An Introduction to UV LED Technology

Jennifer Heathcote
Integration Technology Limited
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RADTECH UV&EB 2012

INTEGRATION TECHNOLOGY

IST® METZ HOLDING
more than UV

UV LED End User Session

Start Time	End Time	Topic	Company	Presenter
1:00 pm	1:20 pm	Overview	Integration Technology	Jennifer Heathcote
1:20	1:40	Coatings	Phoseon	Cad Taggard
1:40	2:00	Photoinitiators	DSM	Beth Rundlett
2:00	2:10	• • • • • • • • • • B R E A K • • • • • • • • •		
2:10	2:30	Measurement	E.I.T.	Paul Mills
2:30	2:50	Printing	Lumen Dynamics	Nidal Abbas
2:50	3:10	Resins	Cytec	Jon Shaw
3:10	3:15	• • • • • • • P A N E L S E T - U P • • • • • • •		
3:15	4:00	• • • • • • • • • P A N E L • • • • • • • • •		

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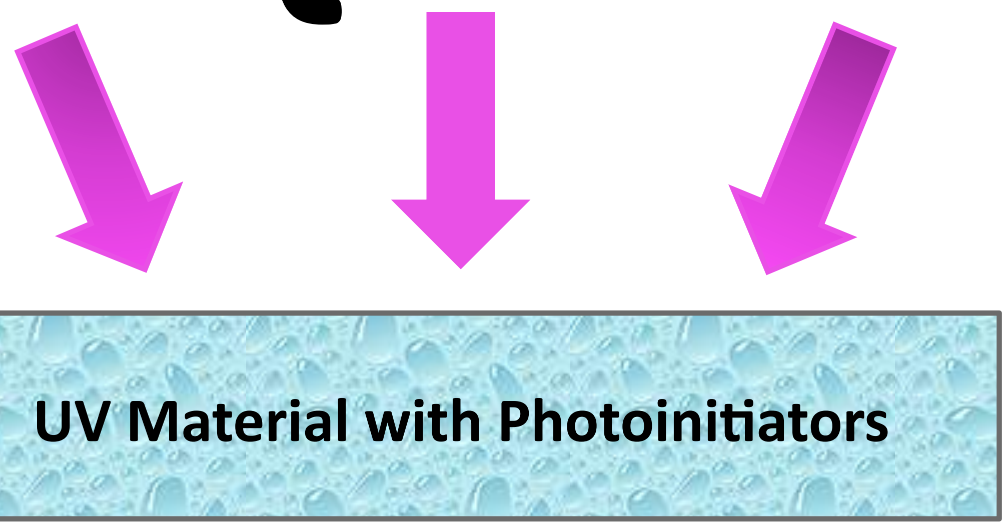
Integration Technology Limited (ITL)

- UK Company - founded in 2000
- Developer and manufacturer of UV Systems (Arc & LED)
- Innovative R&D culture
- Global reach with local support
- Company owned offices in Chicago, Oxford, Shanghai, Seoul, and Tokyo.
- 14 total offices through German based strategic partner IST METZ

UV "Source" Selection

UV Energy

- Wavelength (nm)
- Irradiance (Watts/cm^2)
- Energy Density (Joules/cm^2)



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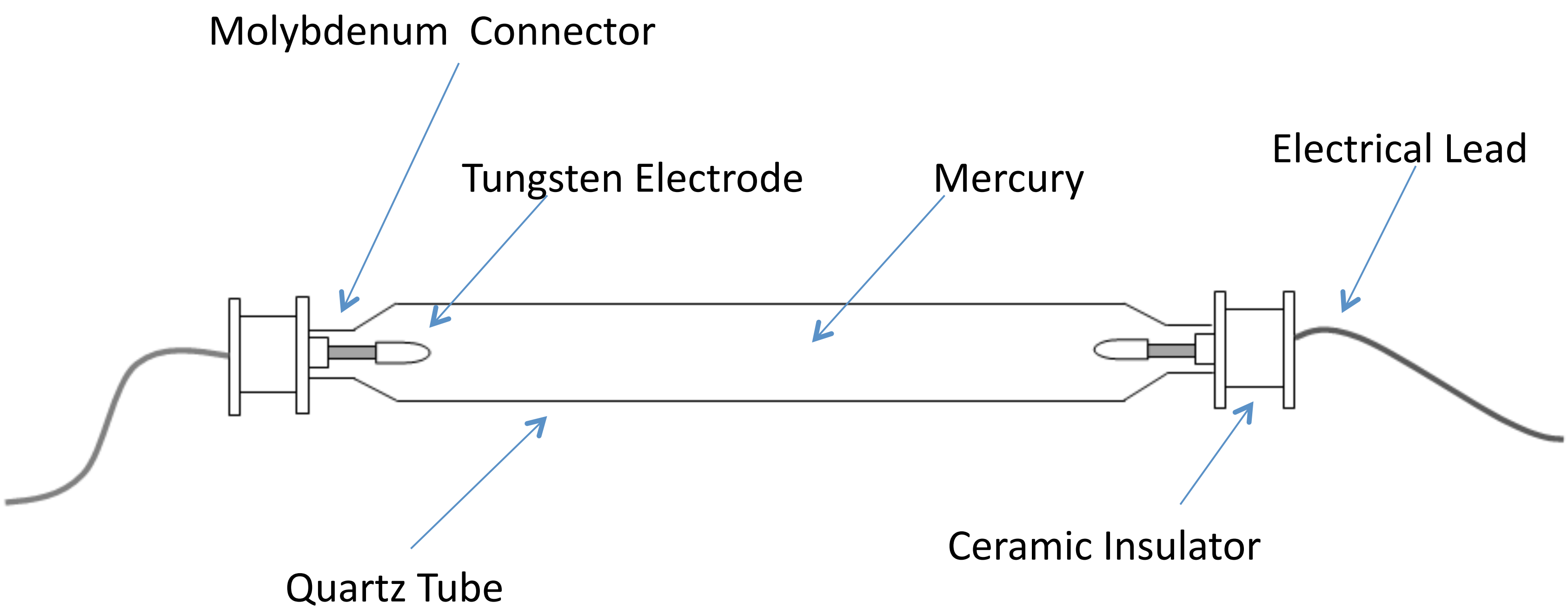
UV “Arc” Technology



Vaporized mercury inside sealed quartz tube emits a peak UV wavelength at 365 nm.

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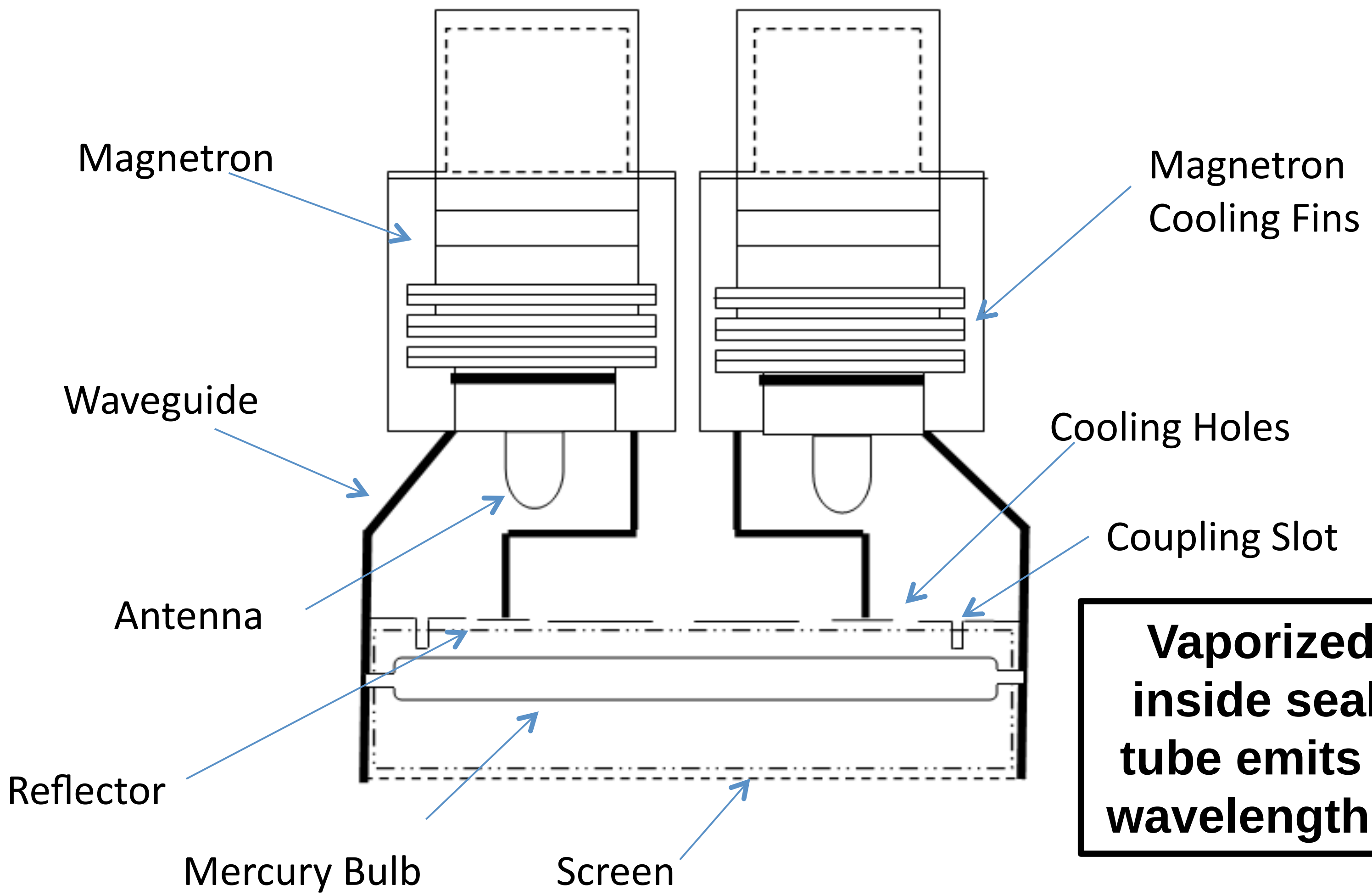
UV “Microwave” Technology



Vaporized mercury inside sealed quartz tube emits a peak UV wavelength at 365 nm.

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UV LED P-N Junction

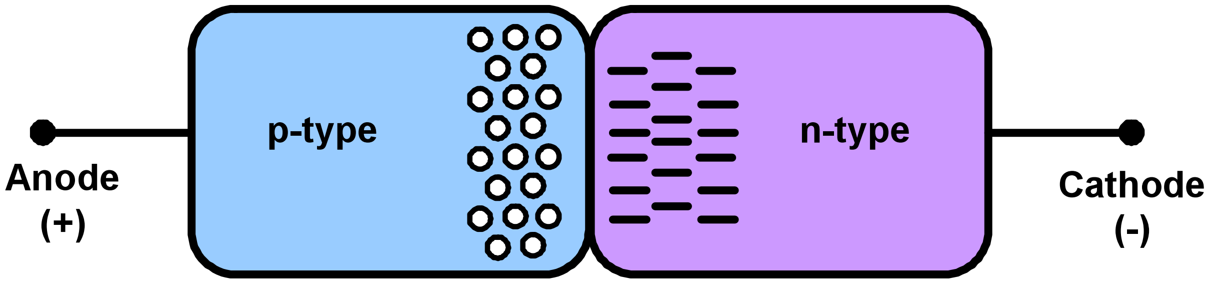

Illustration of a single Positive-Negative Junction, Light Emitting Diode (LED), Chip, Diode, Die, Semiconductor…

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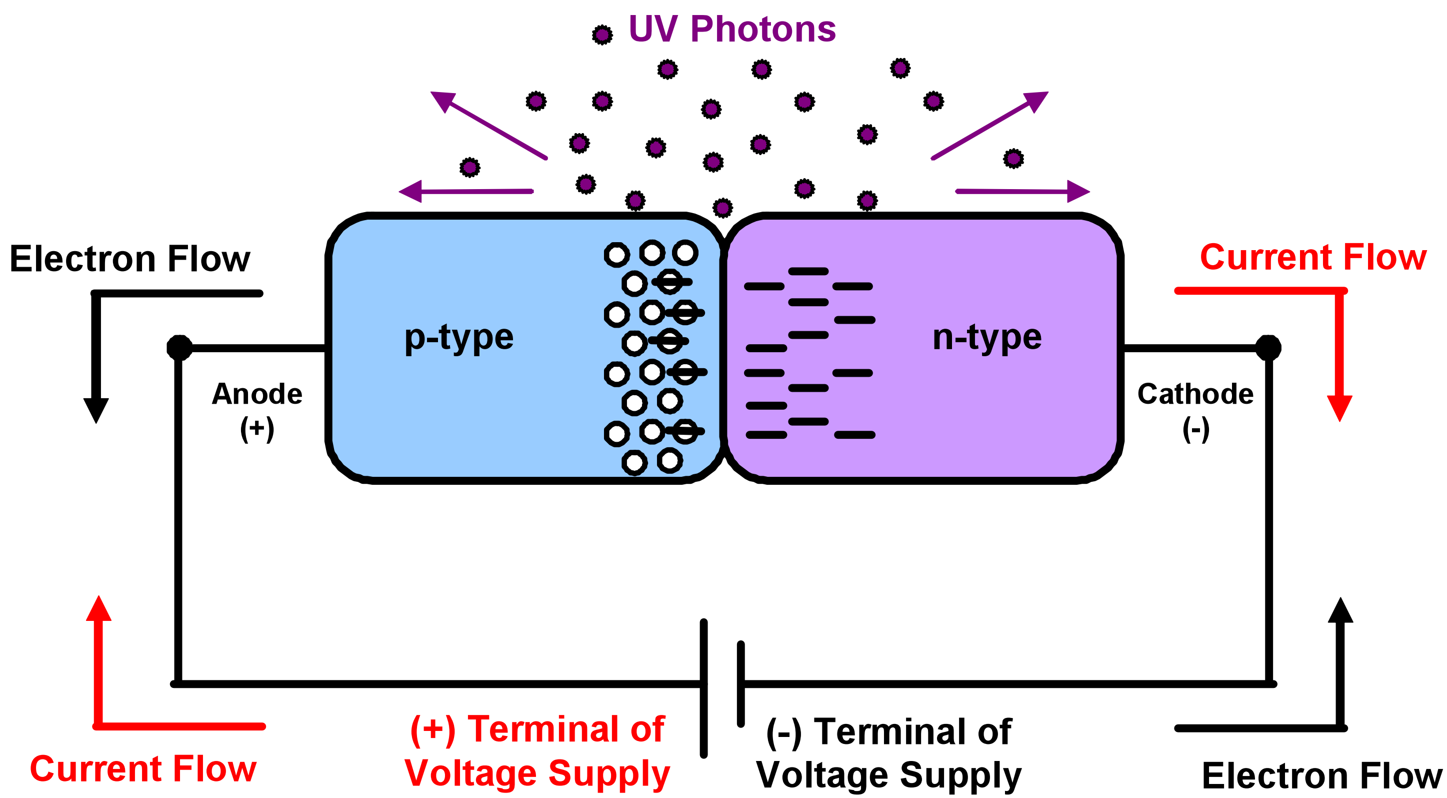
UV LED P-N Junction



↑ **Current** ↑ **Irradiance (Watts/cm^2), but it's neither a linear relationship nor one without limit.**

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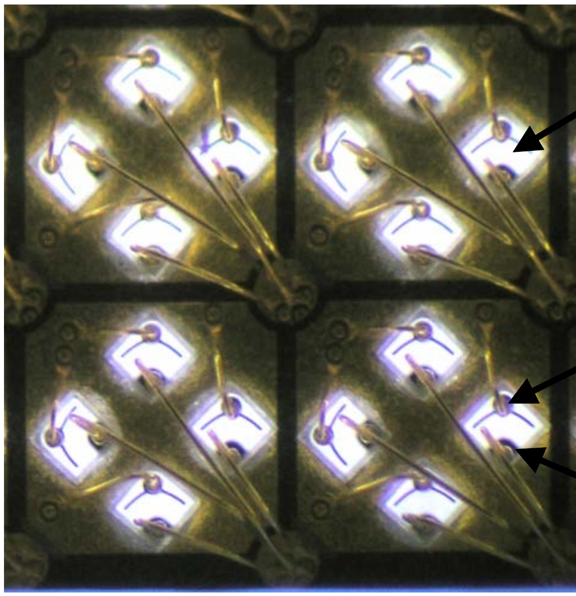
UV LED Technology (Packaging)



2.5 mm

2.5 mm

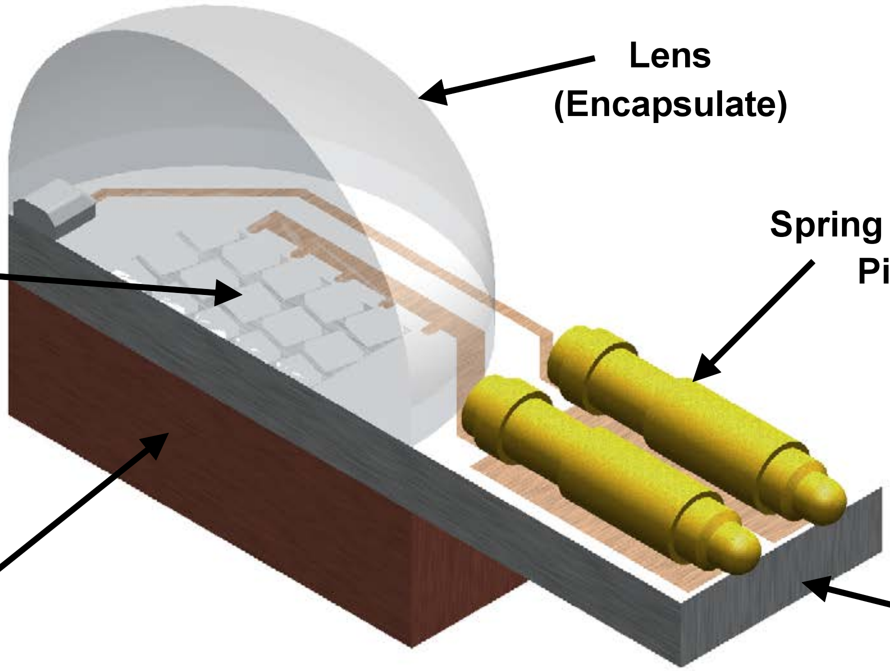
16 x LED, Chip, Diode, Die, Semiconductor

16 x Anode Wire Bond

16 x Cathode Wire Bond

Wire bond temps must not exceed 110^{0}C typically. Cooling is critical.

UV LED Technology (Packaging)



LEDs are typically < 20% efficient at converting electricity to UV.
Air or liquid cooled heat sinks move heat away from diode & wire bonds.
Every ºC ↑ in diode temperature typically ↓ irradiance 0.5%.

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UV LED Systems

Components

- UV LED Array (Head)
- DC Power Supply / Controller
- Cables
- Cooling system
  (Air or Liquid)
- Light shielding
- Interlocks

HiCure (air cooled)

SolidCure (liquid cooled)

PinCure (air cooled)

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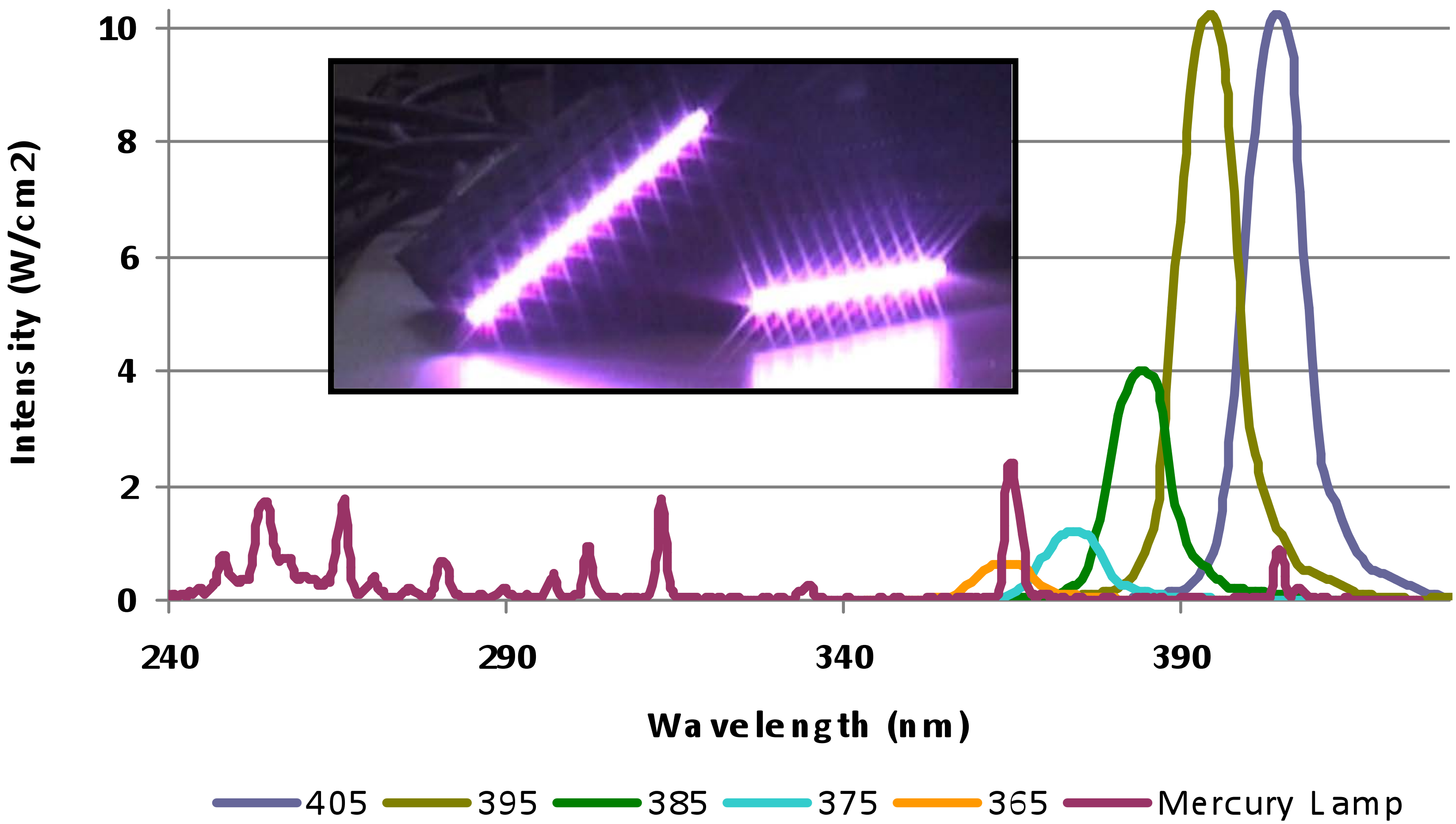
Relative Spectral Outputs (Mercury and UV LED)



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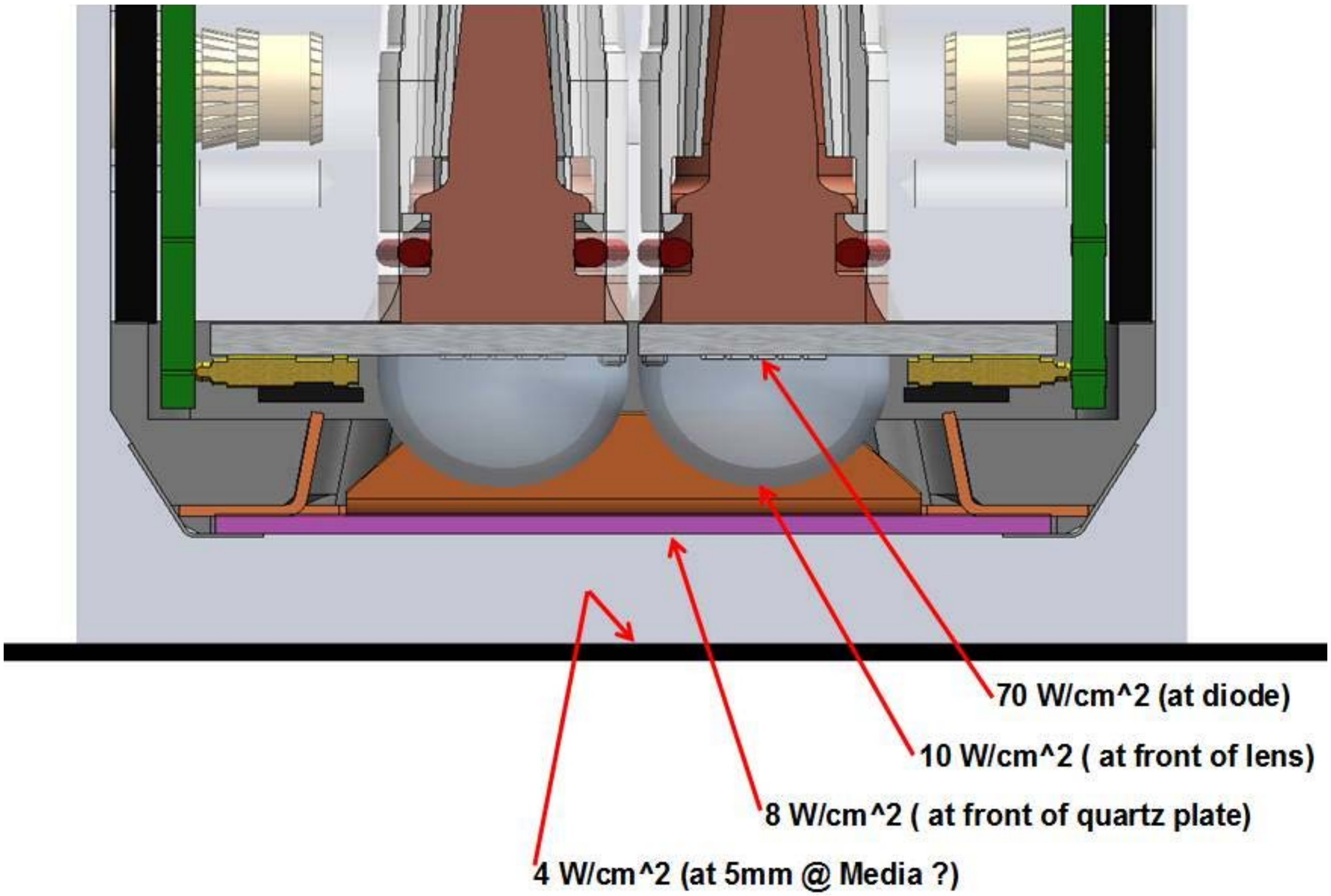
But where is the location of reference for Irradiance Specifications (Watts/cm²)?



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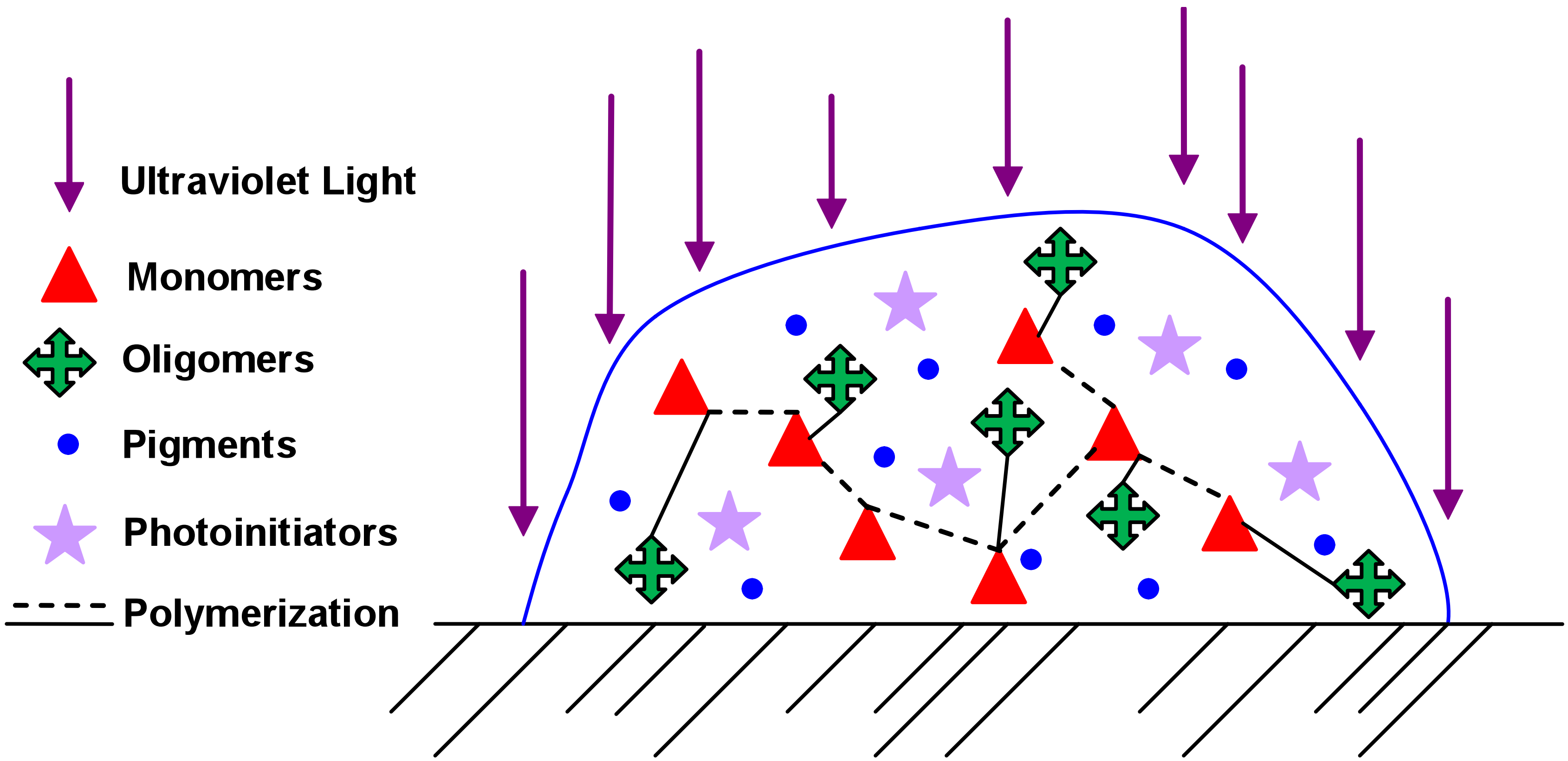
Photopolymerization



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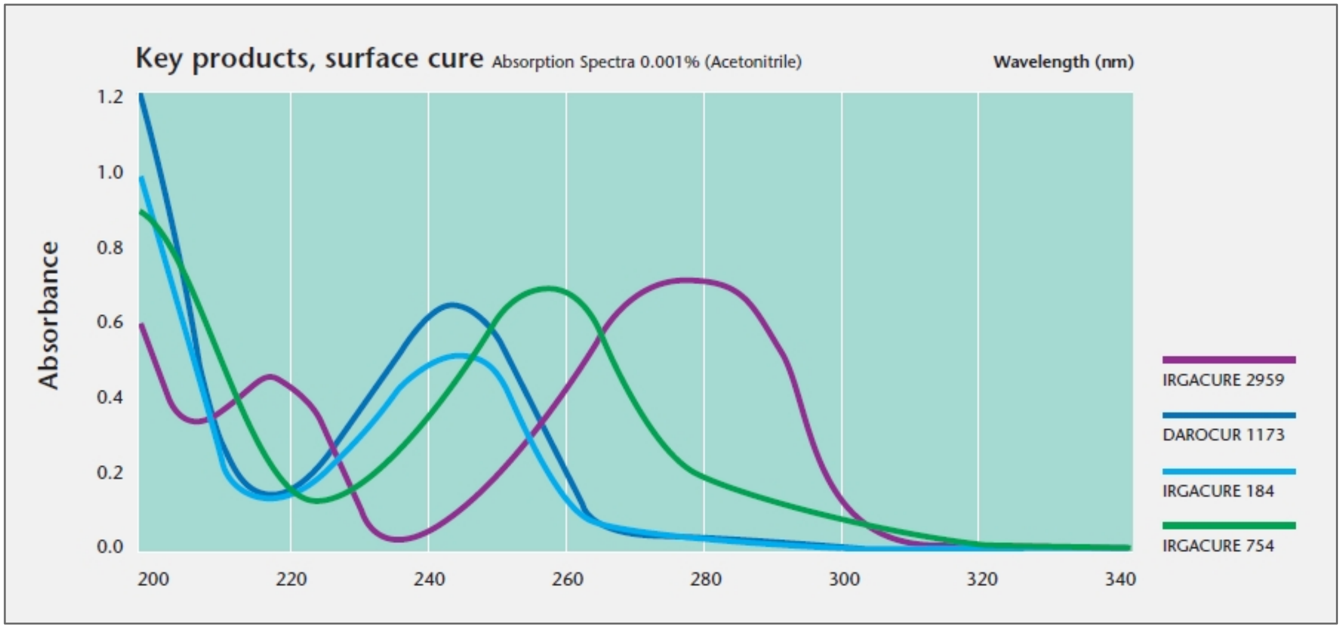
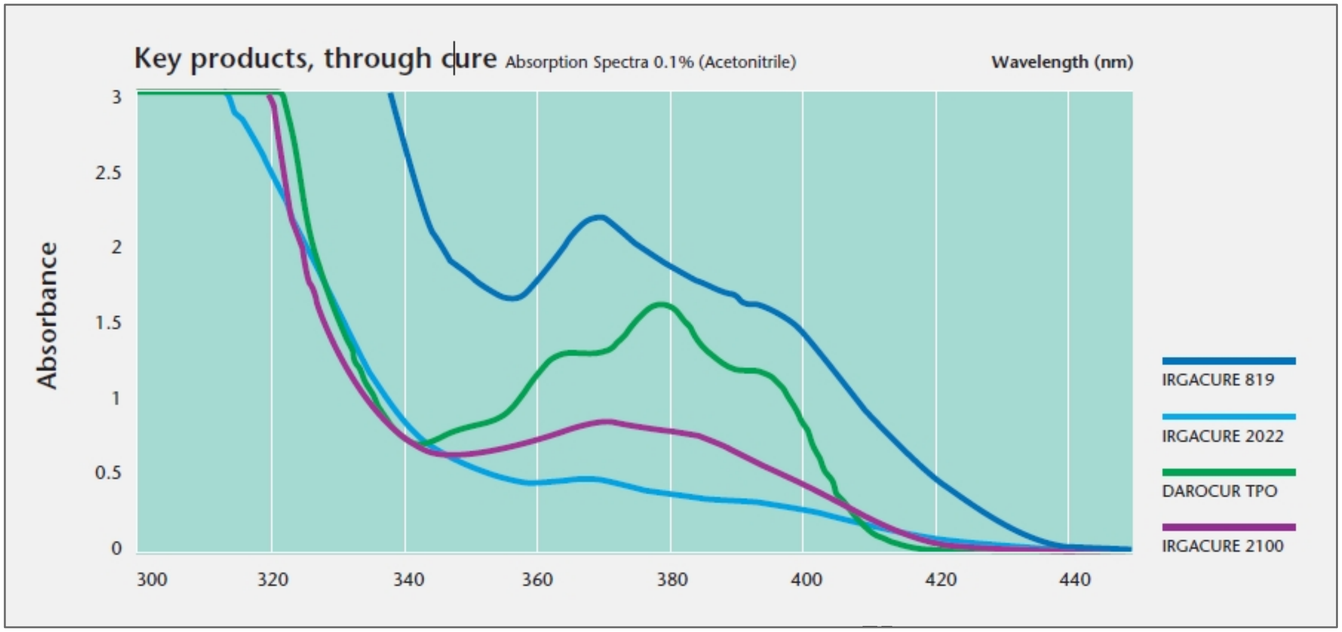


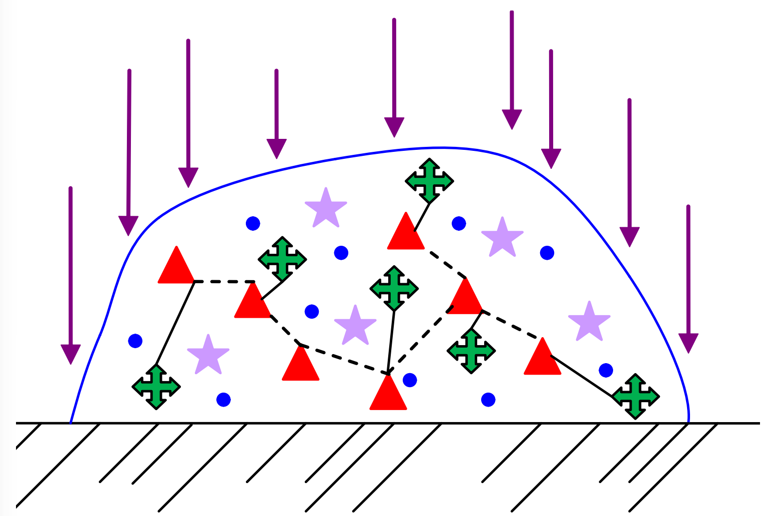


Source: Ciba/ BASF

Photoinitiator Selection Guide

UV Curing Applications	IRGACURE 184	IRGACURE 500	IRGACURE 754	DAROCUR 1173	IRGACURE 2959	DAROCUR MBF	IRGACURE 651	IRGACURE 369	IRGACURE 907	IRGACURE 1300	DAROCUR TPO	DAROCUR 4265	IRGACURE 819	IRGACURE 819 DW	IRGACURE 2022	IRGACURE 2100	IRGACURE 784	IRGACURE 250
	Surface cure, co-initiator for pigment systems							Through cure, pigmented systems										
UPES Wood Top and Intermediate Coat	●	○		○			●				●		●		●	●		
Acrylated Wood Top and Intermediate Coat	●	●	●	●	○	○							○		●	●		
Wood Fillers	○			○			●				○	○	●		○	●		
Clear Top Coats on Plastic and Metal	●	○	●	○	○	○												○
Pigmented Top Coats on Plastic and Metal	●	○	●	●	○	○					○	○	●	●	●	●		●
UV Powder Coatings					●		○						●					
Dispersions for Facades		●	○											○				
Adhesives	●			○	●		○	○			○	○	●		○	○		●
Glass Fiber Composites	●						○				○		●		●			
Gel Coats	●						○				○		●		●			
Etch Resists for PCB							●	●	●				○				●	
Solder Masks							○	●	●				○				●	
Epoxy Resists																		○
Flexo Printing Plates							●	○					○					
Laser Direct Imaging Offset Printing Plates																	●	
Offset Inks	○			○	○			●	●	●	○	○	●		●	●		
Screen Inks	●			○	○			●	●	○	○	○	●		●	●		●
Flexo Inks Inkjet Inks	○			○	○			●	●	●	○	○	●		●	●		●
Over Print Varnishes	●	●	●	●	●	○							○					○
Cationic Polymerization																		●
Thick Sections Polymerization											○	○	●		●			○
UV Stabilized Clear Coatings	●		●	○	○	○					○	○	●	●	●	●		
Water-based UV Formulations		●	●	○	●	○								●	○	○		
Xi- and Xn-free Applications	●				●	●	●	●		●								
Low Volatility, Low Odor			●		●			●					●	●		●		

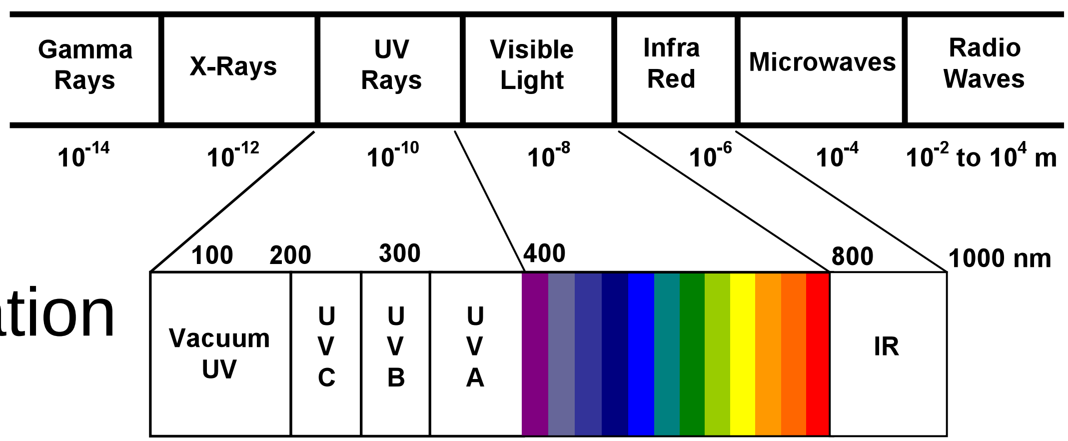
● recommended application
○ possible application



Source: CIBA Specialty C Chemicals / BASF

UV LED System Advantages

- Instant on/off (no shutters)
- Uniform radiation across the exposure width
- Long service life (>20,000 hours)
- Consistent UV output over operating life
- No air extraction or conditioned plant make-up air
- No infrared in spectrum (less heat on substrate)
- No harmful UVC
- No ozone
- Compact
- Lower cost of operation



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UV LED System Challenges

- Rapidly evolving technology
- Evolution dependent on diode development, packaging, cooling, and use of optics
- Higher irradiances typically require liquid cooling
- High irradiances don't always deliver high energy density
- Misleading product specs
- Different products needed for different applications
- Marginal cost for larger arrays relatively high
- Not all conventional formulations work with LEDs
- Limited choice of specially formulated LED chemistry
- Higher speed applications often cost prohibitive

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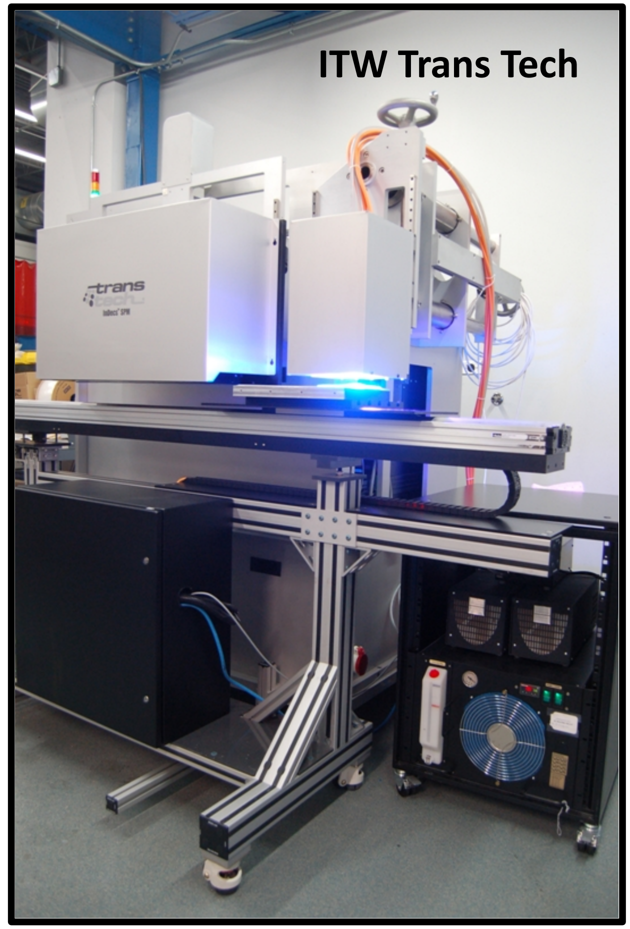
Characteristics of Application Successes

- Photoinitiator absorption curve overlaps LED spectral output curve
- UV LED source can be "close" to cure surface (<1.5")
- Lower speed applications (faster speeds are possible but require many more diodes….can be cost prohibitive)



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Driving Factors of Application Successes

- Applications with heat sensitive substrates
- Companies striving for high tech or environmentally green manufacturing processes
- Desire to understand (gradual adoption)
- Economics (overall plant savings in operation, maintenance, and scrap costs)

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Points to Consider Regarding Irradiance (Watts/cm^2)...

- LED systems often produce much greater irradiance levels than conventional UV systems
- Highest irradiance occurs at the diode
- Irradiance @ cure surface ↓ the further array is located from cure surface (< 1.5 inches typical)
- Higher irradiance seems to provide an initial benefit for curing at faster line speeds and achieving surface cure
- Increasing irradiance further doesn't necessarily guarantee better cure or adhesion (recent evidence indicate ≤ 8 Watts/cm^2 seems sufficient)
- Higher irradiance LED systems are less efficient and produce more heat…need better or increased cooling

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Points to Consider Regarding Energy Density (Joules/cm²)….

- Dose (Joules/cm²) is a factor of:
  - Number of passes under UV source
  - Line speed (dwell time under UV source)
  - Number of diodes in LED array
- Higher speed applications require many more LED diodes to generate necessary energy density. This can make some high speed applications cost prohibitive.

Autobond Spot Varnish


Kammann Screen Printer Installed at Empire

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Points to Consider Regarding Applications….

- No one-size-fits all UV LED solution
- No industry standards exist at present – difficult to compare market offerings. Actual trials needed.
- The technology has evolved such that "a solution" can be found for most applications…..but bear in mind that the solution may often be too expensive or physical constraints of existing machinery may prevent array(s) from being located close enough to cure surface to be effective.
- Technology push…..need application feedback for next generation of products.
- Full plant cost analysis should be done to determine impact and pay back of adopting UV LEDs.

Flint's linyloflex®
NExT Exposure F III

Conclusions….

- Overall adoption of UV LEDs is steadily increasing
- General interest and education regarding UV LEDs is growing across all markets
- UV LED technology can be made to work if companies are willing to do the formulation work
- UV LEDs are not currently a replacement for all traditional arc lamp or microwave applications due to economics and inability to cure cost effectively at high speeds and from a distance
- Misinformation and misunderstanding cloud the picture and delay adoption
- Digital inkjet, sealants, adhesives, and screen represent the greatest short term opportunities. High Speed offset and 3D Industrial are longer term.

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Thank You!

Integration Technology Limited
Jennifer Heathcote
General Manager North America
jheathcote@uvintegration.com
www.uvintegration.com

IST America
Joe Ooten
Vice President Sales and Marketing
joe.ooten@usa.ist-uv.com
www.ist-uv.com

UV LED Curing Association
www.uvledcuring.org
Integration Technology is a founding member of the UV LED Curing Association

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