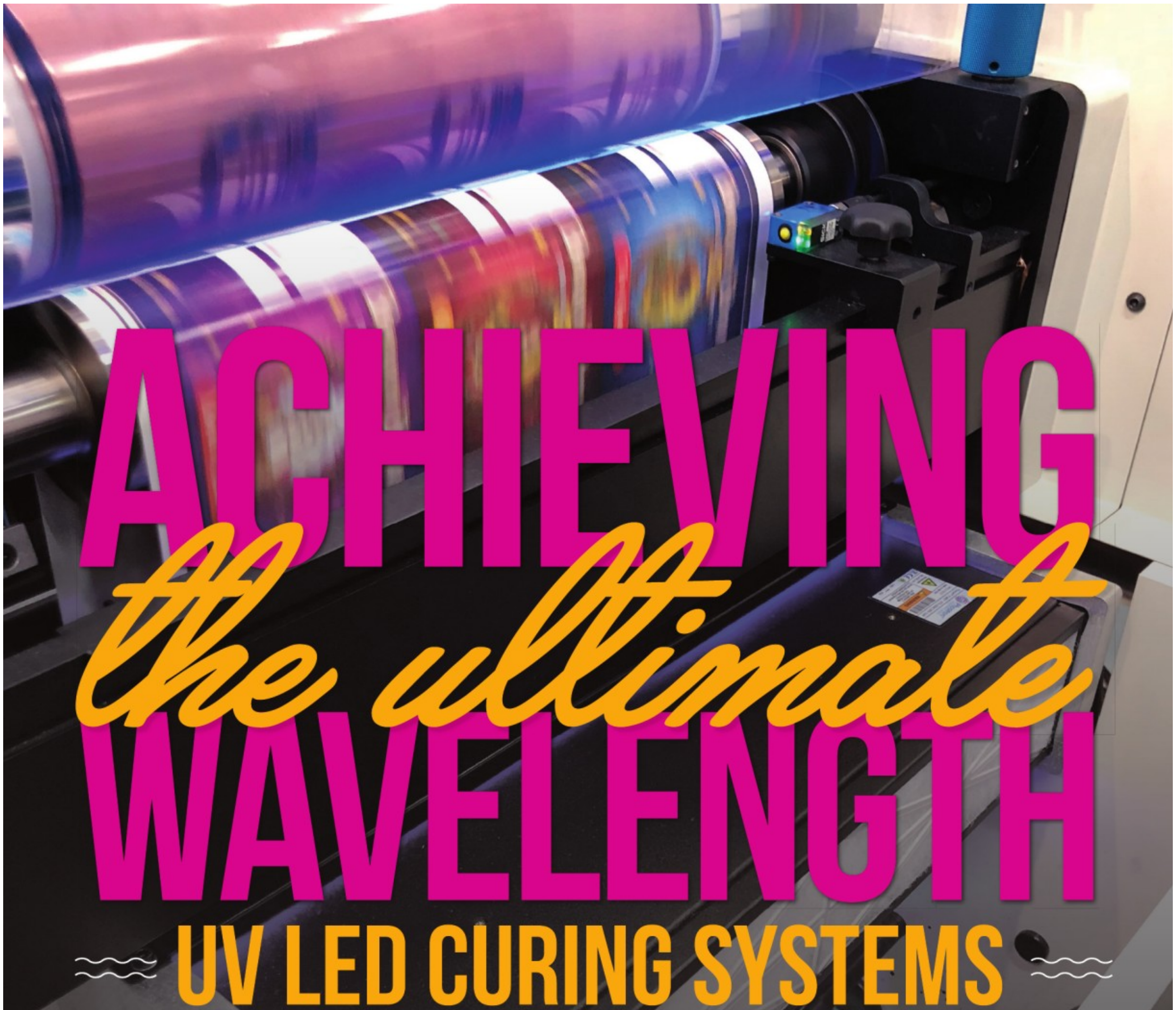

ACHIEVING *the ultimate* WAVELENGTH

UV LED CURING SYSTEMS

by Melissa Donovan

UV LED curing is used throughout the print process to dry or cure anything from ink to coatings. It works very quickly compared to other curing processes like conventional UV and mercury arc lamps in addition to many other advantages. Consequently, the speed of curing allows for heat-sensitive and thinner materials to be used—unlike longer curing processes where a thinner material may melt—expanding application options. For manufacturers in different industry verticals, a customized UV LED curing solution is essential to increasing efficiencies in their organization.

MANY USE CASES

Implementing digital printing into a manufacturing workflow can also mean integrating UV LED curing technology. Adoption is prevalent in a number of industry verticals primarily because of UV LED's rapid curing abilities, energy efficiency, and variety of applicable applications.

"UV LED is suitable where fast turnaround of printing jobs is required due to its fast drying process, for example, the media, labels, sign, or textile industries. This is driven by the end customer's increasing requirements for short and/or custom print runs," explains Ken Reynolds, business and technology manager, ProPhotonix Limited.

Label printing is a popular market for UV LED curing systems. "An advantage is its low temperature load on the substrate and the possibility of a small design so that the curing units fit in very narrow spaces," shares Dieter Stirner, sales director, Dr. Hönle AG/Eltosch Grafix, member of Hönle Group.

Printing on pre-manufactured objects, package printing, bottle printing, three dimensional (3D) printing, coding and marking, and posters and signage is also possible thanks to UV

Above: Phoseon works closely with OEMs during the product design phase to determine light source and solution requirements.

LED curing. "UV LED technology offers increased productivity, operating economics, and sustainability for these applications. The ability to provide consistent output, even for long-lasting, high-volume jobs—when curing sensitive products—makes UV LED technology an effective solution in these manufacturing settings," admits Sara Jennings, senior technical marketing engineer, Phoseon Technology.

Adrian Lockwood, CEO and Staci Reeson, marketing manager, Integration Technology Ltd., believe the most prevalent industries benefiting from UV LED are wood decoration, adhesives, electronics, and the decoration of injection molded plastic parts—especially in automotive.

"The reasons vary on a case by case basis, however it is frequently because UV LED can deliver an effect or a process, which cannot be achieved by conventional UV alone—for example tactile or 3D coatings. UV LED also offers precise, controllable, and repeatable results in terms of dose and exposure, which are highly important in applications such as medical device and electronics manufacturing. Finally, the instant on/off feature of UV LED makes it well suited to indexing-type production lines," explain Lockwood and Reeson.

According to Reynolds, all of the aforementioned industries further benefit from UV LED's pinning capabilities. "UV pinning enhances the management of drop size and image integrity, minimizing the unwanted mixing of drops and providing high-definition image quality with sharp color rendering."

GAME CHANGER

UV LED curing is a game changer in relation to drying or curing both ink and coatings. Alternative curing processes include mercury arc lamps, electron beam, and conventional UV. Compared to UV LED, these systems still serve a purpose but only for certain applications.

"UV LED is definitely a game changer, though I wouldn't say it is necessarily more effective, but a different method of reaching the end result. That end result is cured inks and coatings, as well as other chemistries. In order to decide if it is more effective involves the application and benefits over conventional UV, overall performance over time, upfront capital equipment costs including installation, and overall operating costs," suggests David Snyder, Southern regional sales manager, UV curing group, American Ultraviolet, Inc.

Mercury arc lamps offer a lower initial investment, however operational costs are greater due to elevated energy requirements, shorter lifetimes, and higher repair and maintenance costs, says Reynolds. While UV LEDs have an expected lifetime of 20,000 hours or more, he cites mercury arc lamps as only having a lifetime of 500 to 2,000 hours.

Some of the energy emitted from mercury lamps is infrared light. "Infrared light can cause surface areas to be cured that were not intended to be cured and cause over curing of some surfaces. Additionally, mercury lamps operate at high temperatures, which can damage heat-sensitive substrates. This may restrict the choice of materials used when operating mercury lamps. Other disadvantages include the requirement for warmup times as well as the environmental impact and disposal costs associated with this technology," warns Reynolds.

"Comparatively, all the light emitted from UV LED systems is ultraviolet, the light does not generate heat so it is a cold cure technology. The LED curing light intensity can be controlled to ensure consistent output over the lifetime of the lamp," continues Reynolds.

Lockwood and Reeson add that UV LED is more penetrative than conventional mercury arc sources, so it performs well in high deposition or heavily pigmented applications.

Another alternative is electron beam—Reynolds says its main advantage is the inks do not require a photoinitiator, which may lower print production costs. Similar to UV LED, it is suitable for heat-sensitive substrates. It is used for limited applications in flexographic printing press facilities.

Conventional UV lamps require a large amount of power compared to their UV LED counterparts, thus having a greater impact on the environment, according to Akira Taguchi, senior manager, EP devices development department, printing device research and development division, corporate printing device group, Kyocera Corporation.

"The environmental benefits set the technology apart, as there are no volatile organic compounds or mercury and significant energy savings. Unlike alternative curing processes that require heaters, blowers, and ventilation, UV LEDs are also easily adaptable and integrated into print systems," agrees Pamela Lee, senior product manager, OmniCure UV LED curing solutions, Excelitas Technologies.

The integration of UV LEDs into print systems provides minimal challenges. According to Stirner, curing units can be built modularly. "This makes it possible to switch off single LED segments and adapt the irradiation width to the printing width."

1. The Excelitas OmniCure AC9-Series heads emit UV light in the UV-A band at 395 nanometers.

Thinking about it from an energy perspective, James B. McCusker, sales, Honle UV America, Inc., shares that UV LED offers a longer life system versus conventional UV—using a third of the overall energy

"LEDs are based on semiconductor technology. The specific wavelengths are directly emitted by the current input. So it can be switched on and off at any time—without any warming or cooling phase, no standby mode. This is not only an advantage regarding energy efficiency, above all it makes UV LED curing ideal for cycled operation even in the millisecond range," explains Stirner.

BEGINNING THE PROCESS

For manufacturers looking to create a new system with UV LED curing or retrofit an existing system with UV LED, it's important to assess specific requirements in regards to the UV LED's intensity, dose, light output profile, cooling system, and form factor restraints. Ink sets or

One Manufacturer Benefits from UV LED Curing

Duracote, based in Cleveland, OH, manufactures products that make up the top layers in countertops, cabinets, and other surfaces. These are resistant to chemicals, abrasion, heat, and fingerprints. Traditionally, the manufacturer worked with microwave-powered UV lamp systems with multiple heads for curing compounds that ultimately result in thermally-fused laminates. However, it recently adapted the OmniCure AC9-Series UV LED curing system from Excelitas Technologies.

The typical workflow at Duracote is a continuous roll-to-roll process where UV-curable compounds are coated to a specific thickness, partially cured with UV light, and rewound on themselves. The partially cured rolls are shipped to the end customer, where they experience a final cure.

When its original UV lamp curing system reached the end of its life, the Duracote team had to decide whether to replace it or upgrade to UV LED. In its search, it looked for a similarly efficient and consistent system.

"We needed to decide whether to stay with the traditional bulb system or plan for the future. We felt that UV LEDs were the way the future was going," admits John Petroski, research and development director, Duracote.

Understanding the advantages of UV LED curing like long lifespans, low power consumption, and ability to cure thinner and heat-sensitive materials, Duracote had its own list of characteristics when it came to what it was looking for in a curing system.

It required minimal heat generation to prevent unwanted curing or substrate deformation, since its compounds are coated and only partially cured throughout its manufacturing process. Low electrical consumption, longer life, and uniform irradiance across multiple UV heads spanning a 66-inch width were also important. Future considerations included potential for higher throughput in the production line and increased flexibility in product development.

Duracote reached out to a supplier of custom industrial UV curing solutions, INPRO Technologies Inc., whom it used to install its current microwave-powered UV lamp curing systems. The supplier suggested a customized Excelitas OmniCure AC9-Series UV LED curing system.

To address the 66-inch width, the application required six curing heads, including five OmniCure AC9300 heads with an active optical area of 300x25 millimeters (mm) and a single AC9150 head with an active optical area of 150x25 mm. The engineers at Excelitas also developed and delivered a custom controller for the system.

Transitioning from UV lamps to UV LED curing created some back-and-forth between Excelitas, Duracote, and INPRO to get the system just right. The OmniCure AC9-Series heads emit UV light in the UV-A band at 395 nanometers, while UV lamp systems emit UV light over a wider bandwidth including UV-A, UV-B, and UV-C bands. As a result, formulas, feed rates, and line speeds were optimized for curing with UV LEDs.

While it tested the UV LED system, Duracote ran its microwave UV lamp system. "So if we ran into a process that didn't respond well to LEDs, we could turn back to the lamp system as a de-risking strategy," explains Jack Pallay, president, Duracote.

Duracote fully incorporated the Excelitas system into its production line after three line trials and experienced many advantages. For one, the individual UV LED module control and factory calibration of the OmniCure AC9-Series enables the heads to deliver UV irradiance with a high degree of longitudinal uniformity. Further, intelligent system monitoring ensures the correct dose of UV energy is delivered on every exposure. This level of control allows Duracote to use the system on different materials.

Heating—which often causes wrinkles in the substrate—is rapidly reduced. There are no errant microwaves, so no additional microwave screens or RF detectors are needed. The power consumption of the OmniCure AC9-Series heads is about one-fourth that of UV lamps used in the same application. Fan noise is reduced because UV LED heads generate less heat, which means the cooling fans produce less noise.

With the OmniCure system, the Duracote team hoped to match the yields and throughput of the older microwave UV lamp systems. The manufacturer plans to improve throughput by ten percent or more over UV lamp curing after further process refinement.


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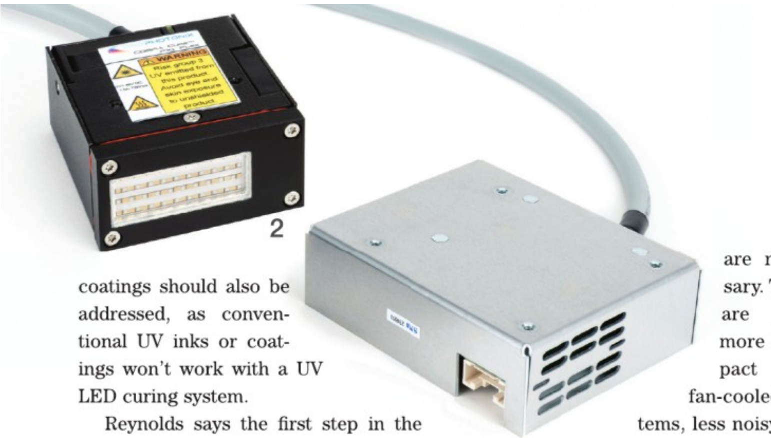

coatings should also be addressed, as conventional UV inks or coatings won't work with a UV LED curing system.

Reynolds says the first step in the process is to determine the intensity and dose requirements of the UV LED. He recommends over specifying by at least ten to 15 percent. "This provides an operational safety margin and a longer life. In general, if you want your production process to run faster, higher intensity light at the optimum wavelength produces a faster cure."

The light output profile and working distance also needs to be addressed. "Some users request a collimated or narrow-angled light to avoid UV light reflections curing ink at the printhead, leading to blockages. The tradeoff is that generally, the light output efficiency is lower in comparison to UV LED with wider angle output profiles," admits Reynolds.

He points out that UV LED generally requires fan- or water-cooled systems, so it is necessary to decide between the two early on. "Fan-cooled systems do not require any extra equipment, but higher intensity systems may become bulky due to the requirement for bigger and/or more fans to regulate the temperature. For higher intensity applications, water-cooled systems are necessary. These are often more compact than fan-cooled systems, less noisy, and can be operated at much higher power. However, your system needs to accommodate a chiller, which adds complexity and cost."

2. ProPhotonix recently launched the COBRA Cure Mini. The light head can be separate from the electronics, which minimizes both weight and form factor.

Lastly, Reynolds advises manufacturers to look at the constraints of the UV LED's form factor. This is based on the available space and the effect it has on optical design strategy. A number of form factors are available from compact modular systems to medium sizes integrated into production lines, or large-scale systems where size does not matter.

Beyond the physical construction of the system, it is important to identify the ink or coating to be cured. "Manufacturers need to understand that conventional UV inks and coatings are not compatible with UV LED curing systems, so they need to use specifically formulated inks matched to the particular monochromatic wavelength of the UV LED systems they are using. Conventional UV inks and UV LED are not interchangeable; manufacturers need to maintain separate systems unless they are fully converting equipment to UV LED," warns Snyder.

This is especially true if the manufacturer already uses a non-UV manufacturing line and wants to retrofit it with UV LED. "There are issues to consider beyond LED curable inks having and needing a higher amount of photoinitiators compared to conventional UV inks. Light shielding, control system, and machine communication are additional concerns. The overall costs of retrofitting always depend on the individual application," advises Stirner.

Lee emphasizes that if retrofitting, replacing conventional UV lamps with UV LED is not a one-to-one drop-in replacement. "The characteristics and monochromatic output of LEDs are different from the broad spectral distribution of lamp-based systems. Modifications to the process are required, starting with the testing, validation, and use of LED compatible inks."

Testing is necessary, agree Lockwood and Reeson. "Manufacturers should endeavor to understand not only the benefits and key features of UV LED hardware but also understand any limitations. Not all UV LEDs are the same and it is difficult to judge performance from just reading technical specifications on paper."

"The best solution should take into account not only the upfront costs of the system, but also the lifetime costs in comparison to alternative solutions and the measured impact on the business," advises Reynolds.

MAKE THE MOVE

Incorporating UV LED systems into manufacturing lines is advantageous for many reasons. Many industries benefit from this and those considering the change shouldn't hesitate. "Making the move to UV LED is simple and straightforward. With thousands of printers running 100 percent pure UV LED curing systems, we have not seen a single press operator ask to return to their traditional approach. Once the change is experienced, there is no reason to go back to the pain of a traditional mercury-based solution," recommends Jennings. ***IPM***

COMPANIES MENTIONED IPMdirect See page 24 for more information.

INFO#	Company	Website
105	American Ultraviolet, Inc.	americanultraviolet.com
106	Dr. Hönle AG/Eltosch Grafix, member of Hönle Group	hoenle.com/eltosch-grafix.com
107	Excelitas Technologies	excelitas.com
108	Honle UV America, Inc.	honleuv.com
109	INPRO Technologies Inc.	inprotechnologies.com
110	Integration Technology Ltd.	uvintegration.com
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