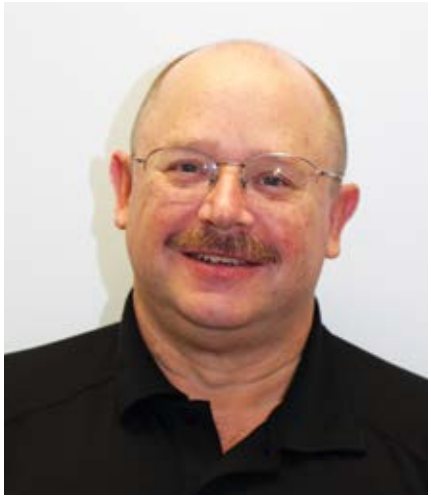
TAKE THE MYSTERY OUT OF UV LEDS

Jim Raymont from EIT delves into the world of UV LEDs exploring their parameters, power and energy density, maintenance, measurement and process control



Jim Raymont, Director of Sales at EIT

Many of today's new digital printers use UV LEDs. The LED arrays are lightweight, provide instant on/off capabilities, support high-speed printing and provide sufficient cure power when properly maintained. UV inks have also evolved to cure well under the narrow spectral output of energy emitted from UV LEDs.

Digital printers are complex and include handling equipment, printheads, ink delivery systems, ink, substrate, user interfaces, software and UV LEDs in one system. It is important for the printer to understand its UV system, UV curing, process-control parameters and maintenance steps to remove the mystery of UV LEDs and maximise the return on its investment.

UV LED PARAMETERS

UV LEDs have their spectral output concentrated in one narrow area compared to the wide output from a mercury-based UV source (see **Figure 1**). LEDs are classified by their centre wavelength (CWL) expressed in nanometres (nm) with 365, 385, 395 and 405nm popular spectral output choices. Most LED manufacturers use a +/- 5nm tolerance for the CWL to allow for variations in how the individual LED diodes are screened and selected (binned). The peak output for a 395nm LED is expected to fall between 390–400nm. The spectral distribution widens to 15–20nm at the 50% power level and to 30+nm at the 10% level (see **Figure 2**). The spectral output from the LED is matched to the UV ink photo-initiator package for optimum performance.

POWER

Irradiance (i.e., intensity) is the power of the UV LED source arriving at the cure surface. It is important for proper adhesion, penetration and depth of ink cure. Irradiance is measured in watts/cm^2, and LED manufacturers typically specify their UV LED output based on the value at the array's optical window or 'glass'. It is important to understand how the irradiance changes, based on power settings, distance and cleanliness of the optics window. A profiling radiometer can help determine how the UV LED performs at different heights above the substrate.

ENERGY DENSITY

Sometimes called 'dose', the energy density is the time integration of the power. Measured in joules/cm^2, it incorporates time (one watt for one second = one joule) and is important for the complete cure of the ink.

"Anything that you can measure, you have a better chance of controlling"

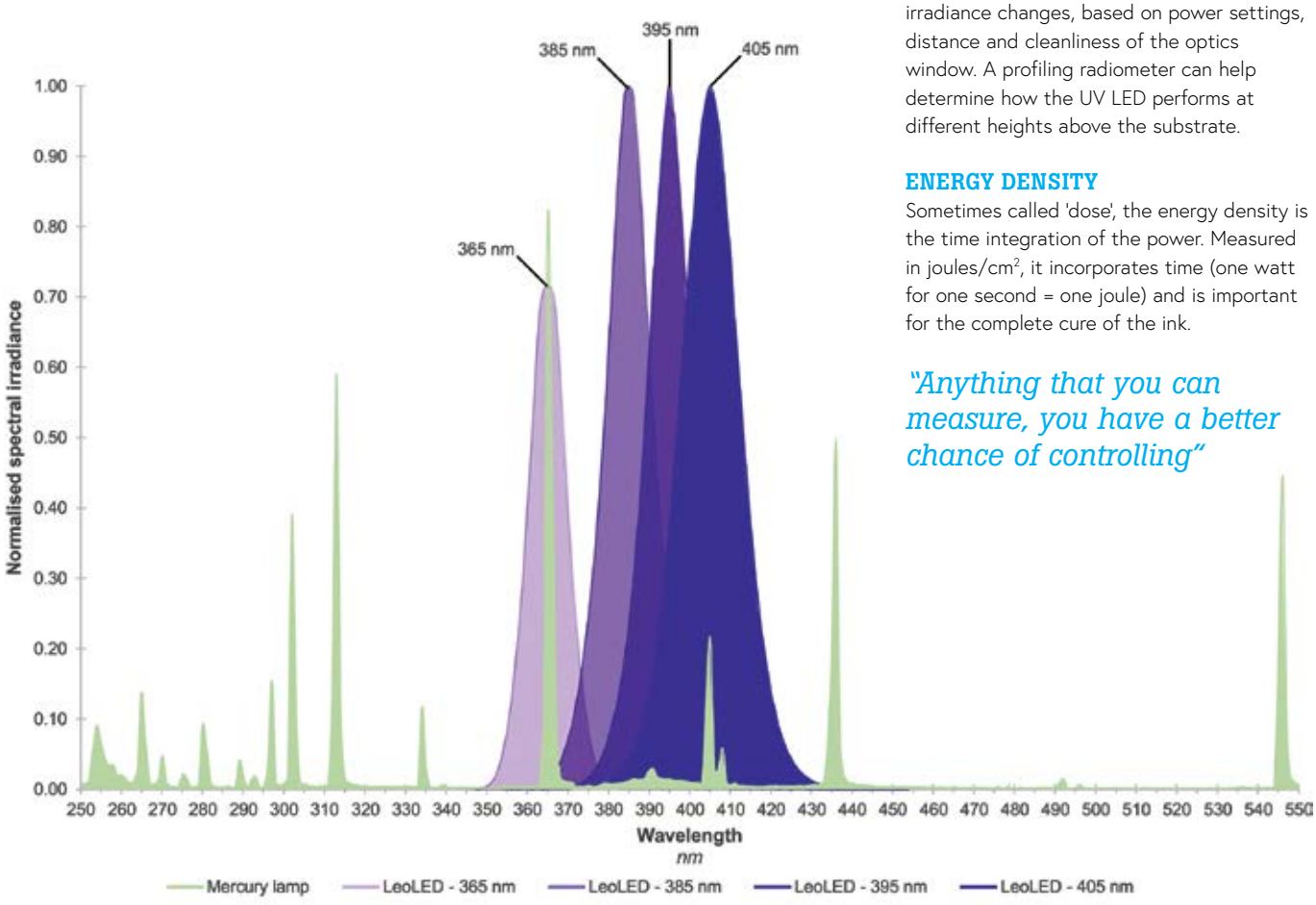


Figure 1: Spectral distribution comparison between mercury and LED source (Courtesy of GEW, UK)

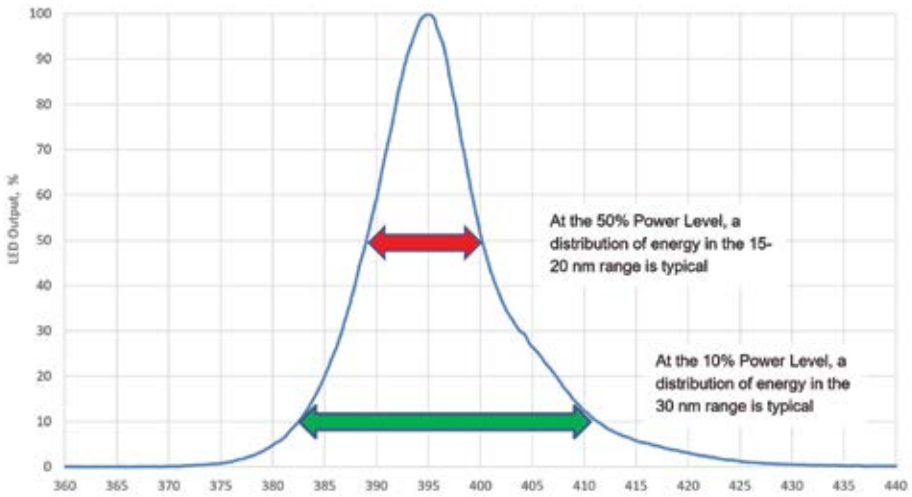


Figure 2: Typical energy distribution for LED (Courtesy of EIT LLC)

UV LEDS ARE NOT CREATED EQUAL

In terms of their spectral output, two LEDs both classified as 395nm LEDs may have different spectral outputs based on how they were binned and where their CWL falls. Additionally, it is necessary to notice if the CWL for a particular source, falls outside the +/- 5nm range.

LED source suppliers initially focused on how much power their latest LED delivered. The early thinking was that the higher the irradiance, the better the LED. Today's LEDs, in most cases, deliver plenty of power. Using an LED in a power class slightly above requirement can enable it to run at a slightly lower power level (i.e., 75% versus 100%), potentially increasing its useful life.

Both irradiance (W/cm^2) and energy density (J/cm^2) values need to be considered when comparing LEDs. It is critical to make sure that the LED selected delivers the required energy density (J/cm^2) for the process or application based on specific requirements for the exposure/cycle time or line speed. The width of the LED array can impact the amount of energy density delivered to the ink.

Follow the manufacturer's guidelines for maintaining your LED. Check and keep the quartz window clean. Be aware that LEDs are cooler than broadband sources but not completely heat free and consider how this impacts your process.

UV MEASUREMENT

"Anything that you can measure, you have a better chance of controlling. Things that you do not measure become the cause of mysterious problems." (Larry Goldberg, Beta Industries)

Mysterious problems cost money and time. Measuring UV on a regular basis gives you a better chance of controlling and preventing UV curing from becoming such a problem.

With measurement, savings include:

- Confirmation of UV conditions prior to starting a production run leading to less waste during set-up
- Increased throughput and reduced scrap during production runs
- Production decisions made on actual UV conditions
- Reduced time during set-up or first article inspection
- Scheduled preventative maintenance
- Effective targeted maintenance approach versus trial-and-error
- Reduced communication time both internally and between suppliers

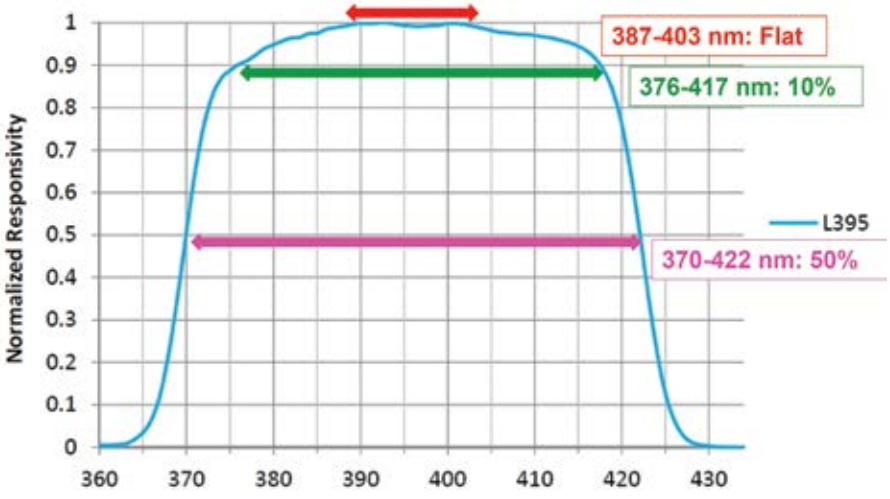


Figure 3: EIT L395 response that is matched to the output of an LED

MAINTENANCE

UV LEDs offer the potential to provide stable output over tens of thousands of hours. This does not mean that UV LEDs are 'set and forget'. UV LEDs require regular maintenance (especially cleaning of the quartz window), checking and measurement. It is vital to be familiar with the suggested cleaning and maintenance programme. Get a good understanding of your process window and what your inks need to cure properly.

WHEN AND HOW OFTEN SHOULD I MEASURE THE UV?

In an ideal world, measuring would start when the process is established as it takes work and time. The process is an investment and establishes a solid foundation that will pay you back down the road.

Evaluate the following factors to determine how often to measure:

- The stability of your LED systems and process
- The type of product being produced and your liability if the ink is not cured properly
- The value and financial exposure if the product needs to be scrapped
- Your familiarity with process and equipment
- The level of staff knowledge and training
- The customer documentation requirements

The information that you collect about your process will dictate the measurement frequency. It is much easier to collect more readings at first to establish a baseline.

PROCESS CONTROL

A UV radiometer is an important part of maintaining the process window. Waiting for the ink supplier to take a reading with their UV radiometer may leave you line down. Waiting until you have a curing problem rather than trying to establish control when things are working will hurt your bottom line.

"Today's LEDs, in most cases, deliver plenty of power"

Know what the radiometer numbers mean, along with the other variables, specific to your system and process. There are several variables that you need to monitor, maintain and document in addition to watts and joules. Some of the variables have numbers that can be attached to their values.

DO YOU HAVE TARGET WATT AND JOULE VALUES?

When it comes to measurement, ensure that the radiometer response is matched to the LED (see **Figure 3**). Dynamic range will cover

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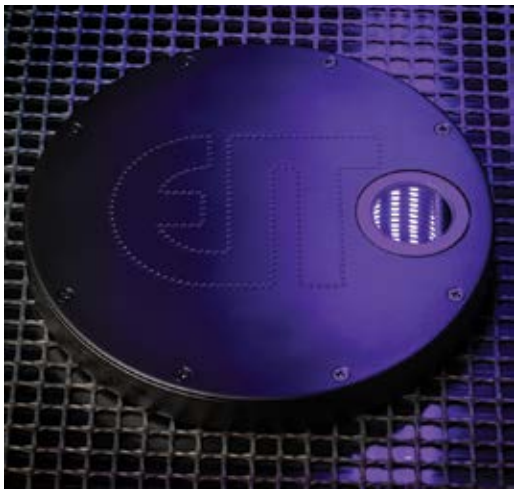

LED cure under LED source (Courtesy EIT LLC)

the LED and the instrument sample rate will support the speed at which data is collected. Collecting data on a digital printer with the LED running at 300ft/min requires a faster sample rate than a printer with the LED running at 50ft/min.

"A profiling radiometer can help determine how the UV LED performs"

DATA

Organise your data and record all information (w/cm^2, j/cm^2) available from the instrument. If your instrument supports transfer of additional data, such as the irradiance profile, also save that information or file. Attach notes if possible and record the numbers that you track on a log.

STABILITY

If there is an issue, it is suggested to take three sets of data with a single instrument under the same exact process conditions to understand the stability of the system and data-collection process. After a system is understood, readings can then be investigated between multiple instruments and/or multiple sources.

CLOSE-UPS

LEDs have thousands of individual point sources. Positioning the instrument optics at different positions under the LED quartz window can lead to slight differences in the readings, especially if you are extremely close to the quartz window of the LED.

"It is much easier to collect more readings at first to establish a baseline"

INSTRUMENT CARE

Follow the guidelines from the manufacturer on how to use, care and clean your instrument. Do not forget that your instruments need periodic calibration and service.

Work with your suppliers. Understanding your UV LED, establishing a process window and method to uniformly collect and record data with a radiometer matched to your application, will help to 'take the mystery out of UV LEDs'. ■

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