UV LED CURING TECHNOLOGY: IMPROVING ELECTRONICS MANUFACTURING PROCESSES

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INTRODUCTION

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2 | TOP 5 BENEFITS FOR ELECTRONICS MANUFACTURING

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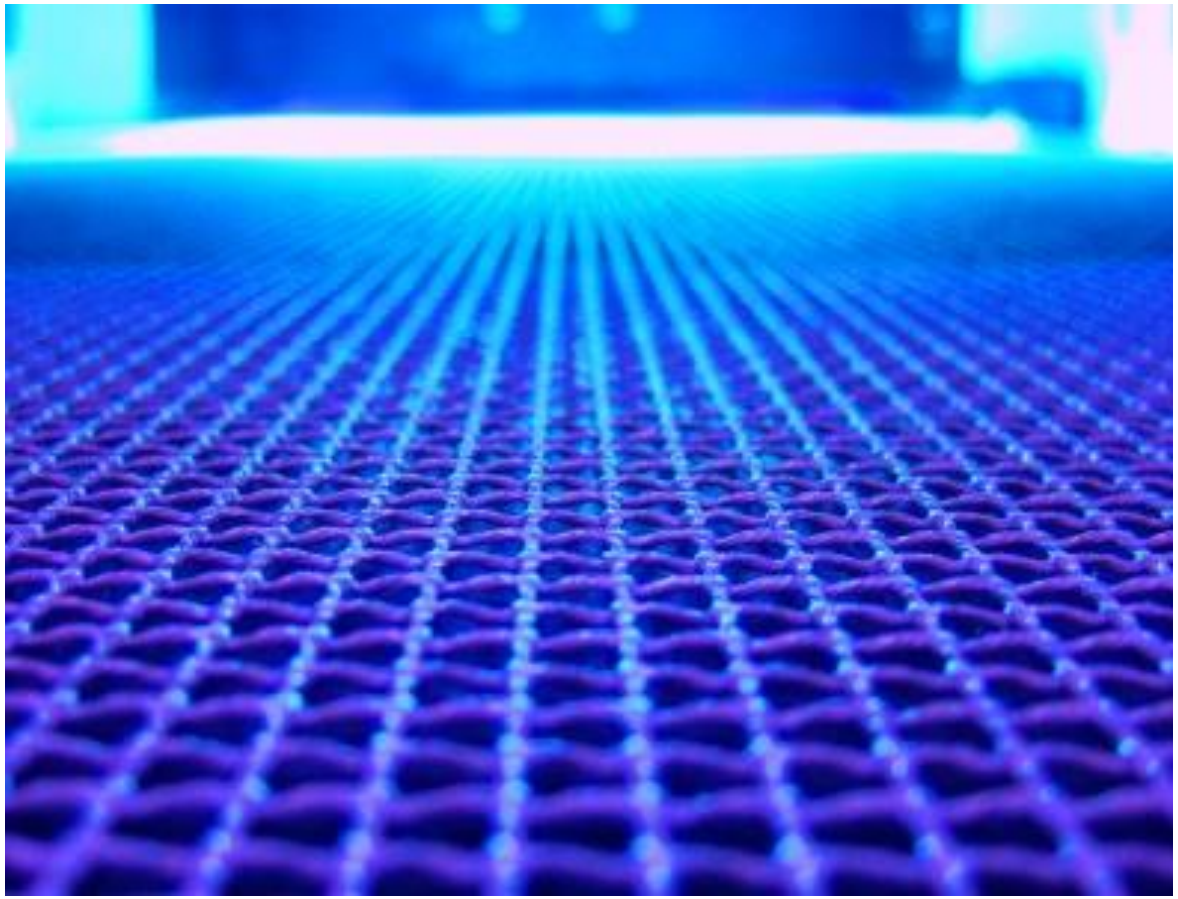


WHO WE ARE.

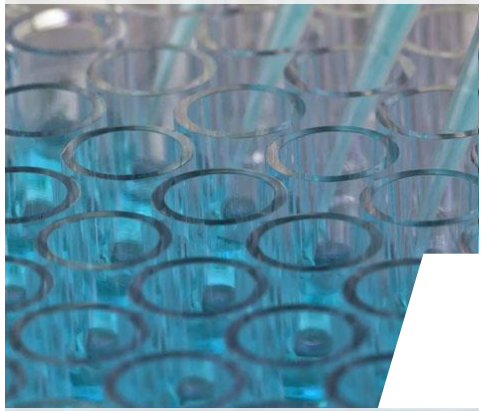
A GLOBAL TECHNOLOGY GROUP
focused on themes such as the environment, energy, health, mobility and industrial applications

OVER **12,400 EMPLOYEES**
AT OVER **100 SITES** IN
38 COUNTRIES

2015 PRODUCT REVENUE:
€ 1.9 BILLION.
2015 TOTAL REVENUE INCL.
PRECIOUS METAL TRADING :
€ 12.2 BILLION

OVER **5,750 PATENTS** AND
PATENT APPLICATIONS

TRUST AND **RELIABILITY** AT THE **CORE OF OUR BUSINESS**



WE CREATE HIGH VALUE SOLUTIONS
and substantially strengthen competitiveness for our customers in the long term combining material expertise with technological know-how.

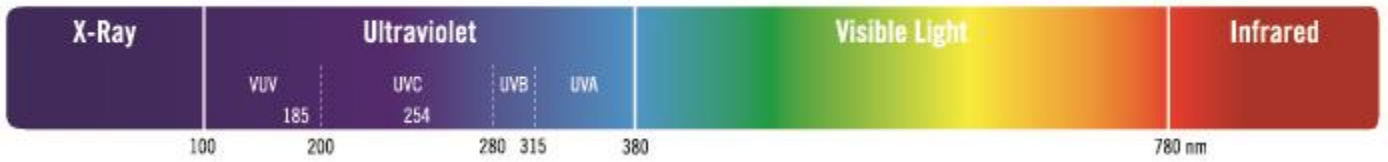
Family-owned for 165 years

Focus on innovations, operational excellence and entrepreneurial leadership

Financial stability

Global compliance & environmental standards

THE INCREDIBLE POWER OF LIGHT®



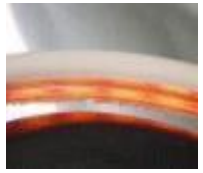
Low and medium pressure mercury lamps and systems

Microwave-powered systems

UV LED systems

Lamps for analytical instruments

Arc and flash lamp solutions



IR emitters and heating solutions

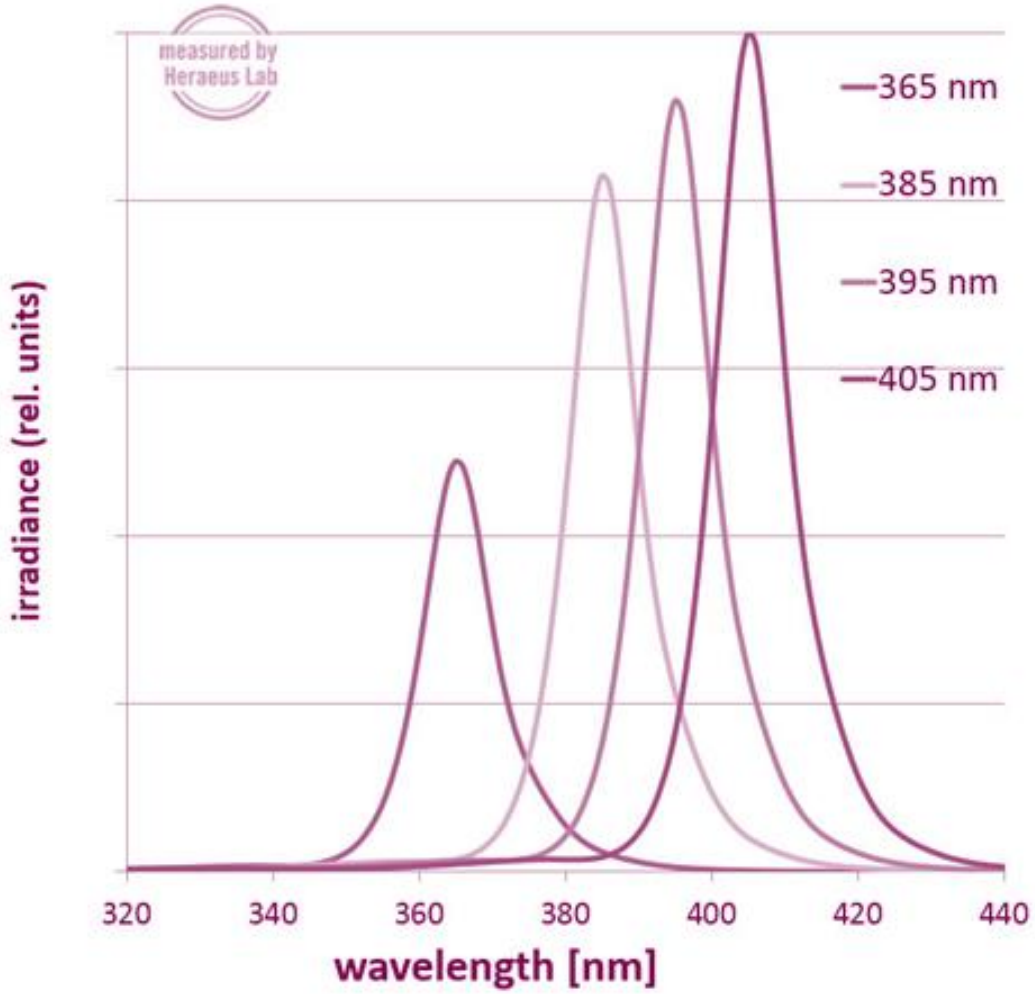
Photonics-based solutions from ultraviolet to infrared

INTRODUCTION TO UV LED CURING

3 narrow, nearly monochromatic, wavelengths

Less wasted output, but…

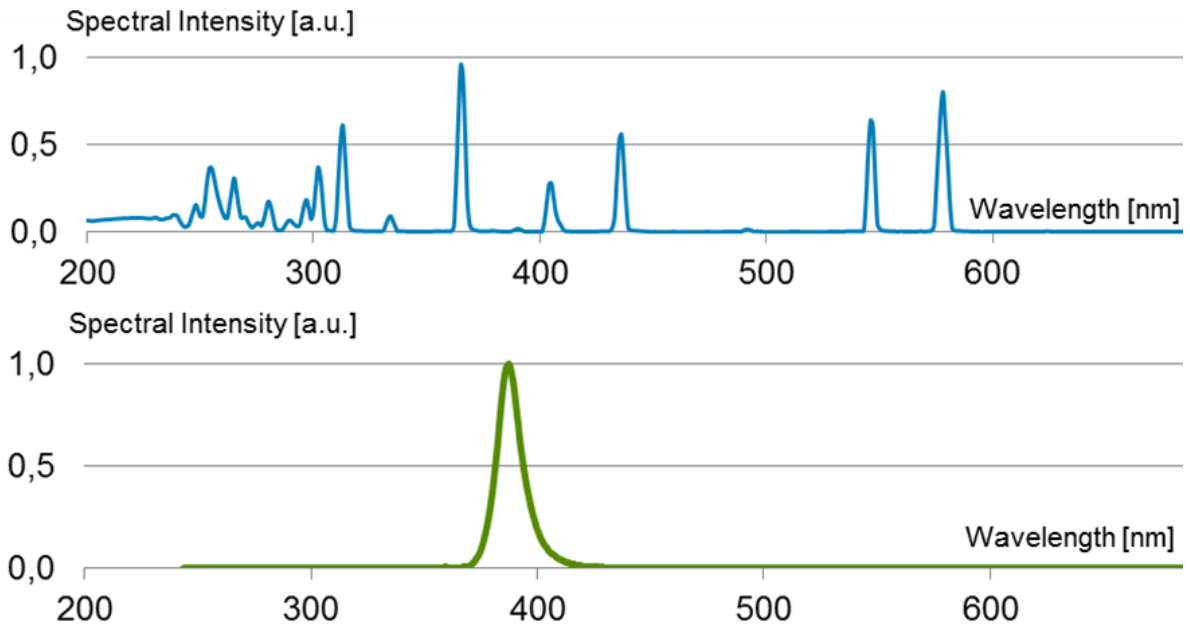
requires chemistries responsive to these wavelengths



INTRODUCTION TO UV LED CURING

Compared to traditional mercury arc UV lamp

- No mercury
- No ozone
- No heat from infrared

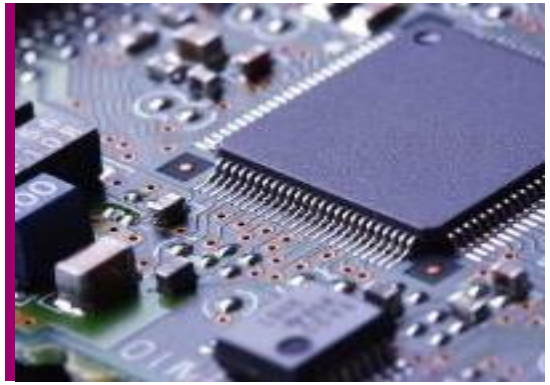


INTRODUCTION TO UV LED CURING

Applications already commercialized since ~ 2005

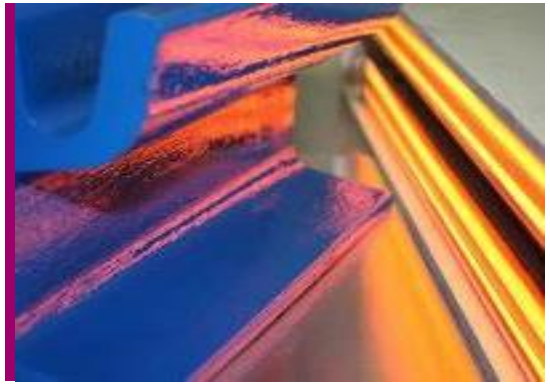
Printing

› Wide format inkjet printing for signage and posters, narrow format inkjet for packaging marking and coding, rotary screen for plastic bottles, offset printing, flexo printing for labels



Adhesives

› Bonding electronic components, medical devices, sealants for electronic devices



Coatings

› Wood coatings, protective coatings for furniture foils

Industrial coatings

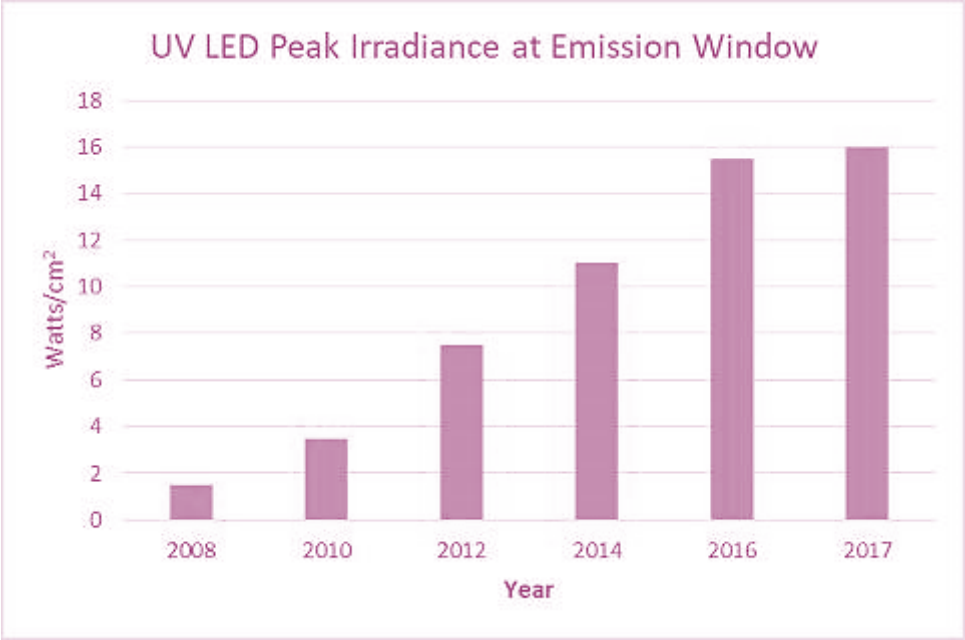
› Optical fiber production, composite manufacture, wind turbine blade repair, coatings in printed electronics

DRIVERS FOR IMPLEMENTATION OF UV LED SYSTEMS

Technology features	Technology benefits
Instant on / off	Ready to use / no warm up time, energy savings and positive impact on lifetime
Low electricity consumption	Energy savings
Low heat output	Positive impact for heat sensitive substrates
No ozone, no Hg	Environmentally friendly and easier integration
Long lifetime, constant output	Lower maintenance costs and better process control
System features	**System benefits**
Format selection	Less stray light, positive impact on lifetime and energy savings
Small form factor	Easier integration, available in spot cure units
Smart sensors	Higher reliability, better process control
Optics	Flexible working distance and less stray light

Successful UV LED applications take full advantage of UV LED features

ADVANCEMENT TRENDS IN UV LED CURING TECHNOLOGY



RAPID UV LED CHIP TECHNOLOGY ADVANCEMENT – 10 TO 20% INCREASES IN EFFICIENCY EVERY 9 TO 12 MONTHS!

ADVANCEMENT TRENDS IN UV LED CURING TECHNOLOGY

UV LED system manufacturers made significant advances in cooling techniques and optics

→ Tighter packaging of LED chips into arrays and significantly improved optical control

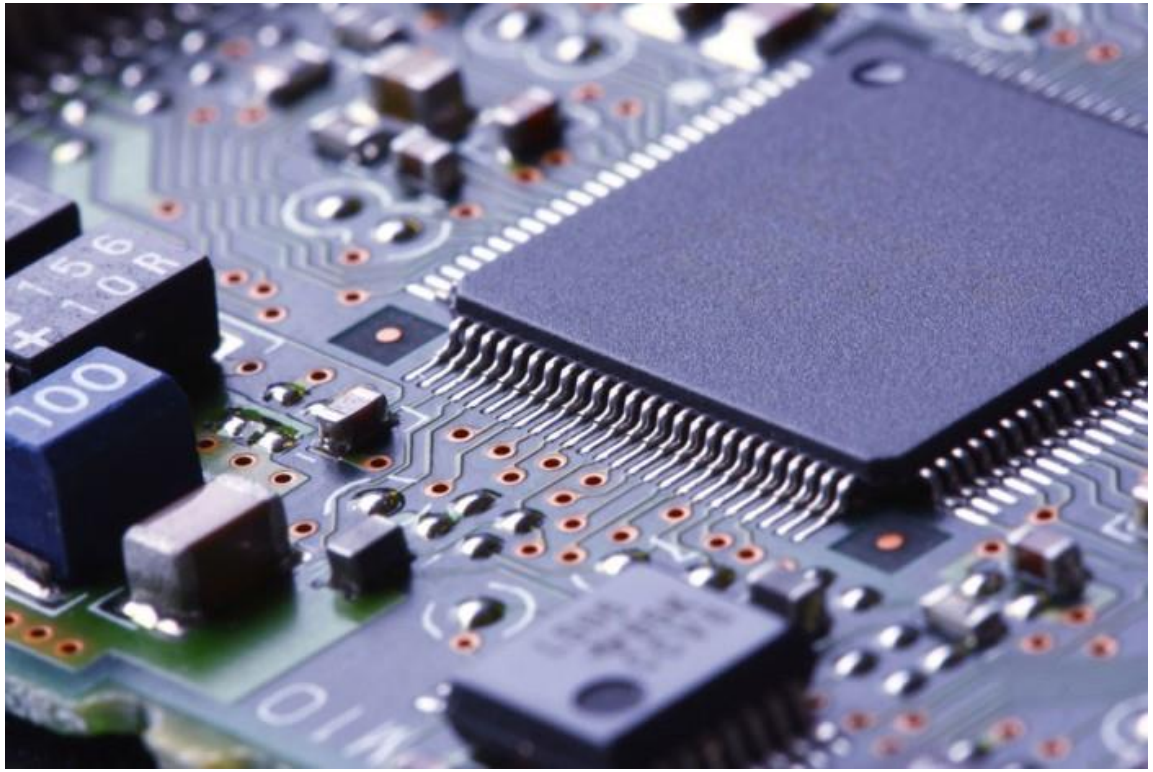
= **Higher UV energy onto the substrate**

NEW CURING APPLICATIONS REQUIRING

FASTER LINE SPEEDS AND HIGHER ENERGY DENSITIES BECOME FEASIBLE!

ELECTRONICS APPLICATIONS – COMMERCIAL AND IN DEVELOPMENT

- Adhesives bonding
- Electronics encapsulating and potting
- Marking
- Gasketing
- Flexible electronics
- Optically clear adhesives for displays
- Conformal coating PCBs



APPLICATIONS USING LONGER WAVELENGTH ADDITIVE ARC LAMPS ARE A NATURAL FIT!

TOP 5 BENEFITS FOR ELECTRONICS MANUFACTURING

- Increased production rates
- Increased process flexibility and control
- Easy to retrofit
- Improved process reliability and global consistency
- Reduced operating costs

INCREASED PRODUCTION RATES

- 10 times longer operating life (10k+ hours) than medium pressure arc UV curing systems
- Instant on/off capability – no waiting to start (3-5 min. w/ arc lamps) or restart – no need for shutters
- UV LED curing system controls integrated – UV stops/restarts instantly when the line stops/restarts
- Modular, plug & play, UV LED systems make lamp replacement quick – seconds instead of 30 minutes or more

RESULTS IN MORE UPTIME TO DELIVER HIGHER PRODUCTION RATES.

INCREASED PROCESS FLEXIBILITY AND CONTROL

- Cooler operating temperatures, ~1/3 less heat enables processing heat sensitive materials, won't damage heat sensitive components
- Dimming controls – dial in UV energy for changing process needs
- More precise bonding – instant cure of small components with higher precision placement and alignment
- Can supplement existing arc lamp curing
  - More production flexibility
  - Use as production "test bed" for UV LED

EXPANDS PRODUCTION CAPABILITIES – DELIVERS HIGHER PRODUCTION LINE UTILIZATION.

EASY TO RETROFIT

- Small form factor
- Low cooling and exhaust air requirements – no bulky and noisy fans, use internal muffin-type fans or water
- No shutters
- Heat and light shielding greatly simplified
- No ozone or mercury – safer working environment
- Commonly retrofitted onto flat conveyor lines or indexing machines

IMPROVED PROCESS RELIABILITY, GLOBAL CONSISTENCY

Higher process reliability

- More consistent UV energy output
- Longer operating life

Global process consistency

- Easy to duplicate process and less $ to relocate equipment – small and light weight
- No concerns about different cooling needs (cfm) at different elevations

REDUCED OPERATING COSTS

30 – 70%
Energy Savings

Fewer Consumable Parts

Lower Maintenance

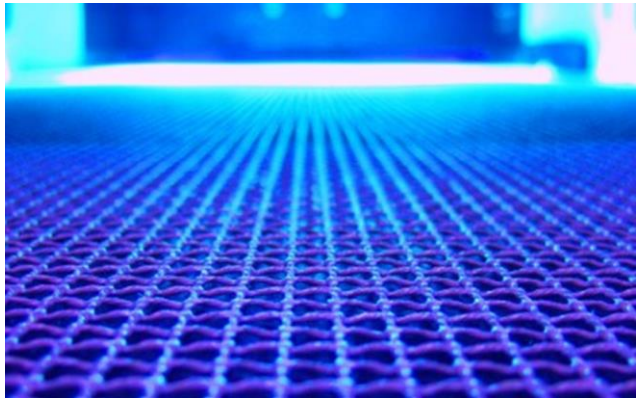
Reduced Operating Costs

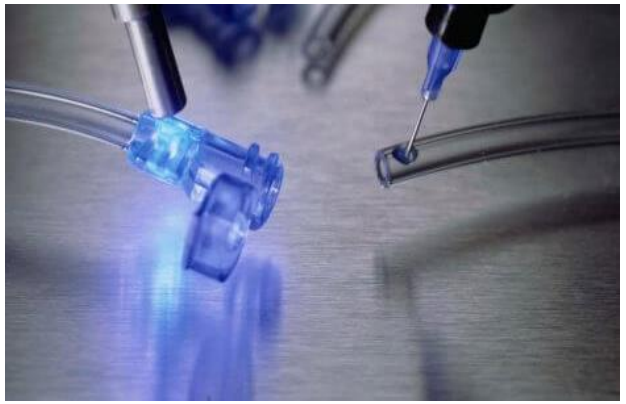
SEMRAY® UV LED CURING PROVIDES SMART ANSWERS TO YOUR NEEDS WITH A **MODULAR, PLUG & PLAY SOLUTION**

- Higher Productivity
- Higher Output
- Convenient Retrofit
- Greater Flexibility
- Improved Performance

Learn more about Semray®

CASE STUDY – ADHESIVE BONDING





Needs

- Manual arc lamp spot curing, using longer wavelengths
- Higher throughput
- Flexibility to run variety of parts

Development

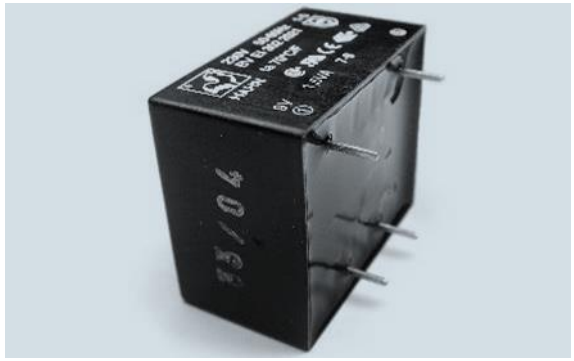
- Material evaluation and testing
- Trials at Heraeus lab and formulator demo center
- Customer validation tests
- Production line validation with appropriate UV LED curing demo equipment

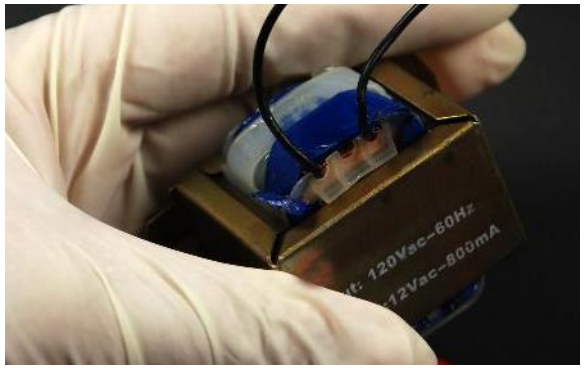
Solutions

- Continuous conveyor or indexing systems
- Targeted UV LED 3D cure chamber
- Various UV wavelengths available to cure through blocking substrates

Increase production rates and ability to cure a variety of products

CASE STUDY - POTTING





Needs

- Have long wavelength iron doped UV arc or microwave lamp
- More consistent curing
- Less maintenance
- Reduced heat load to the substrate

Development

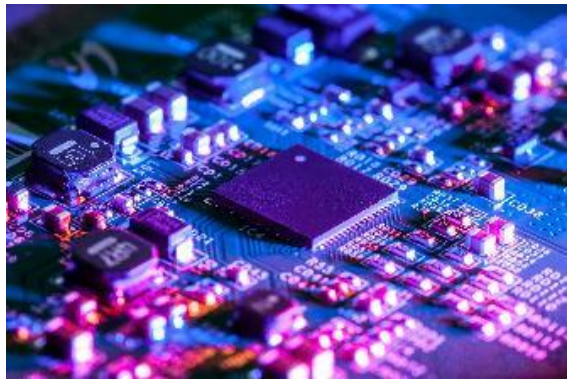
- Testing at Heraeus lab
- Evaluation and validation on customer's line using UV LED curing demo equipment

Solutions

- Continuous conveyor or indexing systems
- Targeted UV LED 3D cure chambers available
- Various UV wavelengths available
- Custom solutions per process requirements

Reduced work in process and improved quality

CASE STUDY – CONFORMAL COATING



Needs

- UV arc lamp curing
- More consistent curing
- Less maintenance

Development

- Testing at Heraeus lab
- Evaluation and validation on customer's line using UV LED curing demo equipment

Solutions

- UV LED retrofitted onto existing conveyor
- Easy maintenance concept
- 24 inches UV LED = 6 Semray® Segments

Reduced work in process and improved quality

CHALLENGES AND NEXT STEPS

UV LED curing will inevitably replace traditional UV curing technology for *some* electronics conformal coating, gasketing, and bonding/adhesive applications, just as LED technology has replaced *some* automotive lighting, interior lighting, and other traditional light sources.

Challenges

- Need suitable chemistry formulations
  - Commercially available
  - Meet end use requirements

- UV LEDs with higher output

NEXT STEPS

- Understand if UV LED curing is a fit for your electronics manufacturing processes – begin evaluating curing processes currently using longer wavelengths now!
- Every UV curing process is unique – type of substrates/component/device, orientation and handling, chemistry, etc.
- Reach out to experienced UV LED curing equipment providers and chemistry formulation partners
- Find knowledgeable partners to assist with lab testing and in-plant trials, process development support, assess feasibility and ROI
- Lab testing (done correctly) easily scales to pilot line and production processes

Learn more about UV LED technology and benefits.

APPLICATIONS AND PROCESS DEVELOPMENT CAPABILITIES

Heraeus Noblelight can help with next steps

- Application Competence Centers in Gaithersburg, MD & Torrance, CA
- Bringing together development team – chemistry formulation partners, machine builders
- Loan out Semray® UV LED systems for laboratory testing, pilot line and in-plant trials
- Many partners have Semray® on equipment & lines available for testing

THANK YOU FOR YOUR ATTENTION: QUESTIONS?

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LEGAL NOTICES