The UV-LED Curing Revolution

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The use of UV-LED systems for the curing of UV inkjet inks continues to expand as equipment manufacturers bring this technology to a wide range of new equipment. Is inkjet ready for prime time, and what are the challenges faced in the adoption of the technology? Three UV experts, John Kuta, Lumen Dynamics; Bea Purcell, Nazdar; and Jim Raymont, EIT Instrument Markets, answer just that.

SGIA: *UV-LED curing is seen as "standard equipment" on an increasing number of inkjet printers. What are the main factors driving this change, and what do you feel is the most compelling reason for equipment manufacturers to adopt this technology for their inkjet solutions?*

Kuta: Without a doubt, the major driver for LED adoption is the cooler cure this technology offers to print integrators and printers. This opens up new applications for print shops and expands the versatility of a printer platform. It becomes possible to print on heat sensitive substrates without shrinking or warping of the material. The latter also has the ancillary benefit of improving printer reliability due to fewer head strikes. That said, UV-LEDs offer numerous other advantages leading to an overall improvement in the cost of ownership for the print shop and easier integration for the printer manufacturer.

The solid state nature of UV-LEDs makes them inherently robust, although there are significant technical challenges that need to be overcome to ensure the maximum benefit is achieved from the LEDs. We strongly encourage printer manufacturers to be thorough in their vendor selection and qualification process. A good UV-LED system will last tens of thousands of hours, provide high levels of irradiance and dose for effective ink curing, tolerate high ambient operating conditions and the reality of today's print shop conditions. It should be easy to operate, and have simplified service requirements compared to arc lamps. All of these capabilities are now available, both in air and water-cooled UV-LED solutions. Air-cooled solutions seem to be preferred by printer and printer manufacturers, however, as they allow simplified printer architecture (no chiller or water tubing). Combined, all of these benefits drive profitability for the print shop.

Raymont: The main factors which are the key to UV-LED acceptance and use in inkjet printers are UV-LED's smaller equipment platform size, the ability for them to be placed very close to the print surface and the ability to turn on and off very quickly when compared to other UV sources. The area of cure for inkjet printers is relatively small compared to the area of cure for other print technologies (wide screen print) and this works in the favor of UV-LED. Lastly, inks and coatings have 'caught up' to the relatively narrow spectral output of UV-LED.

A couple of questions to consider: What is the stability and performance of the UV-LED in the real world after a few years of production use, and will the UV-LED last as long as claimed and/or outlive the equipment, or will end users have sticker shock when it

Dan Marx, Vice President of Markets and Technologies, SGIA

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Bea Purcell,
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comes time to replace the LED system in X-number of years?

Purcell: One of the main advantages of UV-LED is the lack of heat exposure on the media. Since most printed media are plastic, heat coming off the traditional UV curing lamps to the surface of the substrate is a major factor in causing shrinkage and distortion. Another factor is the energy savings since LEDs use a lot less power compared to traditional UV curing with medium pressure mercury and similar types of bulbs.

SGIA: *Early in the implementation cycle of UV-LED curing technology, one of the challenges was to have the LED lamps generate enough energy to cure ink fully, which resulted in a process that was slower than using traditional UV lamps. What specifically has changed in the past two years to increase the effectiveness of UV-LED lamps, making them viable at production speeds?*

Raymont: The suppliers of the building blocks — UV-LED chips and dies — have improved the "LEDs" supplied to companies that integrate them into the UV-LED sources used on inkjet printers. Integrators and suppliers of UV-LED sources have come up with unique and different ways to better package, harness, control, cool and direct the UV photons to the cure surface. More companies are involved in UV-LED and that has resulted in different types of equipment. Will they all last and have the resources to bring products to market and support existing products? That remains to be seen.

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Kuta: UV-LED technology is advancing extremely quickly at this time. Early print systems utilized low irradiance LED sources that compromised productivity, or integrated bulky water-cooled LED systems, which added a new level of complexity to the printer architecture and put flowing water around sensitive print head electronics. The challenges associated with these approaches, in addition to a limited selection of LED specific inks, limited the adoption of LEDs into commercial printers. Over the past six months, high irradiance air-cooled UV-LED systems have become available, which allow for full cure of inks at market leading productivity levels. This has been made possible by technological advances in semiconductor packaging technology, which enables more efficient thermal management of high power UV-LED systems. Combined with high efficiency collection optics, it is now possible to have irradiance levels of greater than eight watts/centimeters squared from air cooled systems and have them operate in ambient environments as hot as 50 degrees Celsius — a critical requirement for printer manufacturers selling in a global market.

SGIA: *For UV-LED to work effectively, the lamps and the ink system need to work symbiotically. What are the specific challenges to ink development that have had to be addressed in order to make UV-LED a viable curing technology for the industry?*

Raymont: Most traditional ink and coating formulations were developed for use with arc and/or microwave sources, which emit a broad spectrum of UV. UV-LED sources only emit UV across a very narrow region of the UV spectrum. Traditionally, shorter (UVC) wavelengths from arc and microwave UV sources have been associated with the surface cure properties (texture, feel, stain resistance) of the cured coating. Changes that have allowed the inks to respond to the relatively narrow band UV-LED source as well as deliver the desired surface cure properties need to be made for acceptance of UV-LED by the industry.

Purcell: The formulation of UV-LED inks must be optimized with photoinitiators, which specifically absorb in the wavelength emitted by the UV-LED.

Kuta: Through ongoing internal evaluation at our ink testing facility, we have observed a significant improvement in the curing efficiency of commercially available LED specific inks. Historically, we had seen issues with achieving surface cure and good ink adhesion through our in-house ink curing studies, particularly with thick ink layers, or with highly absorbing or scattering inks such as black and yellow. These curing issues were partially attributable to ink formulation, but also partly due to the peak irradiance levels that could be delivered by LED curing systems.

SGIA: *Does UV-LED-adjusted ink cure equally as well as traditional UV-inkjet*

Source: UV Process Supply

UV-LED will become the dominant curing technology in the UV digital print market by 2015.

inks, or are there any challenges to adhesion, durability or media diversity? If so, what are these challenges and how are they being addressed in research and development?

Purcell: One of the challenges is proper cure and this is true for traditional UV curing and UV-LED curing. Cure affects adhesion and both chemical and physical properties of the ink film. R&D challenges come from meeting the requirements for the end application. For example, in the industrial/membrane switch overlay application, the cured ink film must be compatible with laminating adhesives; must be flexible for embossing and die cutting; and must pass some weather-ability requirement.

Kuta: Historically we had seen issues with achieving surface cure and good ink adhesion thru our in-house ink curing studies. Partially this is attributable to ink formulation, but partly due to the peak irradiance levels that could be delivered by LED curing systems. Both have been improved to the point that UV-LED curing systems in digital print are now economically and technically viable — hence the increase in adoption.

Raymont: I'll let the formulators respond to the question of "equal curing." The challenge I see is a lack of consistency in how UV-LED is characterized and measured. Many companies feel that the more watts a UV-LED system has, the better it is, but there are no standards as to where the system is measured or whether the watt number being quoted is a theoretical or actual number. The biggest question is how the ink cures and responds to the UV source whether it is two watts or eight watts.

SGIA: *Printing companies purchasing new equipment using UV-LED technology currently face a higher curing-system cost when compared to traditional UV lamp systems. What are the reasons printing companies are accepting of UV-LED technology, and are they able to recoup the additional cost during the expected life of the machine?*

Kuta: Acquisition cost is a bit of a "red herring." Consider, for instance, that UV-LED technology has a better overall cost of ownership than arc lamp systems, plus it expands the versatility of a print system due to the cooler cure it provides. Cost of Ownership (COO) includes not only upfront acquisition costs, but also running and maintenance costs. The higher reliability of LED systems, lower energy costs and longer lifetime combine to create an improved COO relative to arc lamps. Printer manufacturers benefit as well since UV-LED systems are easy to integrate and do not require integrated shutters or high voltage igniters.

In addition, the added versatility cool curing UV-LEDs provide, from a print application perspective, expand the range of jobs that can be addressed on a single printer, offering print providers new opportunities for differentiation and profit. Finally, the environmentally friendly aspect of UV-LED curing cannot be discounted. UV-LED curing systems contain no mercury, do not create ozone and reduce energy demand — all of which support the trend in the print industry

toward sustainable technology.

Purcell: The initial curing system investment is believed to be offset by lower maintenance costs, longevity of the LEDs and savings in energy consumption.

SGIA: *Will UV-LED technology become the primary inkjet curing technology by 2015?*

Purcell: Yes.

Kuta: Yes, it's our opinion that UV-LED will become the dominant curing technology in the UV digital print market by 2015. We base this on our own technology and market roadmaps, and have validated it through direct discussions with leading printer manufacturers.

Raymont: Maybe. The decision to go to inkjet printing — including UV-LED inkjet printing — needs to be based on a realistic economic evaluation versus emotion or new technology decision. How much will the UV-LED system be used? Will it have lower maintenance costs, reduced set up times and do these justify the initial higher cost investment of a UV-LED system? Will the UV-LED system replace something that I have or be a new machine that will allow me to go after new types of work? What is the typical size of the job and is there a better way to print it, i.e. traditional screen printing that is more cost effective? Lastly, do you invest in new equipment or wait to see what the economy will do?

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