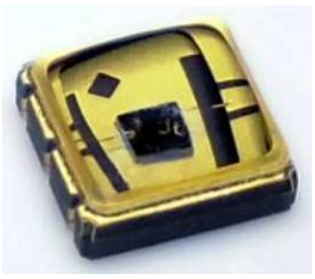
With Dowa UV LEDs there is "no heat in the beam" or thermal energy which in the beam. Traditional deuterium lamps radiate significant heat, can damage or modify heat-sensitive media such as biological or chemical samples, required for analysis in medical, genomic and pharmaceutical lab work. For equipment designers, such as for HPLCs, heat radiated from the irradiation source can be significant and affect the entire instruments design. Excessive heat equates to larger size designs, higher levels of cooling and thermal management, heat can also damage elements within the optical chain and require infrared filtering media. With Diwa UV LEDs, such as the DF8VG, work surface proximities versus drive current can be spaced accordingly in fixed

Irradiance vs Work Distance



wavelength detection systems, and the overall systems design simplified and made more efficient.





Dowa offers a 4-die version as well as a single 1-die version in the same package as the 6-die DF8VG. Dowa also offers Kovar-metal case Headers (TO5, TO18, TO46S foremats) and other SMDs (3020, 3838 formats) in a variety of wavelengths and lens types. Mounted flip-chip bare die are also available along with modular assemblies.

UV-C LEDs offer many benefits. From their performance whole new designs, including portable mobile equipment offerings are now possible, where before only bench-top models were possible. The spectral qualities combined with low power operation as well as other benefits such as their small size enable many elements of previous designs not required. Diffraction gratings, shielding, large power supplies,etc can now be dispensed with. This all adds up to major design freedoms combined with lower equipment costs. In addition, the life-cycle-maintenance-ownership costs in terms of relamping 4 or 5 times a year, lower electricity consumption, elimination of high voltage dangers, more accurate and higher prdouctivity, elimination of recycling costs of spent lamps, all add up to lower operational costs. UV LED benefits are significant and can enable major advances in equipment designs, operation, and refinement of data with higher accuracy. Imagine, low-cost portable units utilized in the field by Paramedics or Ambulance Service Technicians, or by CDC Response Teams. Multi-chambered devices could work on multiple sample media at one time, producing data that is fully distributed via wireless links, with Emergency Response Units gaining real-time data. Or, in a lab scenario, whether at a research or pharmacological center or on-board a ship or fighting vehicle, utilizing various units managed by computer, while achieving higher definition, more accurate imaging and analysis of proteins or other chemicals than heretofore possible. The UV LED revolution has started, and now UV-B and UV-C LEDs can be added to enable scientific instruments to move forward to meet it.

- ☑ Increase In More Accurate, Precision Analysis, Imaging & Data
- ☑ Longer Operational Performance, MTBFs & Lifetimes
- ☑ Lower Systems, Operational & Ownership Costs
- ☑ Fully Digitally Controllable, Add Self-Diagnostics-Repair Loops
- ☑ Lower Equipment Costs & Increased Design Freedom
- ☑ Higher Spectral Quality, “No-Heat-In-The-Beam”

About Dowa

DOWA Group, established in1884, is one of the world’s premier mining and smelting companies. DOWA Electronics Materials Co., Ltd. (DEMC) is one of the operation companies in DOWA Holdings Co., Ltd. DEMC current products are: GaN on Si epi wafers: 3", 4", 5" and 6" and 8" wafers that achieve high breakdown Voltage with thicker epi layers for power switching devices; Si-doped GaAs substrates: 2", 3" and 4" wafers with low etch pit distortion (EPD) levels for Laser Diode and LED applications; Red/IR LED Known-Good-Die (KGD) from 630nm to 940nm λP; UV-B & UV-C LEDs: Known-Good-Die die, discrete Lamps, SMDs & Arrays from 265nm to 340nm λP as well as a variety of High Purity Metals such as 6N Ga, In, Mg, Zn and Sb are also available. Our Deep UV LEDs are a reliable and efficient irradiation source for many scientific, industrial and medical application as they exhibit best-in-class longer lifetimes, higher power output and robust reliability.

About Marubeni-OPTO™

Marubeni is a worldwide material, services and products corporation first established in 1858, and organized as Marubeni Company, Ltd. in 1949. Marubeni-OPTO™ is the optoelectronics and photonics product portion of Marubeni America Corporation (MAC). Marubeni-OPTO™ has for over 30 years supplied solid-state Ultraviolet (UV), Visible and Infrared (IR) LEDs, IR Sensors (photo-diodes/phototransistors), Optics and a variety of electro-optical materials and service to its clients throughout our worldwide network.