Market Update on UV LED Applications

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UV LED Markets

Product Assembly (by cure surface size)
- Spot Cure
- Area Cure

Printing (by print method)
- Ink Jet
- Screen
- Pad
- Flexo
- Offset

Industrial (by formulation)
- Coatings
- Adhesives
- Sealants
- Fillers
- Silicones
UV LED Markets

Product Assembly (by cure surface size)
- Unique UV LED Adoption Drivers

Printing (by print method)
- Unique UV LED Adoption Drivers

Industrial (by formulation)
- Unique UV LED Adoption Drivers

Universal UV LED Adoption Drivers
UV LED Adoption Factors

- Age of market.
- Production volumes of new integrated OEM machines.
- Price point of new integrated OEM machines.
- Length and frequency of machine engineering cycle.
- Expected length of machine life.
- Ease of retrofitting to existing machines.
- Cost of retrofitting to existing machines.
- Availability of technical or engineering resources at OEM or end-user site to manage integration.
UV LED Adoption Factors

- Mounting location of UV source with respect to substrate.
- Production line speed.
- Quantity and activity of formulators, component suppliers, and machine builders.
- Type and function of formulation required.
- Does UV LED hold up to supplier’s published specifications?
- Ability to correlate output of UV LED to conventional UV for established processes.
- Desire of end user or OEM machine builder to drive adoption.
- Market examples and previous personal experience with LED technology.
# Universal UV LED Adoption Drivers

<table>
<thead>
<tr>
<th><strong>BENEFIT</strong></th>
<th><strong>FEATURE</strong></th>
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<tbody>
<tr>
<td><strong>Advanced Capabilities</strong></td>
<td>Heat-sensitive, thin substrates.</td>
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<td>Deep, through curing.</td>
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<td>Controlled curing irradiance.</td>
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<td><strong>Operating Economics</strong></td>
<td>Energy efficient.</td>
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<td>Long lifetime &amp; low maintenance.</td>
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<td>Low operating temperatures.</td>
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<td><strong>Environmental Advantages</strong></td>
<td>Mercury &amp; ozone free.</td>
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<td>Safe UV-A wavelength.</td>
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<td>Workplace safety.</td>
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**UV LEDs provide un-matched process stability & control.**
Universal UV LED Adoption Drivers

UV LED lamps available at 365 or 385 or 395 or 405nm wavelengths. Materials must be formulated to take advantage of narrow wavelength. Output power can exceed 1kW of pure UV-A energy.

UV LEDs emit extremely high power in a narrow spectral range.
Universal UV LED Adoption Drivers

UV LEDs show consistent improvement that is further leveraged to maximize performance.
Universal UV LED Adoption Drivers

Sourcing

Access to sourced components
Tight specifications
Rigid qualifications

Manufacturing

Clean-room environment
Workstation cells
Calibrated instruments

Testing

Burn-in
Recalibration
Packaging

UV LEDs are high-tech electronics that must be built & tested to semiconductor standards.
Universal UV LED Adoption Drivers

Highly Accelerated Life Test Chamber
Temperature: -70 °C → +150 °C in 3 min
Random 6-axis vibration testing

Environmental Chamber
Temperature: -10 °C → +80 °C
Relative Humidity: 10% → 90%

To ensure years of safe & reliable service, curing system suppliers must invest in pre-shipment product testing.
UV LED Markets

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Spot Cure - UV LED Adoption Drivers

**Application:** curing sealants, adhesives, and coatings in small-scale (often bench-top) product assembly operations.

- Energy density tends to be more important than peak irradiance.
- Often need to cure only a small and specific area.
- Slower process speeds allow energy density to build over time.
- Often sold as bundle (dispenser, formulation, curing system).
Application: curing sealants, adhesives, and coatings in large production assembly processes...particularly large flat screen electronics (smart phones, tablets, TVs, monitors).

- Eliminates masking step to protect electronics sensitive to broad band UV emissions.

- Assemblies often include heat sensitive components.

- Energy density tends to be more important than peak irradiance.

- Slower process speeds allow energy density to build over time.

- Often need to cover wide area with a uniform emission.

- Often incorporated into brand new green-field sites.

- Often sold as bundle (dispenser, formulation, curing system).
Inkjet Printing - UV LED Adoption Drivers

Application: producing roll-to-roll and flat bed, cut-sheet graphics and POP displays as well as direct to product marking, coding, and decoration via X-Y scanning and single pass print configurations.

- New market more receptive to innovative technology.
- Print heads mounted close to substrate.
- LED formulated Inks work well at 395 nm.
- Slower line speeds.
- Shorter printer engineering cycles.
- Shorter printer life cycles.
- Numerous formulation and component suppliers driving activity.
3D Printing - UV LED Adoption Drivers

Application: making a physical object from a 3D model by laying down and curing many successive thin layers of material. Classified as additive manufacturing.

- New market more receptive to innovative technology.
- UV LED curing units have small form factors.
- Print heads mounted close to substrate.
- Slower line speeds.
- Shorter printer engineering cycles.
- Shorter printer life cycles.
- Formulation activity ongoing.
Screen Printing - UV LED Adoption Drivers

Application: forcing ink through a prepared screen of fine material to create a functional or decorative patterns for nameplates, overlays, membrane switches, decals, labels, graphics, bar codes, containers & bottles, etc.

- LED inks work well at 395 nm.
- Arrays easily mounted close to substrate and easily adapted to existing machines.
- Slower line speeds.
- Enables curing of more opaque white inks and more pigmented inks.
- Eliminates need for fiberglass belts (reduces plant dust).
- Decreases post press processing delay.
- Challenge: Slower adoption due to fragmented industry structure.
Application: transferring a 2D image from an etched plate onto a 3D object using a flexible silicone pad. Utilized to decorate household products, appliances, packaging, electronics, promotional goods, medical devices, sporting goods, etc.

- Minimal activity in this area by all relevant parties.
- Arrays easily mounted close to substrate and adaptable to machines.
- Existing conventional UV inks often work well at 395 nm and are very similar to UV LED screen inks.
- Enables instant product packing.
- UV inks have greater longevity.
- Challenges: Solvent based inks already cure quickly. Few inks formulated specifically for UV LED. Lower price point machines.
Application: utilizes a flexible relief plate to print on almost any type of substrate (plastic, metallic films, cellophane, and paper) to create labels, packaging, game cards, etc.

- Arrays mount close to substrate and adaptable to existing machines. Base machines built to last. End-users replacing conventional UV that has exceeded the end of its useful life.

- Large multi-national companies with dedicated R&D centers making investments and taking a corporate approach.

- More ink, adhesive, and coatings companies formulating for LED.

- UV LED inks and adhesives work well at 395 nm.

- Enables curing on heat sensitive shrink films without chilled rollers.

- New machines selling.
Offset Printing - UV LED Drivers

Application: inked image is transferred (or “offset”) from a plate to a rubber blanket, then to the printing surface. Used to decorate or apply graphics to sheet metal, plastic and paper containers, and various paper media.

- Older and very established market segment.
- Often incorporate relatively fast line speeds.
- Fewer new machines being built.
- LED installations on existing paper media presses only.
- Machine form factors and designs often prevent arrays from being mounted close to cure surface....requiring more powerful arrays or special optics.
- Much more work required to reformulate or requalify existing inks, coatings, and adhesives.
Industrial Coatings - UV LED Drivers

Application: roll, vacuum, spray, curtain, etc. applied and cured coatings on 3D parts made from metal, wood, and plastic.

- Minimal activity in this area by all relevant parties.
- Increasing interest by end-users (example: pipe and tube anti-corrosion coatings) and more awareness of necessary future activity by formulators.
- Often fast line speeds.
- UV sources often positioned at a greater distance from cure surface.
- Often complicated 3D part profiles.
- Functional coatings often require photoinitiators outside 395 nm range.
Wood Coatings - UV LED Adoption Drivers

**Application:** roll coating and curing of fillers and top coats onto home and office cabinets, commercial doors, and high-end furniture.

- Reduced board surface temperature (BST).
- Arrays mount close to substrate and adaptable to existing machines. Base machines built to last. End-users replacing conventional UV that has exceeded the end of its useful life. Reduced curing space & reduced line length requirements.
- Commercial installations in Europe - transitioning to US.
- Challenge: Hybrid solution still requires low powered mercury arc for final cure. Hopeful that higher power 365 nm units may allow for 100% LED.
## Choosing a UV LED Component Supplier

<table>
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<th>FACTOR</th>
<th>QUESTIONS</th>
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| UV LED Capability     | 1) Percentage of resources dedicated to UV LED?  
2) Percentage of revenue from UV LED?  
3) Demo units / samples available for testing? |
| Intellectual Property | 1) How many UV LED patents?  
2) Enable end-users freedom to operate? |
| Reliability           | 1) Utilize Highly Accelerated Life Tests (HALT)?  
2) Utilize semiconductor mfg and burn-in process?  
3) Certifications?  
4) Long-term life testing > 40,000 hours? |
| Support               | 1) Worldwide Sales & Technical support?  
2) Worldwide UV LED understanding?  
3) Root cause analysis & reporting? |
Ongoing Development Trends

- Irradiance continues to increase in UVA region (365, 385, 395, 405 nm).
- R&D efforts continue in UVB and UVC region.
- Availability of more high-powered, air-cooled solutions.
- Reliability and useful life continues to improve (>20,000 hours).
- More formulators, more OEMS, more integrators, more end-users embracing the technology and driving new developments.
- End-users opting to integrated directly to existing production systems.
- Increasing awareness and increasing understanding.
- Greater collaboration and focus.
Thank You!

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