WHITE PAPER

# MEASURING BROADBAND UVA AND VIOLET LED LIGHT SOURCES FOR INDUSTRIAL AND MEDICAL APPLICATIONS

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**As the development of new UV LED sources continues at an ever-growing pace, so do the industrial applications that utilize them. UV LEDs are being put to work in various industrial processes, medical applications, and – especially due to COVID-19 – increasingly used to develop solutions for disinfection purposes. Efficient utilization of the UV radiation requires good measurement tools. However, accurate light measurement in this spectral range presents challenges, such as how to accurately measure the irradiance if the wavelength of the light is not known.**

### Irradiance and dosage measurement

For the above-mentioned applications, the following measurements are typically used:

1. **Irradiance measurement**
2. **Irradiance uniformity mapping**
3. **Dosage measurement of a static or moving source**

### Irradiance measurement

With this type of measurement, we normally want to measure the irradiance at a certain distance from the source. The sensor should be able to collect light at steep angles and measure it correctly. This property is called 'cosine correction' because, by definition, the irradiance equals the power density multiplied by the cosine of the angle of incidence and is usually achieved using a PTFE diffuser as the input optic of the sensor (See Fig. 1).

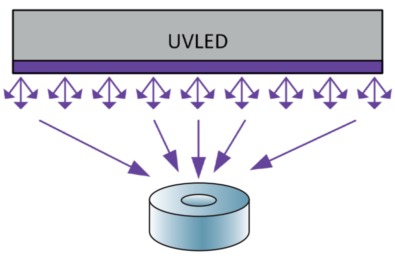



*Figure 1. Irradiance measurement of light at different angles.*

### Irradiance uniformity mapping

With this type of measurement, we want to measure the irradiance distribution on the illuminated area (See Fig. 2). Consistent processing with UV light requires uniform illumination. Uneven illumination can lead to under exposure in some areas and over exposure and cracking in others.

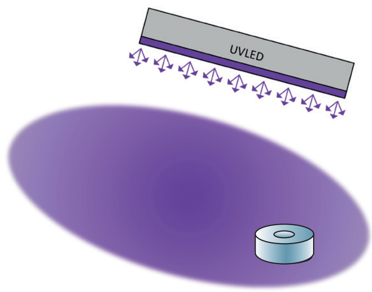



*Figure 2. Irradiance uniformity measurement.*

For this application, the sensor should have a small aperture in order to allow mapping with good spatial resolution. However, achieving a small aperture of a few millimeters and good cosine correction is challenging, and users usually must choose one or the other. This is due to shadowing effects that occur when the thickness of the diffuser and aperture become comparable with the aperture diameter.

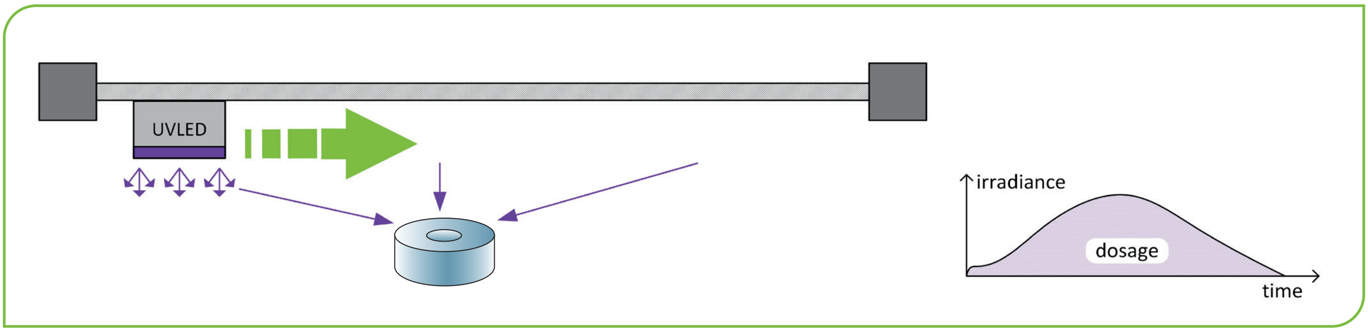



*Figure 3. Dosage measurement.*

### Dosage measurement of a static or moving source

In the dosage measurement application, the irradiance is accumulated over time and the total energy density in [J/cm2] is measured. This is the true measurement of the number of photons reaching an area to perform the curing process. If the UV source is scanning over the work area, as is the case in UV 3D printers, or if the work area is a conveyor passing underneath a static UV source, as is often the case in large UV curing machines, the sensor should be able to sample at a high rate and track the changes in irradiation (see Fig. 3). Good cosine response is also important because the sensor will be illuminated from different directions due to the motion of the source or the sensor.

### LED wavelength – three types of sensors

In printing, curing, and 3D printing of polymers, LEDs in the UVA range (mostly 365-395 nm) are used. Some applications also make use of violet LEDs at 405-425 nm. Unlike the fixed and narrow UV spectral lines of traditional mercury lamps at 254 nm, 365 nm, and 405 nm, LEDs have a spectral bandwidth of 10-25 nm. Their peak wavelength is specified with an uncertainty of several nanometers and tends to shift when they heat up.

The first graph in Fig 4 shows the spectra of three different LED sources with the same peak wavelength and different spectral bandwidths (a). The second graph shows three different LED sources with same spectral widths but different peak wavelengths (b). With the third graph, the spectra of three different LED sources are presented, each with a specific peak wavelength and different spectral bandwidth (c).

To see how this affects measurement accuracy, we need to consider three types of irradiance sensors.

1. **Sensor without spectral response calibration**
2. **Sensor with spectral response calibration**
3. **Sensor with flat spectral response**

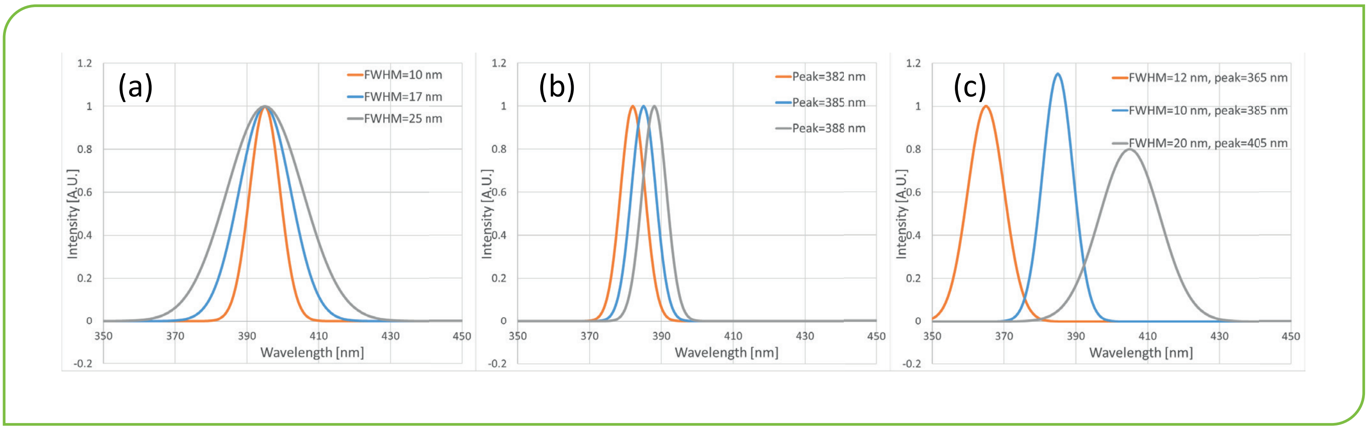



*Figure 4. Different LED spectra to be measured with irradiance sensor*

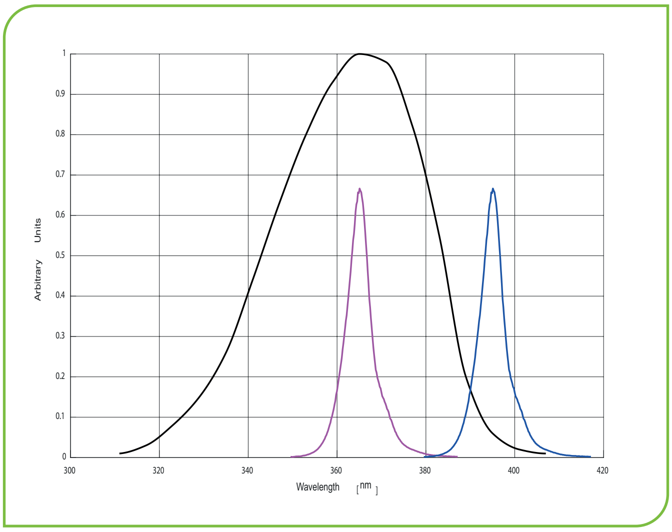



*Figure 5. Typical spectral response of a sensor*


*Figure 6. Ophir's PD300RM-UVA sensor*

**A sensor without spectral response calibration** uses a wideband filter for UVA (315-400 nm), UVB (280-315 nm), or UVC (200-280 nm). The sensitivity changes significantly within the spectral range of the sensor and the user has no way of 'telling' the sensor which wavelength is being measured. In the example shown above, an LED at 365 nm peak will produce a measurement 10 times higher than that of a 395 nm LED with the same power. See illustration in Fig. 5.

**A sensor with a calibrated spectral response** offers the user the possibility of entering the LED wavelength, thus adjusting the measurement accordingly. While this is a great improvement over the previous method, some limitations still exist, because as already mentioned, the wavelength is not exactly known, or can shift and LEDs have a finite bandwidth. Put together, these can still cause measurement errors of 15%. Additionally, the two types just described cannot handle measurement of several LEDs with different wavelengths simultaneously.

Taking the above aspects into consideration, a **sensor with a flat spectral response** will be the best choice when it comes to measuring irradiance without being sensitive to LED wavelength, bandwidth, and the combination of several LEDs.

MKS Instruments has developed a new sensor that meets those requirements. The Ophir PD300RM-UVA is an irradiance and dosage sensor that combines a flat spectral response, a small aperture, and cosine corrected response (see Fig. 6).

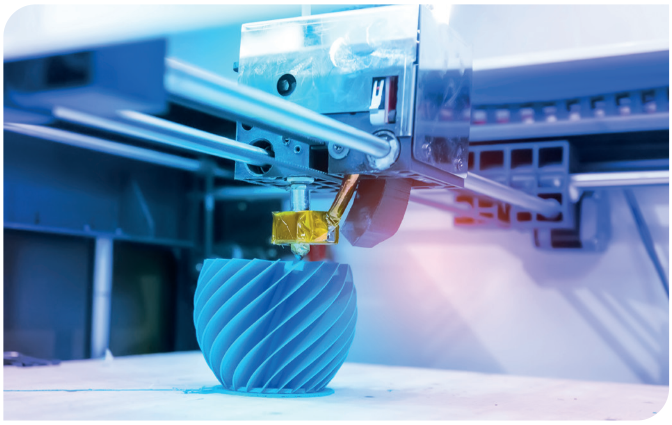
The PD300RM-UVA solves the above issues as well as the uncertainty of UV LED light by offering several enhanced features:

- Flat spectral response in the range 350-450 nm, achieved by a special optical filter
- Small aperture of 2.75 mm
- Cosine corrected response achieved by a PTFE diffuser
- Irradiance and dosage measurement with 500 Hz sample rate
- UV resistance cable
- Clear anodized finish for reduced heat absorption and heating of the sensor

The PD300RM-UVA is compatible with Ophir's Starlite and Starbright hand held displays and the Juno+ PC interface. A COM Object library allows software integration into C, C#, LabVIEW, etc. environments for system automation.

## Conclusion

New applications of UV-LED sources are under development and there is a strong need to quickly and reliably measure the LED sources, even if the precise bandwidth of the light is unknown. With its new irradiance sensor, Ophir allows the user to measure light sources without knowing much about their spectra and also supports simultaneous measurement of different light sources (e.g., LEDs with different peak wavelengths and bandwidth). With its small form factor, UV-resistant design, and its NIST-traceable calibration, this sensor generates accurate and reproducible irradiance and dosage measurements that are highly needed in industrial and medical applications that rely on UV LEDs for their operation. This sensor is specifically designed to measure LEDs in the spectral range of 350-450 nm and it is supported by several Ophir meters. By offering its unique flat spectral response, the PD300RM-UVA measurement device offers significant advantages in early R&D, in fully-operational machines, or for calibration and maintenance at customer sites.



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