# Process Design Comparison Chart: Traditional UV versus UV LED Curing for Converting Applications

When considering UV LED curing for your converting processes it's helpful to compare the available UV curing technologies. This chart provides a concise and easy comparisons of UV curing technology (medium pressure arc, microwave, and UV LED), the characteristics of each and process design considerations for typical wide web converting processes.

| | ARC (medium pressure) | Microwave | UV LED | Notes |
|---|---|---|---|---|
| **Technology Characteristics** | | | | |
| **Useful Life (hours)** | 500 - 3,000* | 6,000 - 8,000 | 10,000+ | All UV lamps degrade over time, so it's important to understand „useful life", which is the expected operating hours where adequate curing can still be achieved for your process. *Arc lamp life is significantly reduced if the lamp is not kept within a narrow operating temperature range and by the number of on/off cycles. Additive arc lamps have a shorter useful life than mercury arc lamps. |
| **Cooling Needs** | External Fans - complicated and critical | External fans - complicated, exhaust required | Internal Fans - simple | Water cooling sometimes used for all types. In general, UV LED systems require about 10 times less cooling than traditional UV systems and dynamic cooling, like that used in Semray UV LED systems, ensures longevity and optimal operation. |
| **Energy Use** | High | Higher | Low | UV LED curing systems use 30 to 70% less energy than traditional UV curing systems. |
| **Power Class** | 600 W/inch | 600 W/inch | 14 - 22 W/ $cm^2$ | This is a general indication of the class of curing system, but does not indicate UV energy reaching a substrate. For arc and microwave systems this is actually the input power. For UV LEDs their rating is typically the peak irradiance at the emission window. Since there is no standard for energy density ratings of UV curing systems, users need to run tests or obtain data from individual manufacturers. |
| **Wavelength Output** | Broad - short and long; additive lamps | Broad - short and long; additive lamps | Narrow, nearly monochromatic; 365, 385, or 395nm | Wavelength output needs to be a best match for the chemistry formulation being cured. This is normally available from your chemistry supplier. The longer wavelengths of UV LEDs are ideal for laminating adhesives and PSAs, but surface curing for hard coats is challenging. |
| **Lamp Length** | Up to 110 inches | 10-inch multiple modular units to cover wide webs up to 20 feet | Custom array lengths or multiple modular segments to span wide webs | Long arc lamps require rotating at least each week to prevent bowing of the lamp. Modular UV LED curing platforms like Semray enable quick changes to different wavelengths and less costly upgrades as UV LED technology advances. (see fig. 1) |
| **Dimming** | 38 - 100%, step or continuous | 35 - 100% continuous | 30 - 100% continuous | Controls typically tied into overall coating line controls to improve process flexibility and consistency. Power supply technology is advancing rapidly to include smart, self-monitoring dynamic controls like that found in Semray UV LED systems. |
| **Warm-up Time** | ~ 5 min. | 15 seconds | 0 | The instant on/off capability of UV LEDs offer a significant advantage over arc lamps resulting in higher line utilization and production rates. |

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|---|---|---|---|---|
| **Restrike Time** | long, must use shutters | rapid cycle (0-5 sec), sometimes shutters | 0 | Unexpected line stops and changeovers between production runs become non-events with UV LED. No worries that a shutter may break. |
| **Mercury** | Yes | Yes | No | UV LED offers a safer work environment, more sustainable production process. |
| **Ozone** | Yes | Yes | No | Short wavelength UV energy generates ozone. Since UV LED does not emmit short wavelengths, there is no ozone - you get a safer work environment and more sustainable production process. |
| **Weight** | Heavy | Heavy | Light | UV LED units weight much less, but also the mounting and UV light shielding is significantly less weight. |
| **Form Factor** | Large, Bulky | Large, Bulky | Compact | UV LED is so compact that it is easy to retrofit on existing lines and even use in combination with existing arc lamps for converting applications that need surface curing, i.e. hardcoats on film. With UV LED there are no bulky cooling/ exhaust ducts and external fans. |
| **Optical Output Strategies** | Internal Parabolic Reflectors | Internal Elliptical Reflectors | Various Micro-optics or External Means to Collect Stray Energy | UV LEDs do not use reflectors internally since the energy is all forward facing. Some UV LEDs incorporate external mirrors, glass rods, etc. or internal micro-optics as a means to better control and enhance the output onto the substrate (see fig. 2). |
| **Process Design Considerations** | | | | |
| **Working Distance** | 2.1 inches | 2.1 inches | 5mm to 20mm | Distance from the face of a UV curing system to the substrate surface. UV energy reaching the substrate drops significantly the larger the working distance, even more so with UV LED systems which emit energy from the emission window at high angles. Semray uses micro-optics to focus the energy enabling larger working distances with less drop in UV energy onto the substrate. This results in reduced contamination of the emission window, thus a more consistent process with increased uptime. |
| **Uniformity Across Wide Web** | OK | Best | Best | As an arc lamp ages the lamps ends darken impacting the uniformity of UV energy output across its length, i.e. the width of your converting line. UV LEDs at close distances have poor uniformity, but increasing working distance to improve uniformity decreases energy density on the substrate. Semray uses micro-optics which enables larger working distances which significantly improves uniformity, while maintaining high energy density, especially alongside Semray‘s self-monitoring sensors which dynamically adjust the LEDs to maintain consistent energy output (see fig. 3). |
| **Consistent & Reliable** | Good | Better | Best | UV LED curing offers significantly more consistent UV energy and wavelength output and high process reliabilty, especially compared to arc lamps whose output and wavelength shift cause inconsistent curing, especially for additive lamp processes like laminating. |

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| **Maintenance Costs** | Highest | Middle | Lowest | The savings here can be significant, not only in maintenance labor and consummable parts, but also reduced downtime that results with UV LED curing. Semray's on-board diagnostics and modular platform enable quick troubleshooting and even less maintenance downtime. More infos about reducing downtime with UV LED |
| **First Cost** | Lowest | Middle | Highest | First cost of the UV LED system is typically higher, but installed facilities costs for things like blowers, ducting, and light shielding is significantly less. First cost should be weighed against Total Cost of Ownership (see below), production rates and resulting increased revenues. |
| **Total Cost of Ownership** | Highest | Middle | Lowest | UV LED TCO is lowest based on lower maintenance, energy, consummable parts costs and upgrading. UV LED technology advances rapidly, so TCO depends on a less costly and easily upgradeable platform. Semray's modular plug & play platform enables easy and less costly upgrades (see fig. 4). |
| **Heat Sensitive Substrates** | Good | Better | Best | UV curing is considered a „cooler" process than thermal drying/curing processes. UV LED curing enables curing of heat sensitive substrates not possible with traditional UV curing. As a result, it may be possible now to UV cure new products, expanding converting capabilities on existing lines. |
| **Chemistry Availability** | Mature, many available chemistries | Mature, many available chemistries | Laminating adhesives and PSAs, expanding to other chemistries | UV LED chemistry formulations are available for laminating adhesives, PSAs, and transdermal patch hydrogels or where UV energy can penetrate a transparent film. Additional chemistries are being developed as UV LED curing expands into additional converting applications. Hybrid UV curing, combining the use of traditional UV with UV LED, is another option that provides flexible process solutions and takes advantage of UV LED's benefits. |


Figure 1: UV segment coming out of the backplane


Figure 4: Plug & Play segment

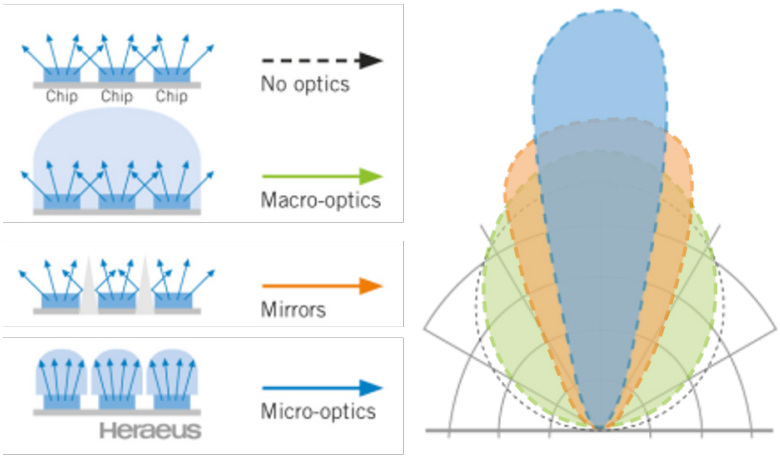


Figure 2: Heraeus UV LED Microoptics

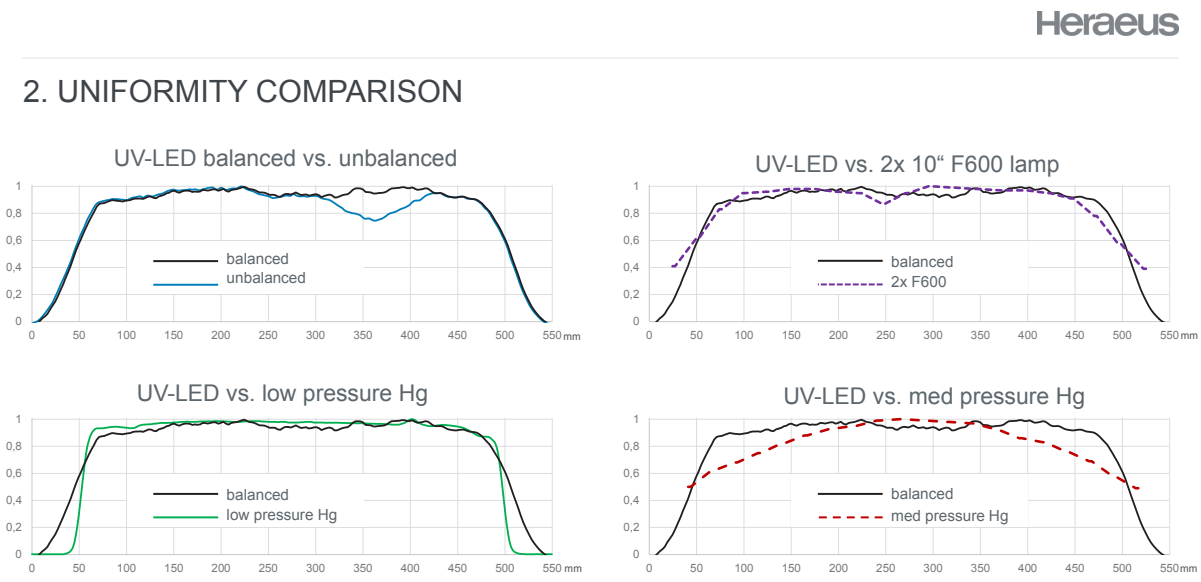


Figure 3: Unifomrity of UV LED