Mercury, LED, and Excimer UV Curing Systems

allnex Customer Summit

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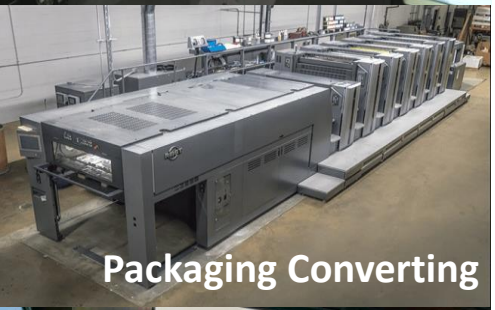
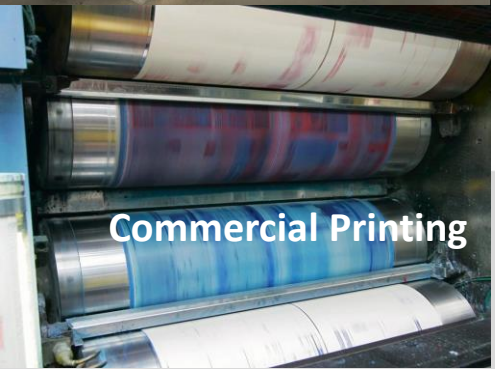
GEW
...engineering UV

GEW (EC) Limited

- UV curing system manufacturer
- founded 1991
- family owned and managed
- UK-based
- regional offices in Germany and USA
- global distribution
- annual revenue >£50M
- >130 employees globally
- >20K systems shipped

UV Curing Market Segments





Application Technologies

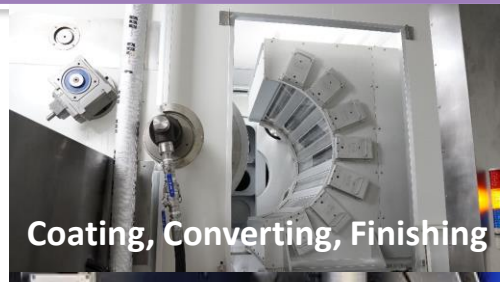
flexo
offset
digital inkjet
gravure
screen
rotary screen
coating
extruding

GEW Focused Market Segments

label converting
commercial printing

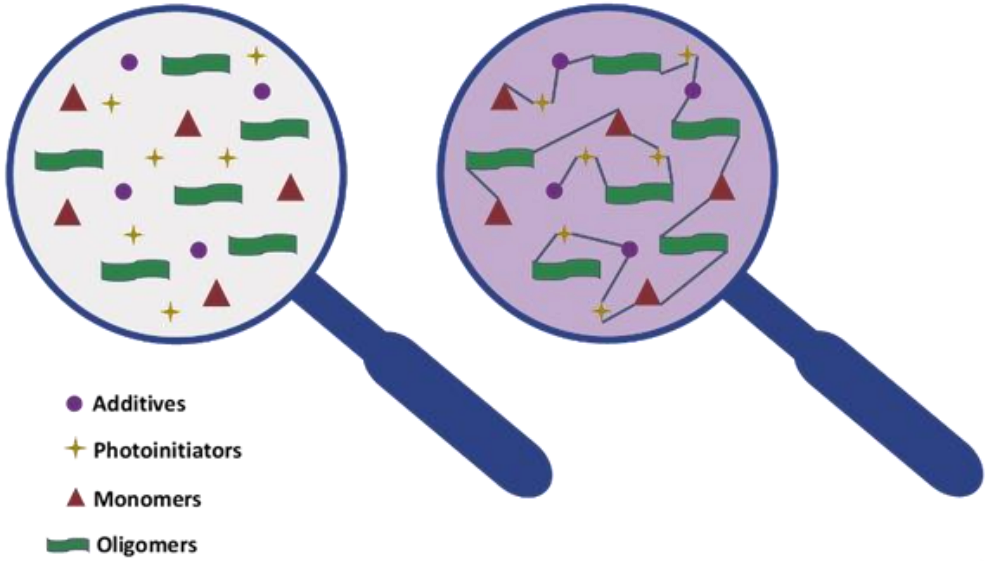
Market & Application Examples

www.gewuv.com/uv-curing-applications/



What is UV Curing?

- **UV Curing** creates strong chemical bonds between molecules via crosslinking
- **UV Curing** produces long continuous molecular chains that drive highly desirable functional and aesthetic properties
- **UV Materials** are typically 100% solids, contain no liquid carriers, and require no thermal drying

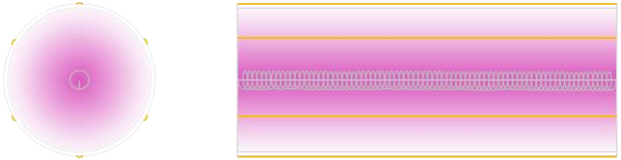


Types of UV Curing Sources

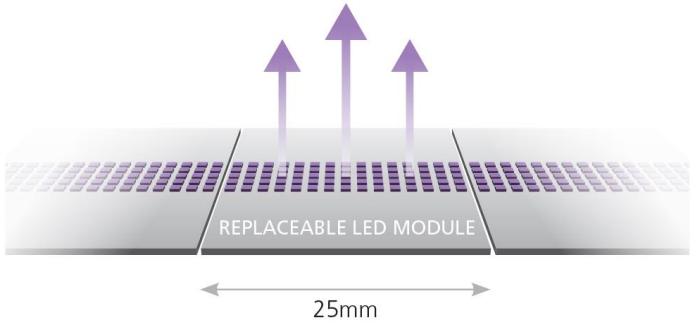
Mercury Vapor: Arc or Microwave
(medium pressure gas discharge)

image is arc lamp

Excimer
(dielectric barrier discharge)



Light Emitting Diode
(solid state semi-conductors)



In depth UV curing source explanations:

https://www.gewuv.com/uv-curing-sources/

Types of UV Curing Sources

Mercury Vapor Arc Lamp
(up to 2.5m)

Light Emitting Diode
(up to 1.7m)

Excimer
(up to 2.3m)

ArcLED® Hybrid
(up to 1.7m)

UV Curing Technologies…

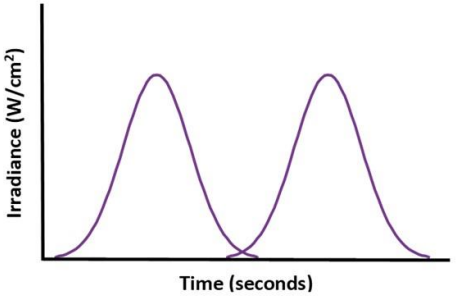
GEW ...engineering UV

Characterizing Output from UV Sources

- **Wavelength (nm)**
  - *distance* between corresponding points on a wave
  - a nanometer (nm) is a billionth of a meter
  - a sheet of paper is 100,000 nm thick; ultraviolet light is between 100 and 450 nm
- **Irradiance (W/cm^2) or intensity**
  - radiant power arriving at a surface from all forward angles per unit area
  - *dose rate* ($J/cm^2/sec$) or rate of energy delivery
- **Energy Density (J/cm^2) or dose**
  - *total radiant energy over time* arriving at a surface per unit area
  - integration of irradiance over exposure time (area under the irradiance profile)
- **Electrical Power (W/cm)**
  - *nominal specification*: wattage of power supply / length of lamp
  - doesn't capture efficiency, lamphead design, set-up, process conditions

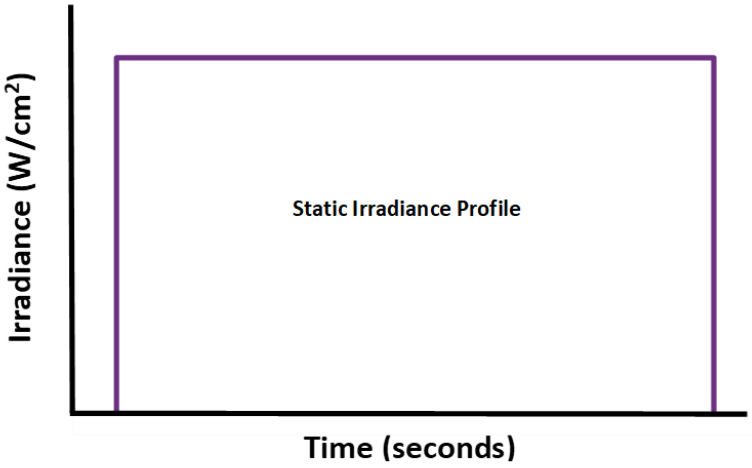
Graphically Illustrating UV Output

- irradiance profiles plot irradiance over time
- energy density is area under the profile
- factors affecting profile shape and magnitude
  - UV source type
  - UV source design
  - power setting
  - lamp life
  - cleanliness and operational up-keep (maintenance)
  - distance of UV source from cure surface
  - path in front of UV source
  - line speed/dwell time under lamps
  - number of lampheads
  - number of passes
  - radiometer

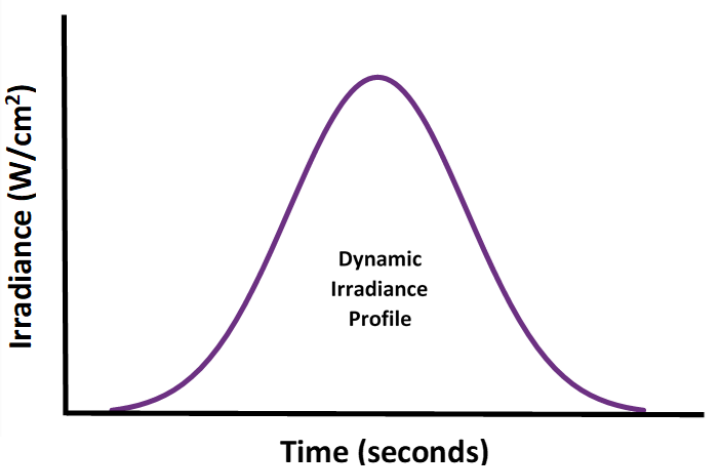


Graphically Illustrating UV Output

Peak Irradiance in (W/cm^2) = ($J/cm^2/sec$) = Dose Rate

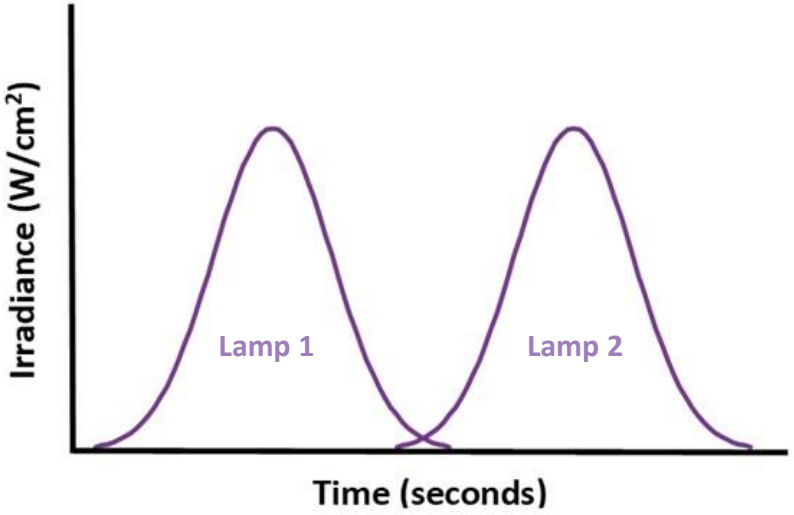


Energy Density in (J/cm^2) = Area Under Curve

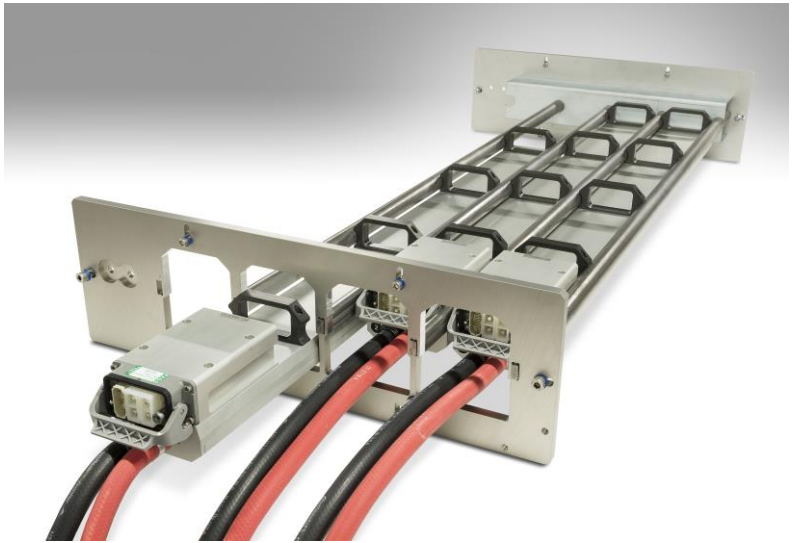


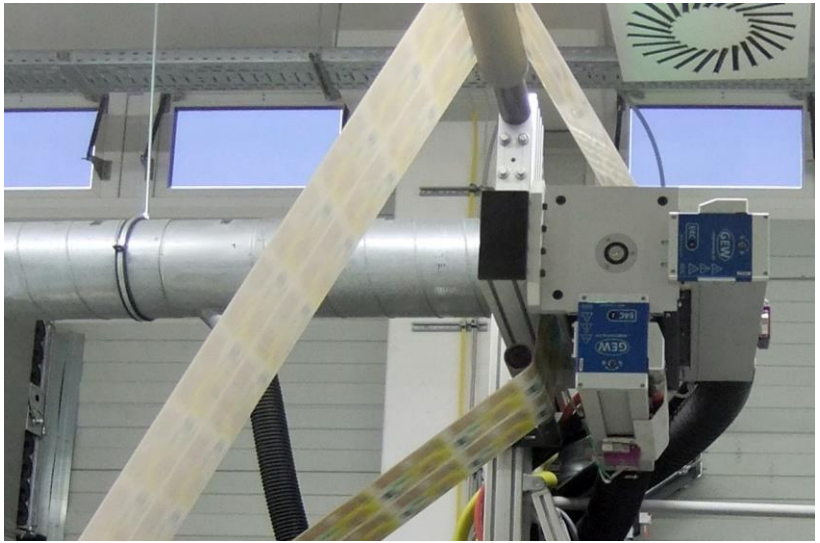
Matching UV Systems to Needs of Applications

- photopolymer chemistry reacts when exposed to optimal wavelength range (nm) at or above the minimum threshold irradiance (W/cm^2)
- desired line speeds are met when enough energy density (J/cm^2) is applied at those conditions
- integration needs and plant environment impact choice of UV system



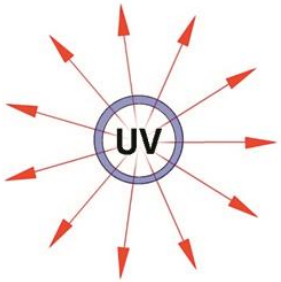
Delivering Greater Energy Density (J/cm^2)



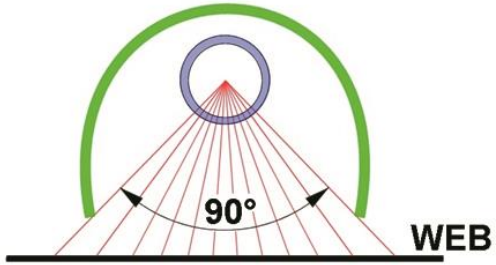


Using multiple lamp heads at the same power level produces increased Energy Density (J/cm^2) at a fixed Irradiance (W/cm^2).

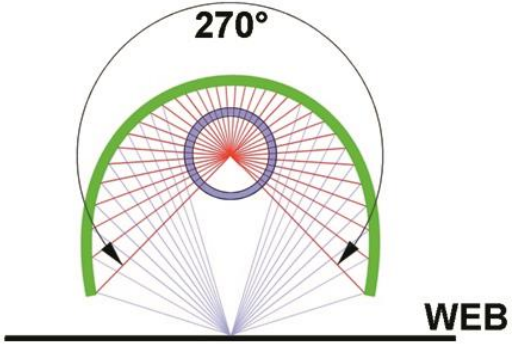
Mercury Vapor and Excimer Lampheads



360° energy radiation



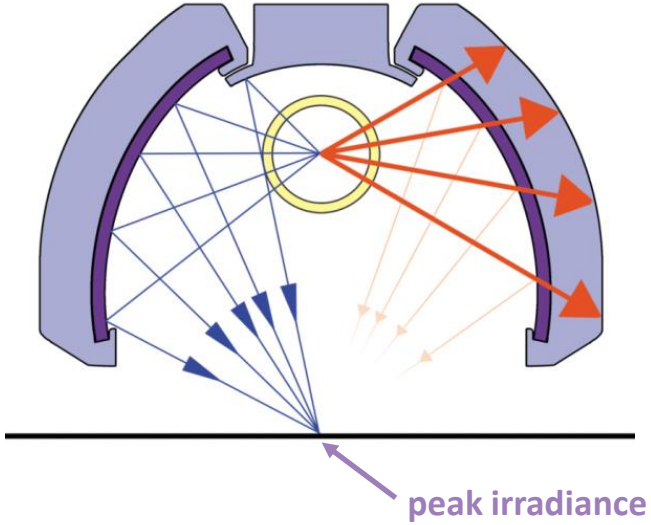
25% directly incident on web



up to 75% reflected to cure surface

Mercury Vapor Lampheads

- focused to increase irradiance
- dichroics pass, absorb, reflect certain wavelengths
- additive/doped lamps shift mercury spectral output (iron, gallium, lead, tin, bismuth, indium)
- assemblies cooled with air or water
- UV below 240 nm produces ozone (O_3) when absorbed by oxygen (O_2) molecules



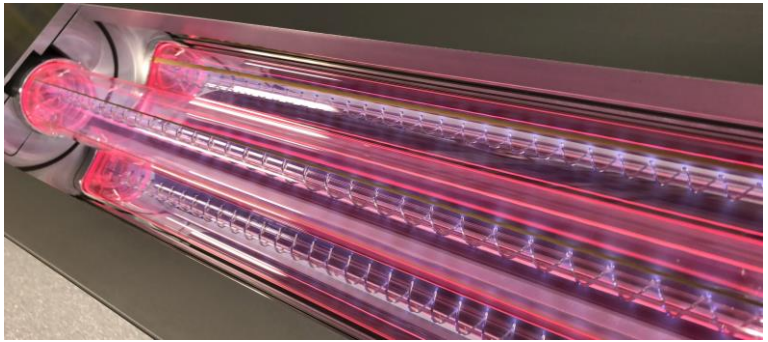
Mercury Regulation

- Minamata Convention on Mercury
  - international treaty ratified by 131 nations
  - no in-country legislative or enforcement authority
  - USA EPA must register rules specifically banning mercury use as authorized by *Frank R. Lautenberg Chemical Safety for the 21st Century Act*
  - EU must issue directives specifically banning mercury use
- EU's RoHS
  - exempts mercury vapor lamps per Annex III (4f) *mercury in other discharge lamps for special purposes not specifically mentioned in Annex*
  - no limits on mercury use or phase-out timelines for (4f)
  - does not apply to large-scale stationary industrial tools and large-scale fixed installations
  - EU reviewing exemptions in July 2021
- IUVA World Congress keynote address June 7:
  Truth and Clarity on Mercury Regulation in UV Technology

mercury regulation is a dynamic situation and will evolve over next 5, 10, 15 years

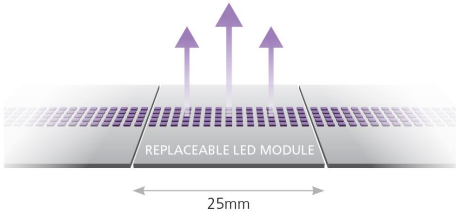
Excimer Lampheads

- dielectric barrier discharge (DBD)
  - high-efficiency source (>40% UV)
  - pulsed operation mode (>60 kHz)
  - instant On/Off
  - minimal if any lamp cooling
- 172 nm (vacuum UV is 100 to 200 nm)
- oxygen (O_2) molecules absorb vacuum UV
- requires nitrogen inertion
- no ozone or extraction if inerted correctly
- used in combination with mercury vapor or LED

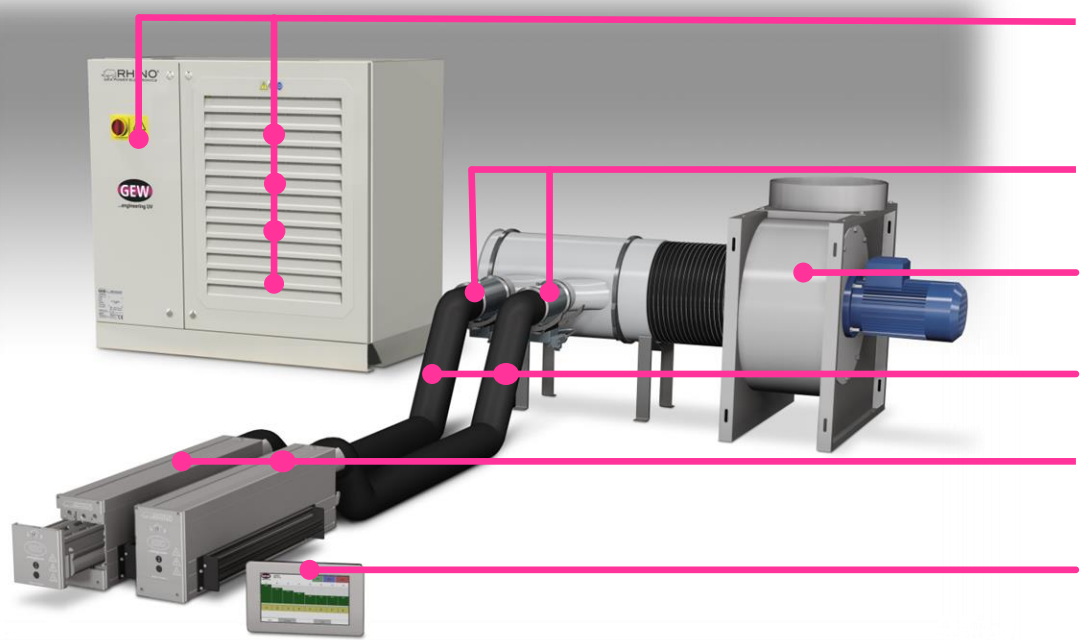


LED Lampheads

- UV lamphead assemblies
  - discrete LEDs optimally packaged into modules
  - modules arranged into lamp head assemblies
  - assemblies ***sealed*** like a smart phone or tablet
  - proper cooling ensures performance and long life
- no infrared wavelengths, less heat transfer to substrate….UV wavelengths are still energy
- consume less energy than mercury vapor
- capable of higher peak irradiances than mercury vapor
- run on DC power



Components vs Systems (air-cooled arc)



power cabinet – distribution and supplies

autodamper valves

exhaust fan

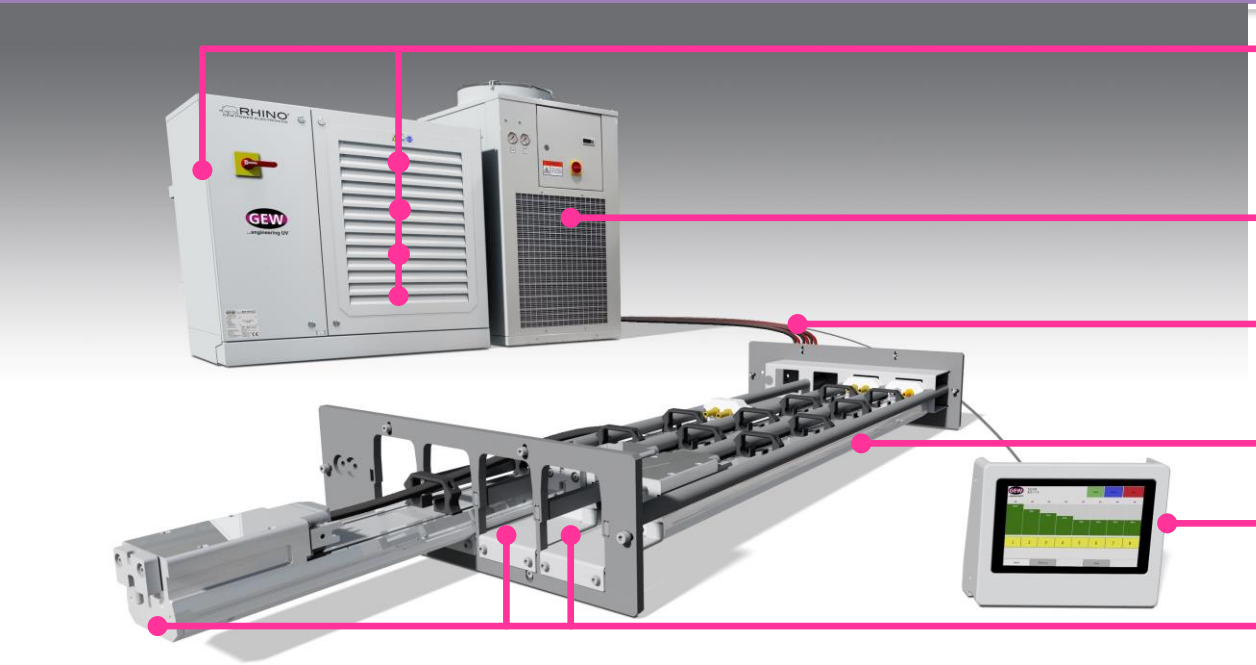
exhaust ducting

lampheads

HMI touchscreen

interconnect cables

Components vs Systems (water-cooled LED)



power cabinet - distribution and supplies

chiller

cables and interconnections

mounting and shielding

HMI touchscreen

LeoLED® lampheads

Ancillary Equipment is Part of the Larger System

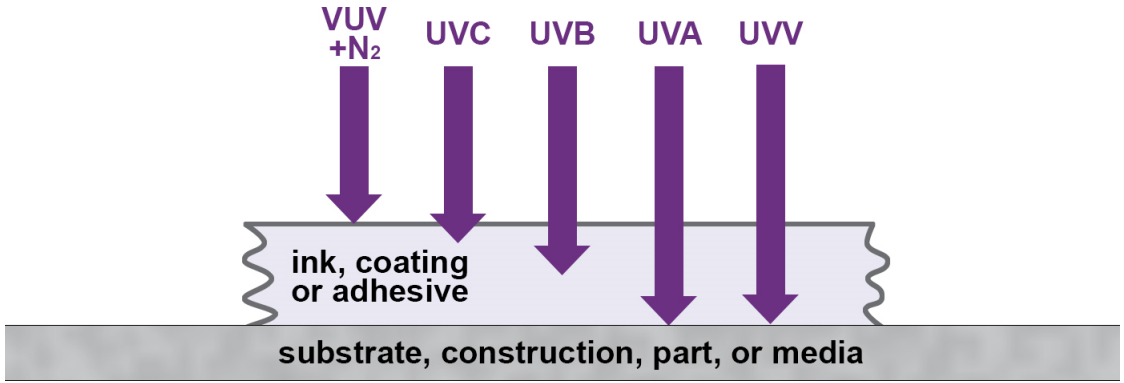
- material handling, shields, guides
- surface pretreatment
- integrated chilled rollers/plates
- nitrogen inertion
- brackets, web slots, docking stations, moveable options, light shielding
- chillers, W2W exchangers, blowers, ventilation
- UV monitoring
- remote monitoring
- safety shielding and light curtains
- post-cure processing components

How does wavelength affect depth of cure?

Decreasing Wavelength & Penetration
Increasing UV Energy

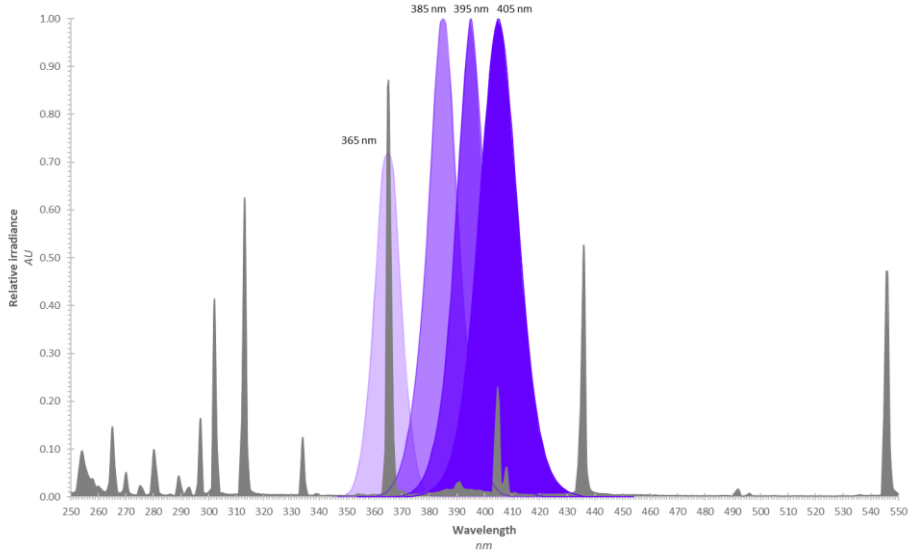
100 to 450 nm

Increasing Wavelength & Penetration
Decreasing UV Energy



Vacuum UV:	100 – 200 nm	UVB:	285 – 315 nm	UVV:	400 – 450 nm	Infrared:	700 nm to 1 mm
UVC:	200 – 285 nm	UVA:	315 – 400 nm	Visible:	400 – 700 nm		

Mercury Vapor vs LED Spectral Output



Mercury vapor lamps emit broadband spectral output.

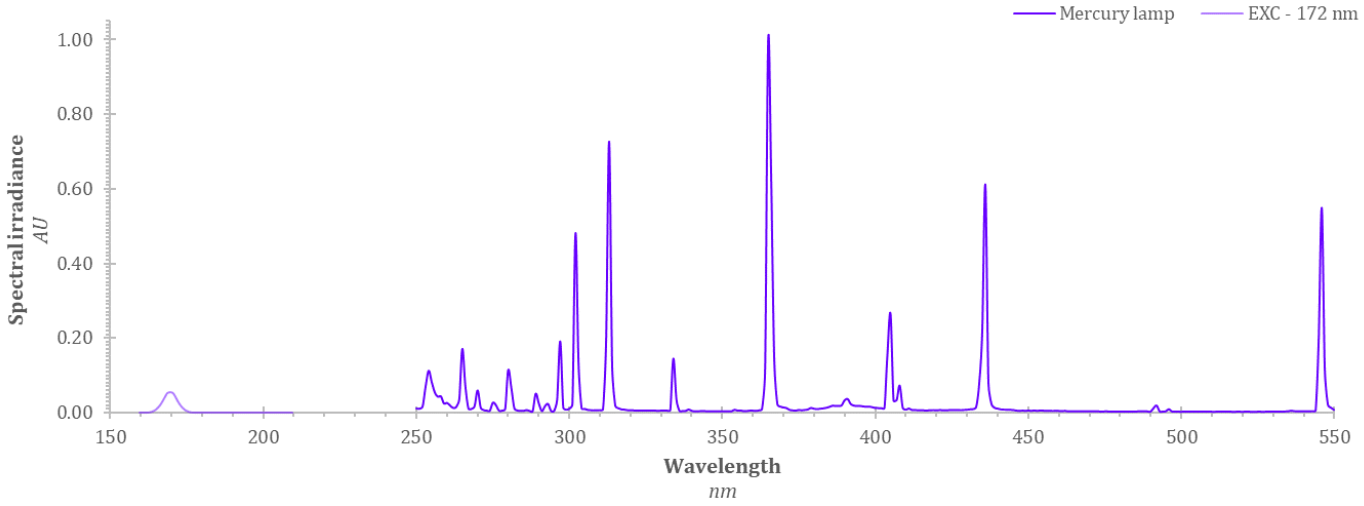
(UVC, UVB, UVA, UVV, visible AND infrared)

UV LEDs emit quasi-monochromatic spectral output.

(365, 385, 395 OR 405 nm)

Vacuum UV:	**100 – 200 nm**	**UVB:**	**285 – 315 nm**	**UVV:**	**400 – 450 nm**	**Infrared:**	**700 nm to 1 mm**
UVC:	**200 – 285 nm**	**UVA:**	**315 – 400 nm**	**Visible:**	**400 – 700 nm**		

Mercury Vapor vs Excimer Spectral Output



Vacuum UV:	100 – 200 nm	UVB:	285 – 315 nm	UVV:	400 – 450 nm	Infrared:	700 nm to 1 mm
UVC:	200 – 285 nm	UVA:	315 – 400 nm	Visible:	400 – 700 nm		

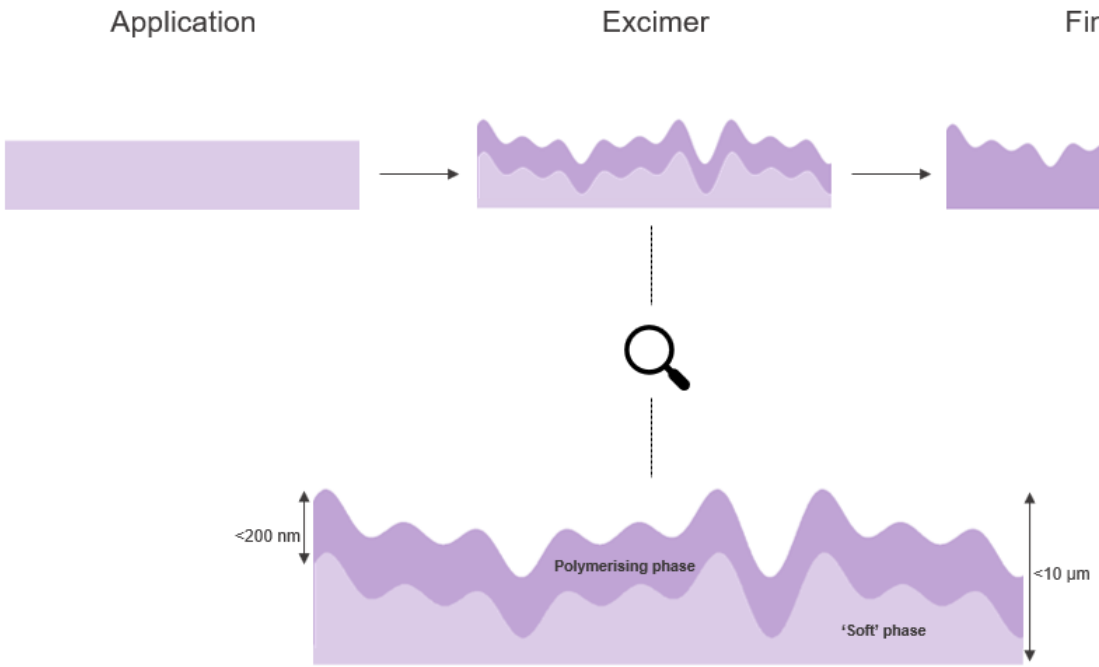
Mercury vapor lamps emit broadband spectral output.

(UVC, UVB, UVA, UVV, visible AND infrared)

Excimer lamps emit quasi-monochromatic spectral output.

(172, 222 OR 308 nm)

How does wavelength affect depth of cure?



(1) Optional pre-gel with LED (UVA)

(2) Optional mattification of top surface with Excimer (VUV) in nitrogen inerted environment

(3) Full cure with LED (UVA) or Mercury Arc (broadband)

What needs are solved through UV Curing?

Mercury Arc, LED, Excimer solve the need to…

- cure instantly at fast line speeds
- reduce thermal dryer size, energy consumption, and carbon footprint
- eliminate solvent chemistry, thermal ovens, afterburners, and greenhouse gases
- adhere to a wide range of materials
- generate bold and vibrant colors
- provide superior chemical, scratch, and mar resistance
- provide superior functional and aesthetic properties
- ship and finish products quickly

LED UV solves the need to…

- reduce thermal transfer
- reduce energy consumption
- provide deep UV penetration
- turn lamp On/Off instantly
- increase lamp life
- improve process control
- eliminate ozone generation and exhaust

Excimer solves the need to…

- provide low gloss and/or stain resistance
- reduce glare and/or fingerprints
- eliminate mattifying agents

Thank you!

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