

Title: UV LED for IML and IMD - Competing Today While Preparing for Tomorrow
Conference: 2019 IMDA Symposium & SPE TopCon
Presenter: Jennifer Heathcote
Position: Technical & Commercial Consulting Advisor, UV Curing
Presentation Date: Monday, June 3, 2019 @ 10:30 am
Company: Eminence UV, LLC
Company Address: 47 W. Division St., #509, Chicago, IL 60610
Cell Phone: +1 (312) 550-5828
Email: jheathcote@eminenceuv.com

It's June of 2019, and the US economy is strong. The real GDP quarterly growth rate has held between 2.2 and 4.2% for the previous eight quarters, and the first quarter of 2019 was a healthy 3.1%. US manufacturing consistently represents greater than 10% of total GDP¹, and according to the Bureau of Economic Analysis, recent manufacturing related contributions included increases in private inventory investments, greater exports, and a resurgence in non-residential fixed investments. The US unemployment rate for May was 3.6% which is the lowest since 1969, and there is currently neither inflation nor deflation on the radar. Volatility in international tariffs and an inability to protect intellectual property is even driving manufacturers to reassess the true cost of manufacturing abroad with some opting to strategically reshore for the first time in decades.

Manufacturing, which currently employs more than 8% of the entire US population¹, is both contributing to and benefiting from the strong economy. Coupled with a shifting geopolitical climate, some areas of domestic manufacturing are experiencing renewed interest. Such a scenario creates revenue generating opportunities for those in a position to capitalize, but it also brings challenges. Two of the leading issues facing manufacturers are an inability to attract and retain critical talent and difficulty keeping up with and utilizing new technologies.

The skilled labor reality is that 6 out of 10 open positions in the US are unfilled.¹ Another 4.6 million manufacturing jobs will be added in the US over the next decade with nearly 2.4 million of those expected to go unfilled.¹ Leading factors are a shifting skill set due to advanced technology and automation, students as well as parents not viewing manufacturing as a suitable employment or career option, and the retirement of baby boomers.¹ 51% of executives responding to a 2018 Deloitte survey felt that an inability to fill open jobs over the next three years was the biggest hinderance to *maintaining or increasing production levels to satisfy growing customer demand*.¹



Just as manufactures are becoming increasingly stretched by increased demand and staffing limitations, the manufacturing industry is simultaneously developing a plethora of new technologies. Unlike any other time in history, an abundance of decentralized innovation is happening at an increasingly high rate of speed, leaving most manufactures overwhelmed and indecisive about how to fully incorporate the latest solutions into both existing and new products and processes.²

Herein lies the dilemma of UV LED curing. Manufacturers are being presented with a fundamentally different yet viable new technology that will eventually push out conventional mercury-based UV systems, but UV LED curing and its potential for IML and IMD product and process innovation struggles to capture the time and attention of the very manufactures it is meant to benefit. New technology today must not only compete with its most obvious alternatives, it must also compete with new and completely unrelated technologies that span

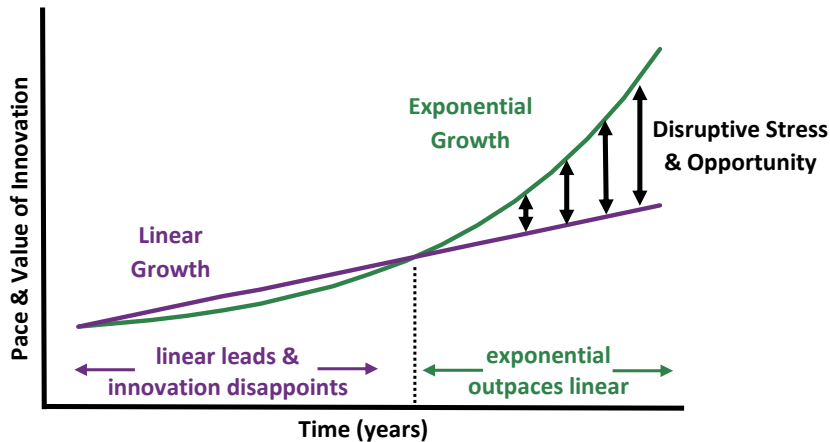
all aspects of business as well as the precious time that increasingly stretched manufacturers must dedicate every day to get quality production out the door.

Smaller and mid-size manufactures increasingly want proven, drop-in solutions and are relying on vendors and even larger competitors to work out the development and implementation before committing themselves. Many manufacturers don't have the internal resources or time to investigate, evaluate, and develop new technologies for their own use in anticipation of future needs. They generally wait until existing equipment fails and needs replaced or production needs drive expansion. In these circumstances, purchasing decisions are often made quickly. In cases where manufacturers haven't previously explored the potential of UV LED technology and haven't been working closely with formulators on development, there is generally a reluctance to proceed. A natural fear lies in an inability to replicate exactly what the current mercury lamp process does today. The true potential of UV LED technology is often discounted by the buyer because further development requires time and resources.

The result is that the majority of UV curing purchasing decisions are conservative and risk-averse. Manufactures either stick with what they know or play it safe with a hybrid solution. In the case of UV LED curing, playing it safe means continuing to use arc and microwave lamps. Dipping a toe in the water means going with a hybrid solution that offers the ability to swap back and forth as needed between conventional mercury and LED lamps.

With growing customer demand, a strained labor supply, and an abundance of new technologies, how do manufacturers successfully compete today while preparing for tomorrow? They do so by consciously managing dual strategies. Present planning (today-for-today) requires one clear strategy and future planning (today-for-tomorrow) another.³ Present planning is a vision of how to operate now given core competencies, target markets, and current opportunities and then fine-tuning alignment across the organization.³ The role of each key function must be clearly defined and optimized for excellence. Doing so allows manufactures to compete within today's market space. Future planning is built on a longer-term vision of change and a strategy for getting there.³ It almost always *involves bold moves away from existing ways of conducting business.*³ Future planning better positions companies against tomorrow's competitors and enables the development of new competitive advantages that will be necessary in the coming years. Planning for tomorrow enables manufactures to navigate geopolitical developments and innovate the products and corresponding processes customers will demand in the future.

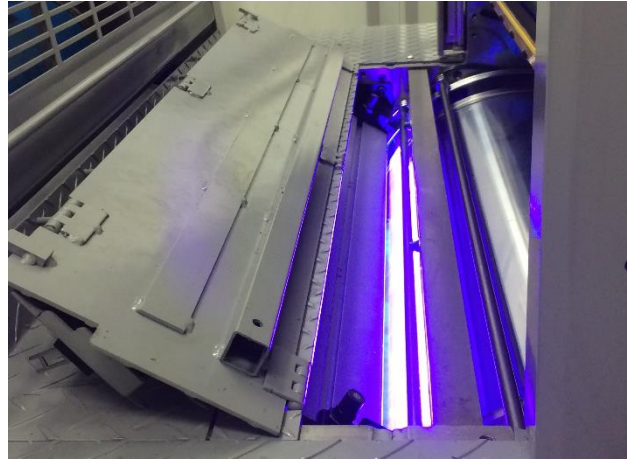
The following chart plots the pace and value of innovation (y-axis) against time (x-axis). The purple line represents existing technology and linear growth, while the green curve represents new innovative technology and exponential growth. With respect to UV curing, conventional microwave and arc lamp systems as well as conventional UV ink, coating, and adhesive formulations are linear growth products. Linear growth introductions incorporate minor changes in design or process and introduce features that modestly improve efficiency, operation, and performance. Meanwhile, the basic technology and utilization of the technology remain the same. Classic linear growth technology is best suited to manufacturers solely focused on present planning. It's what they know and trust, and any misgivings with the technology, they generally learned to accept and accommodate long ago. The green curve illustrates the ongoing evolution of UV LED curing including systems, formulations, presses, manufacturing lines, and end products. This is where innovative companies that establish and implement parallel short-term and long-term planning strategies operate and drive development. Through these concerted efforts, innovative companies *create the fundamental industry shifts and put others in the position of reacting to its initiatives.*³



When technology is new and not yet proven, the exponential growth curve falls below the linear growth curve. Existing technology appears to be the better option because the new technology fails to deliver all the same results as current processes. Risk-averse companies will always focus on one or two things the new technology cannot do while discounting every other way in which it is superior to the current offering. At some point, the curves cross one another, with the exponential growth curve rapidly outpacing the linear growth curve. It is precisely at this moment that disruptive stresses and opportunities clearly materialize and lead to genuine manufacturing advantages. Some curing markets such as digital inkjet wide format printing and IML offset label printing have crossed to the right of the dotted vertical line for UV LED technology, but many markets such as those that use UV curable industrial hard coats on molded or thermoformed plastic products and wide web converting are still operating to the left.

Innovation does not occur when companies implement UV LED curing in ways that produce similar or only marginally better outcomes than conventional curing; although, a hidden benefit to this approach is that it often provides manufactures a safe environment to get comfortable with the new technology. The reality is that it takes experimentation and imagination to create novel and better uses for new technology. Real exponential growth in UV LED curing for IML and IMD will ultimately come from opportunities that leverage less heat transfer to parts, substrates, and machine components. This directly translates into less scrap, less part warpage, less wear and tear on material handling equipment, more immediate post cure part processing, and the ability to use thinner walled parts, lower gauge substrates, and new materials in revolutionary ways. Innovation will also arise in IMD and IML part design due to the unique and unlimited ways in which LEDs discretely deliver UV light during the photopolymerization process, much of which has yet to be explored.

A major UV LED success story is IML label printing where the integration of UV LED curing enables offset converters to reduce heat transfer during printing of very thin, heat sensitive polypropylene films and increase press speeds upwards of 50%. The increase in UV LED press speed is because offset presses equipped with mercury lamps must be run at low power to minimize heat transfer, avoid film distortion, and create good IML labels. Even at higher power levels, UV LED technology often transfers less heat than mercury lamps at low power. Running mercury lamps at low power, however, requires converters to slow the press speed as a means of increasing exposure time underneath the lamps which is necessary to increase energy density and achieve sufficient cure. In some UV LED IML applications, energy consumption can be reduced up to 75% since offset presses running IML can often operate with 1 or 2 LED systems instead of 5 or 6 mercury lamps.



There are currently over a dozen IML film lines running UV LED worldwide with more installations coming online. Most of these, including the press in the photo, are equipped with AMS Spectral UV LED curing systems. AMS Spectral is the leading supplier of UV LED systems for offset IML printing. Once a press is equipped with UV LED, manufacturers are better able to develop novel print innovations that leverage the ways in which UV LED output is different than mercury output.

Waiting to adopt new technology until the growth curves in the previous chart cross one another puts laggards at a disadvantage and requires significant catch-up to understand the true value and best uses. Those who choose to get in early and learn to use the technology where it makes the most sense are the ones most likely to identify and capitalize on genuine innovation, thus enabling them to stay ahead of competitors and more effectively satisfy customer needs. This is surely the case for IML label printers using UV LED today and will be the case for those companies driving innovation in UV LED hard coats.

Unlike conventional curing, the discrete nature of solid-state UV LED technology allows irradiance (Watts/cm²) and energy density (Joules/cm²) to be independently applied to chemistry in ways that cannot be done with mercury lamps. UV LED curing systems have the ability to emit irradiances that range more than 10 times the span of conventional systems while also transferring less heat to the substrate or part. The raw diodes used in the LED lamp head as well as the manner in which the diodes are arranged, packaged, and powered also allows for a much greater range of energy density options. Those companies who are studying this and driving their vendors to study this are already at an advantage. Planning is discovery-driven.³ *Managers probe the future by conducting ongoing series of experiments* and scheduling time to learn how new technology may be a fit for an organization.³ Companies with big imaginations and a willingness to understand the nuances of LED technology will capitalize on disruptive stresses and opportunities to shape the future of plastics decoration.

While UV LED curing technology isn't going to solve the skilled labor shortage, the technology will ultimately replace conventional mercury-based curing systems, and due to its ease of use, longer life, reliability, and need for less maintenance, UV LED technology will make life better for operators and maintenance crews, increase yields, and improve manufacturers' bottom line. For those companies who choose to engage in forward thinking innovation and development, UV LED technology will enable the creation of new plastic part designs that cannot be done today. It will also enable better ways of processing and decorating plastic parts.

The decision of when to adopt UV LED technology as well as how to allocate the necessary development time varies by company and is based on how each company addresses both present and future strategic planning. It also depends on whether a company is more comfortable playing it safe on the linear growth curve and following more innovative competitors or committing time and resources to experiment on the exponential growth curve and drive industry shifts. Where does your company operate today? How will that position your company ten years into the future? Is it time for a new approach?

1. 2018 Deloitte and The Manufacturing Institute skills gap and future of work study. <https://documents.deloitte.com/insights/2018DeloitteSkillsGapFoWManufacturing>
2. 13 Tech Experts Predict the Industry's Biggest Challenges in 2019, Expert Panel, Forbes Technology Council, December 27, 2018. <https://www.forbes.com/sites/forbestechcouncil/2018/12/27/13-tech-experts-predict-the-industrys-biggest-challenges-in-2019/#4866899f1bcd>
3. Competing Today While Preparing for Tomorrow, Derek F. Abell, MIT Sloan Management Review, April 15 1999. <https://sloanreview.mit.edu/article/competing-today-while-preparing-for-tomorrow/>