Fourth Generation Light and Moisture Cure Conformal Coatings

Presentation brought to you by

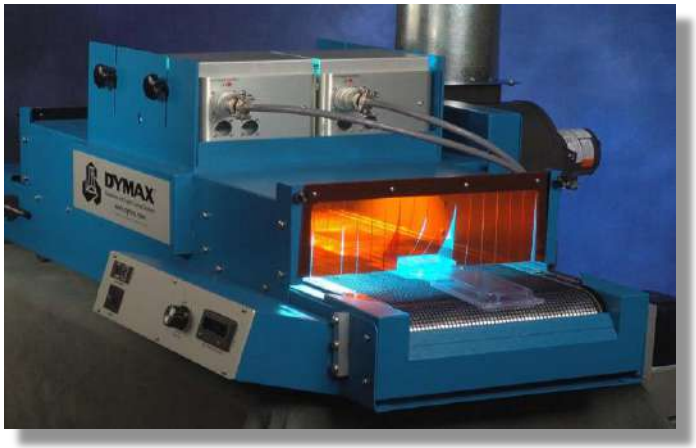
UV Conformal Coatings and Processes

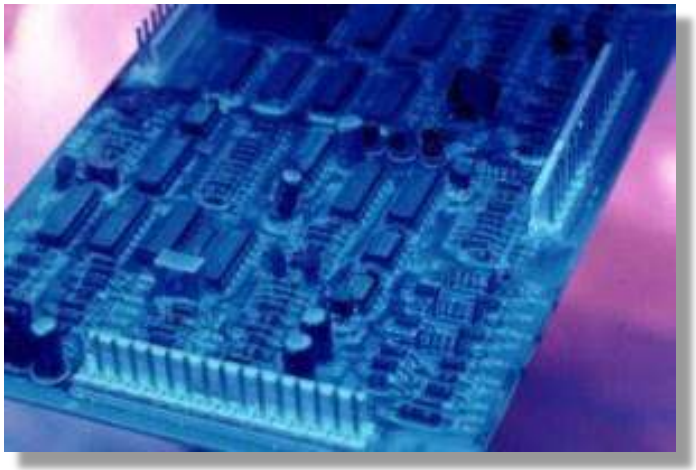
Presentation Outline

- The evolution of Fourth Generation Light Cure Conformal Coatings
- Benefits
- Background (brief) on chemistry and UV/Light cure technology
- Processing – Dispensing and Cure
- Questions

Light Cure Advantages

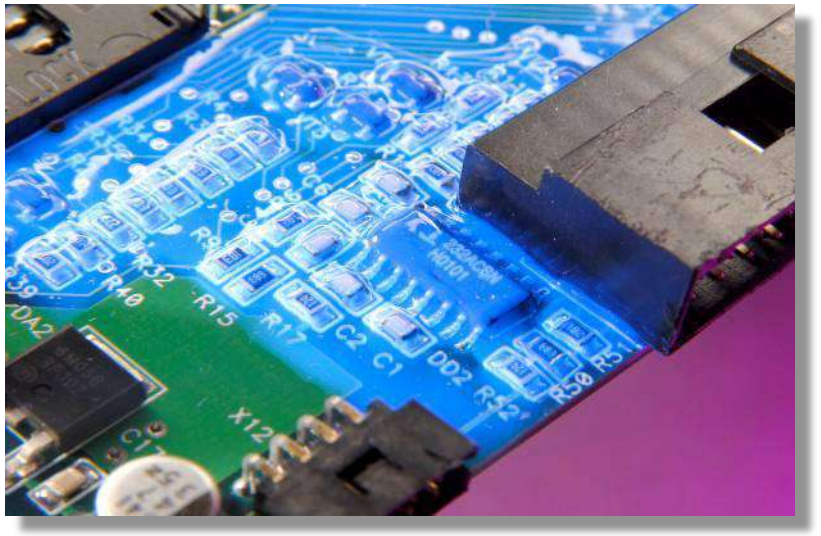
- **Reduce:**
  - **Labor costs**
  - **Process footprint**
  - **Work in process**
  - **Energy costs**
  - **Capital costs**
- **Eliminate:**
  - **Waste and disposal costs**
  - **Solvent emissions**





Acrylated Urethanes

- **Combination AR/UR**
- **Cure in seconds upon exposure to UV/visible light**
  - **Various shadowed area methods. Moisture best**
- **One component**
- **100% solids**



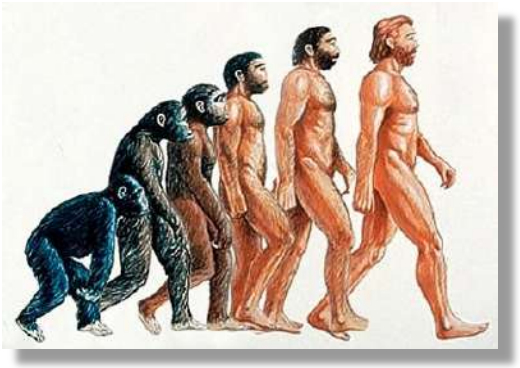
Environmentally Friendly

- Little or no Volatile Organic Compounds (VOCs)
- Little or no hazardous air pollutants (HAPs)
- No waste from mixing
- Less energy consumption – no drying

Environmental Compliances

- RoHS Compliant
- Halogen-free
- REACH – No Substances of Very High Concern
- US EPA – No Substances listed in EPA 33/50

The Evolution of Light Curing Conformal Coatings



First Generation UV Conformal Coatings
- Cured with UV light only
- No visible light cure
- No secondary cure

Second Generation UV Conformal Coatings
- Primary cure with UV light. No visible light sensitivity
- Addition of peroxide catalyst to provide heat cure option
- Peroxide cure slow. Tacky surface. Second operation required

Third Generation Light Cure Conformal Coatings
- Same as second generation with visible light photoinitiators. Faster
- Greater fluorescence. Coating coloration.
- More flexible backbones. Better adhesion, especially through heat cycle

Fourth Generation Light Cure Conformal Coatings with Moisture Cure
- Secondary moisture cure using polyurethane functionality
- Secondary cure not dependent on free radical mechanism – tack-free
- Secondary cure does not require a second processing step

The Evolution of Light Curing Conformal Coatings

- **First Generation UV Conformal Coatings**

Coating + UV Light ---------> Instant cure in UV light exposed areas

- **Second Generation UV Conformal Coatings**

Coating + UV Light ---------> Cure in light exposed areas ---△---> Partial Cure in in shadows with heat
Peroxide

- **Third Generation Light Cure Conformal Coatings**

Coating + UV or Visible Light ---------> Cure in light exposed areas ---△---> Partial Cure in in shadows with heat
Peroxide

- **Fourth Generation Light Cure Conformal Coatings with Moisture Cure**

Coating + UV or Visible Light ---------> Cure in light exposed areas ---Humidity---> Full Cure in in shadows with humidity
Urethane
Functionality

Suppliers of Fourth Generation Conformal Coatings

All Partners with Ellsworth Adhesives

Dymax – Leading supplier of UV technology products, worldwide. 15-years in the business of UV Conformal Coatings.

E-MAX 903-E

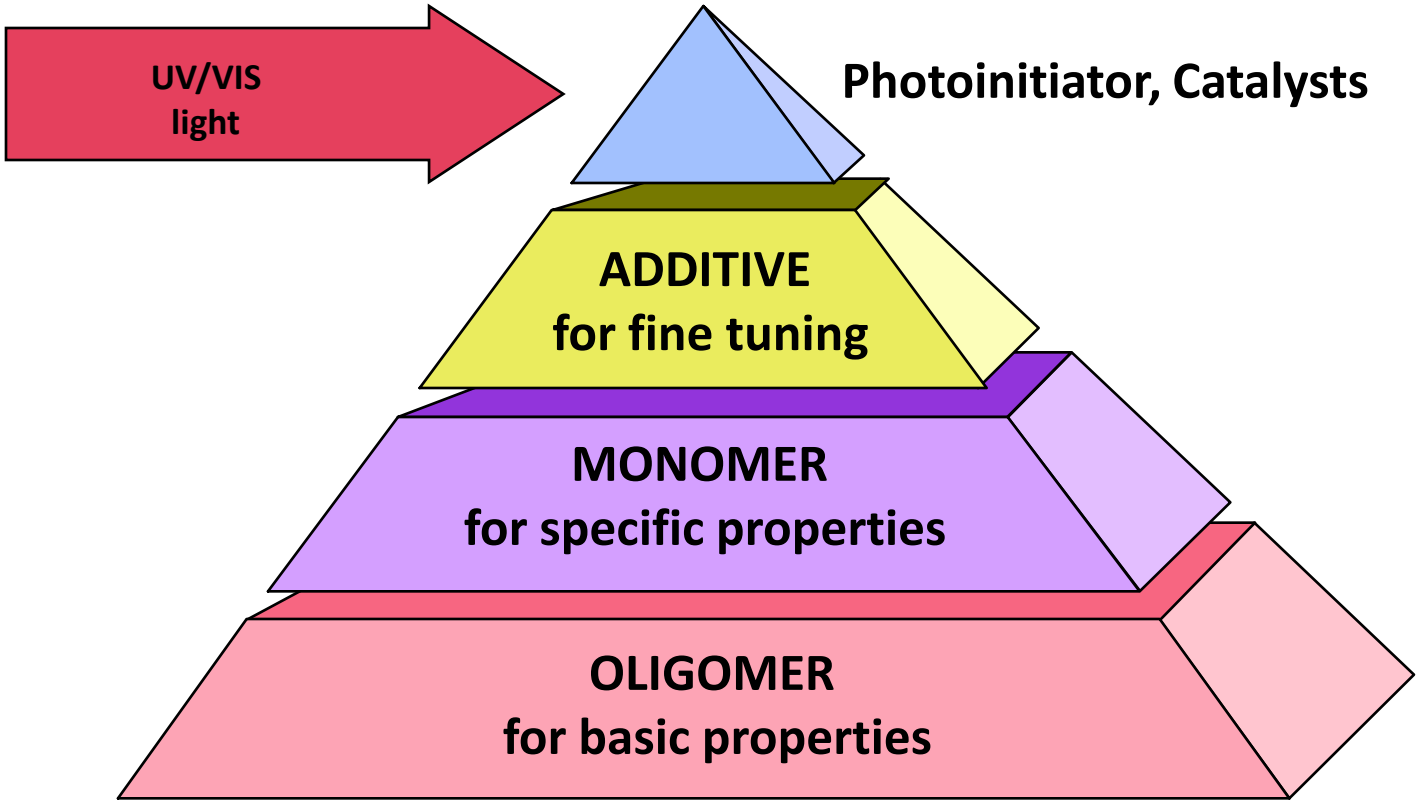
Henkel Loctite – Leading supplier of materials for Electronics Assembly. Parent of Emerson and Cuming, developer of UV Conformal coatings.

UV-7993

Humiseal – Global leader in Conformal Coatings. Full line of products and most complete listing of industry specifications.

UV-40 Series

Light-Curing Acrylate System



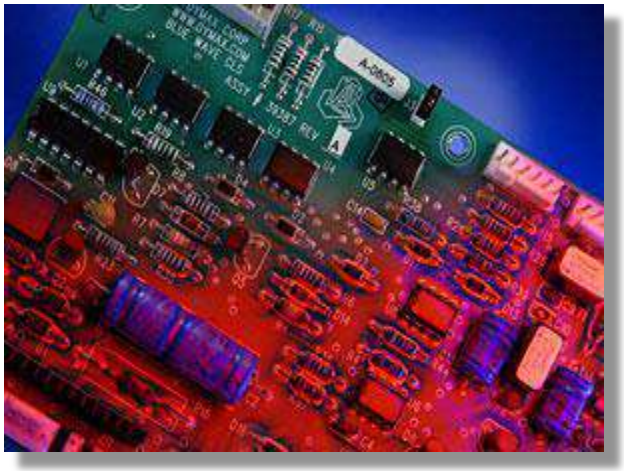
Component Functions

Oligomers:
- Flexibility
- Toughness
- Environmental resistance
- Cure speed and type
- Adhesion
- Viscosity

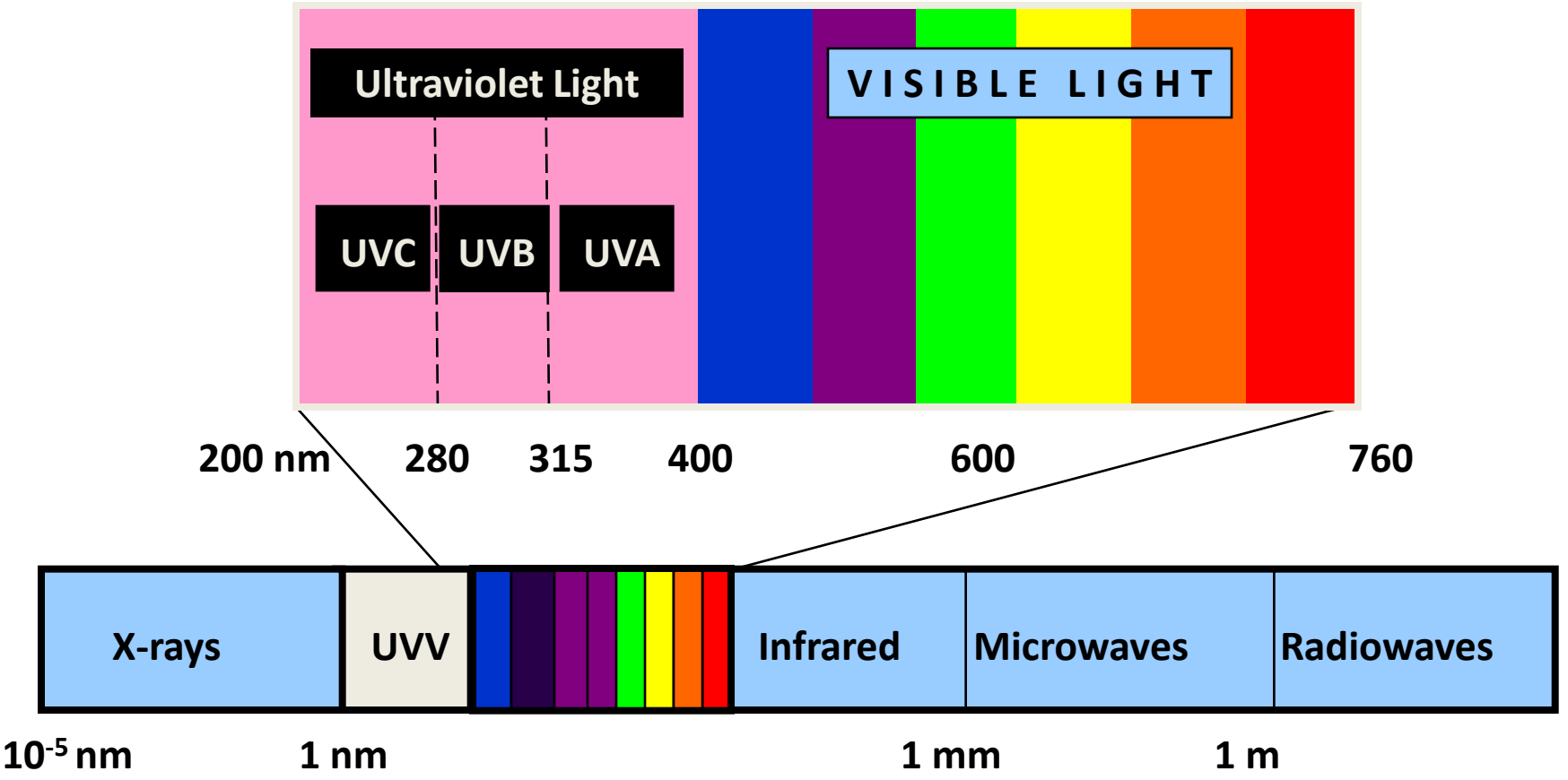
Additives:
- Thixotropy (viscosity under shear)
- Color
- Fluorescence
- Conductivity

Monomers:
- Adhesion
- Cure speed and type
- Viscosity
- Flexibility (controlled by ratio)

Catalysts:
- Photoinitiator package
- Secondary cure catalyst

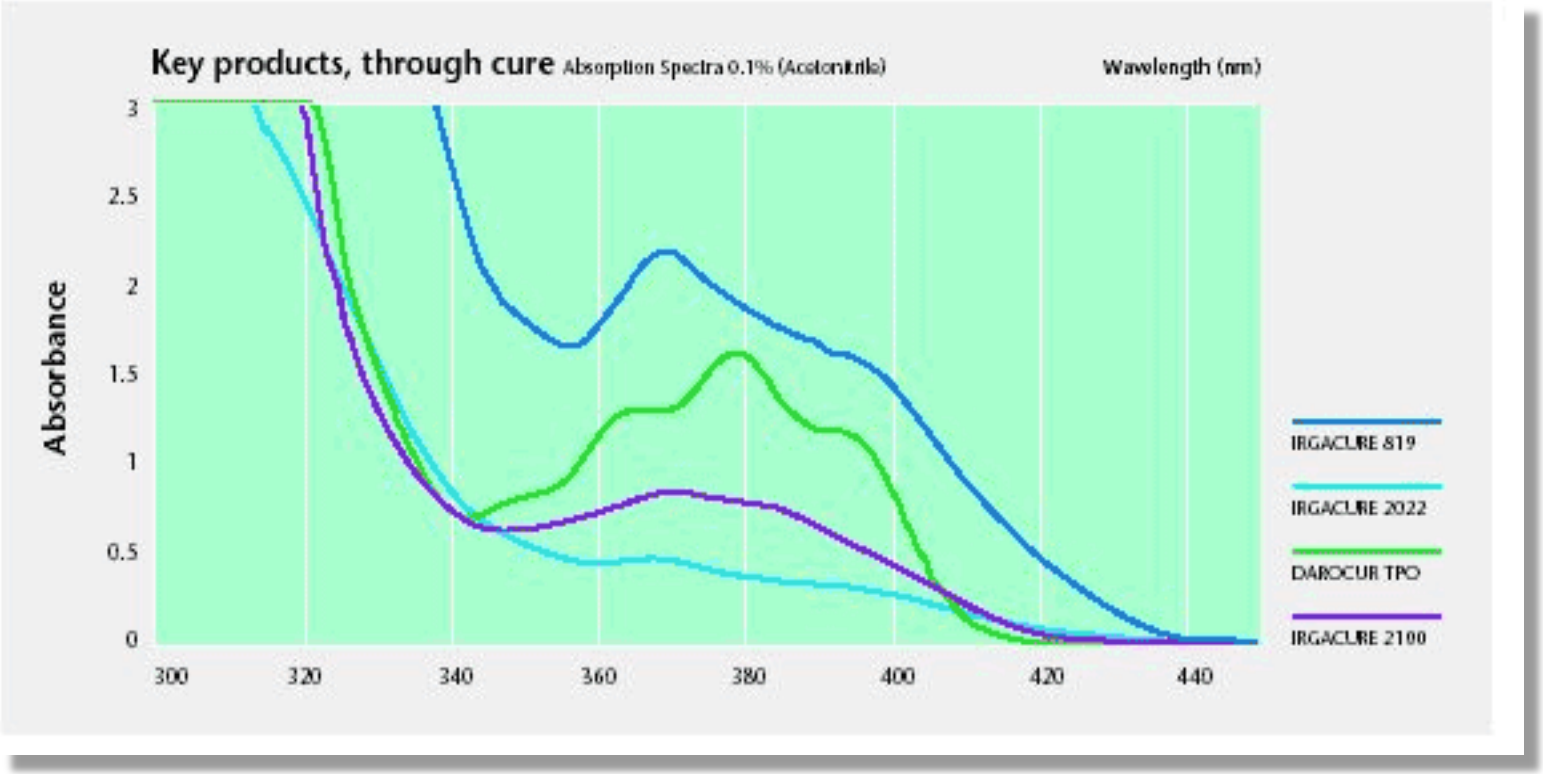


Electromagnetic Spectrum



Absorption Spectra of Common Photoinitiators

Courtesy of Ciba



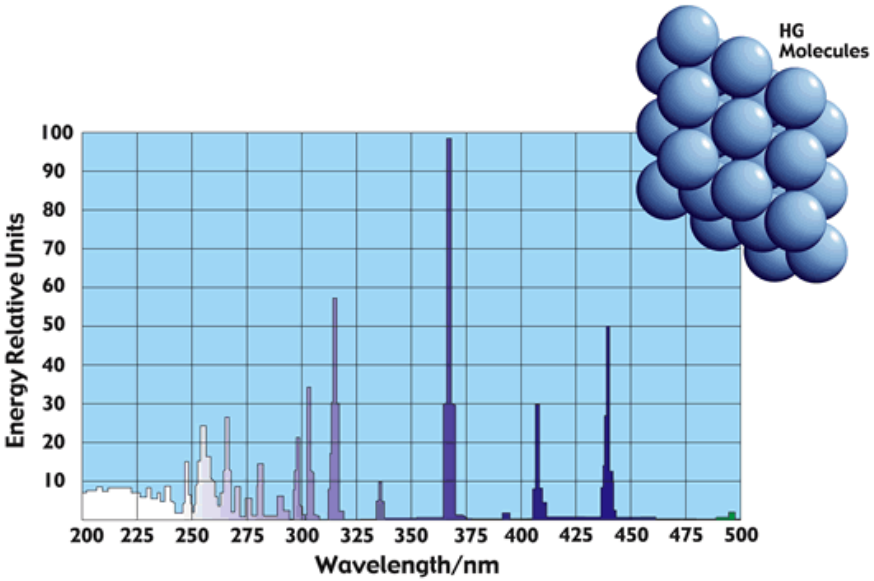
All photoinitiators absorb at short wavelengths.
Formulators try to find absorption at higher wavelengths to reduce oligomer/monomer/substrate interference – increase depth and speed of cure

Basics of UV Lamps

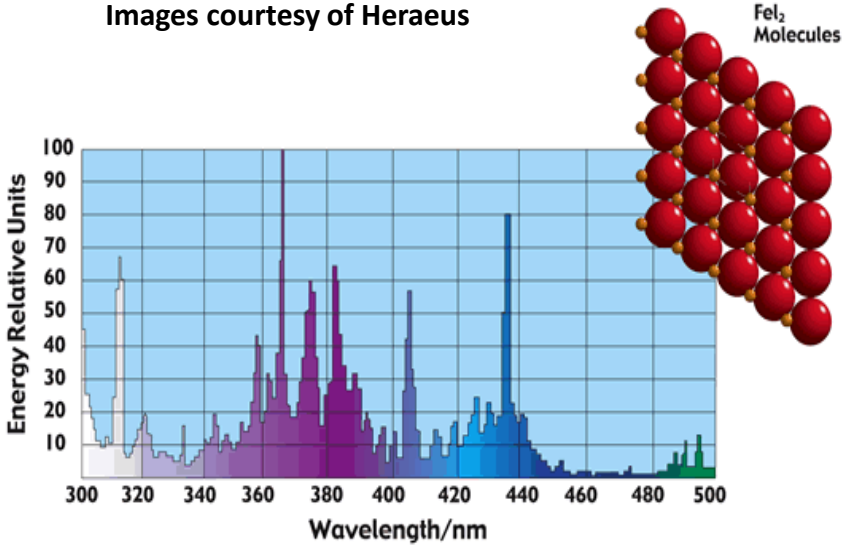
Mercury and Metal Halide Mercury Lamps

- **Mercury vapor provides conduction between anode and cathode.**
- **Emission spectrum determined by chemical gases.**

Images courtesy of Heraeus



TYPICAL APPLICATION: UV curing of inks and varnishes responsive to 365 nm wavelength



Enhances spectral output at 380 nm

TYPICAL APPLICATION: UV curing of inks and varnishes responsive to 380 nm wavelength

The Problem Of Oxygen Inhibition

Free radicals are scavenged by O_2

Acrylate system cures are therefore inhibited by O_2

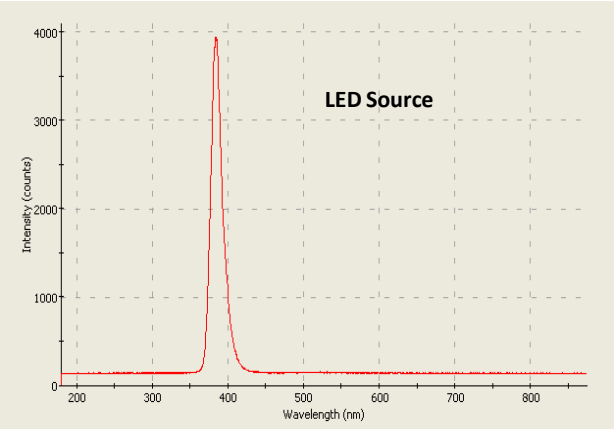
Oxygen inhibition is most important at the material surface

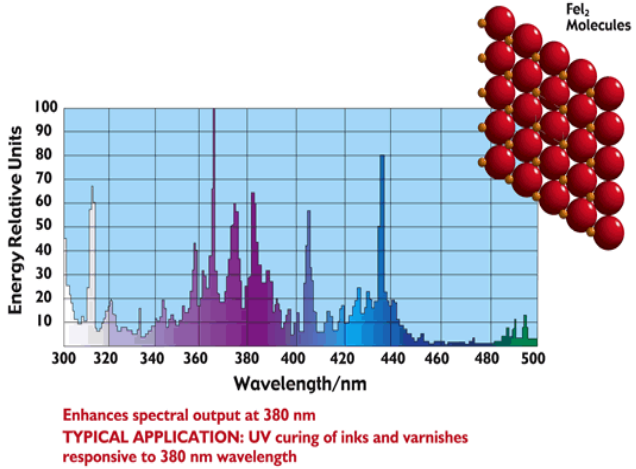
<u>Oxygen inhibition is overcome by:</u>

- **More curing power – overwhelm O_2 by creating more radicals**
- **Shorter wavelength – concentrate power at the surface where interference is minimum and PI absorption is maximum**
- **Fast reacting formulations**

- **Using a secondary cure mechanism not effected by O_2 - Moisture**

Advantages and Disadvantages of LED Sources





Disadvantages:

- **Very narrow emission band. PI capabilities not utilized**
- **Relatively low power even at peak wavelength**
- **Weak power against O_2 inhibition**
- **Focusing**

Advantages:

- **Instant on/off – shutter not required**
- **Very long life**
- **Essentially no intensity degradation**
- **Low heat to lumen ratio. No wasted light**

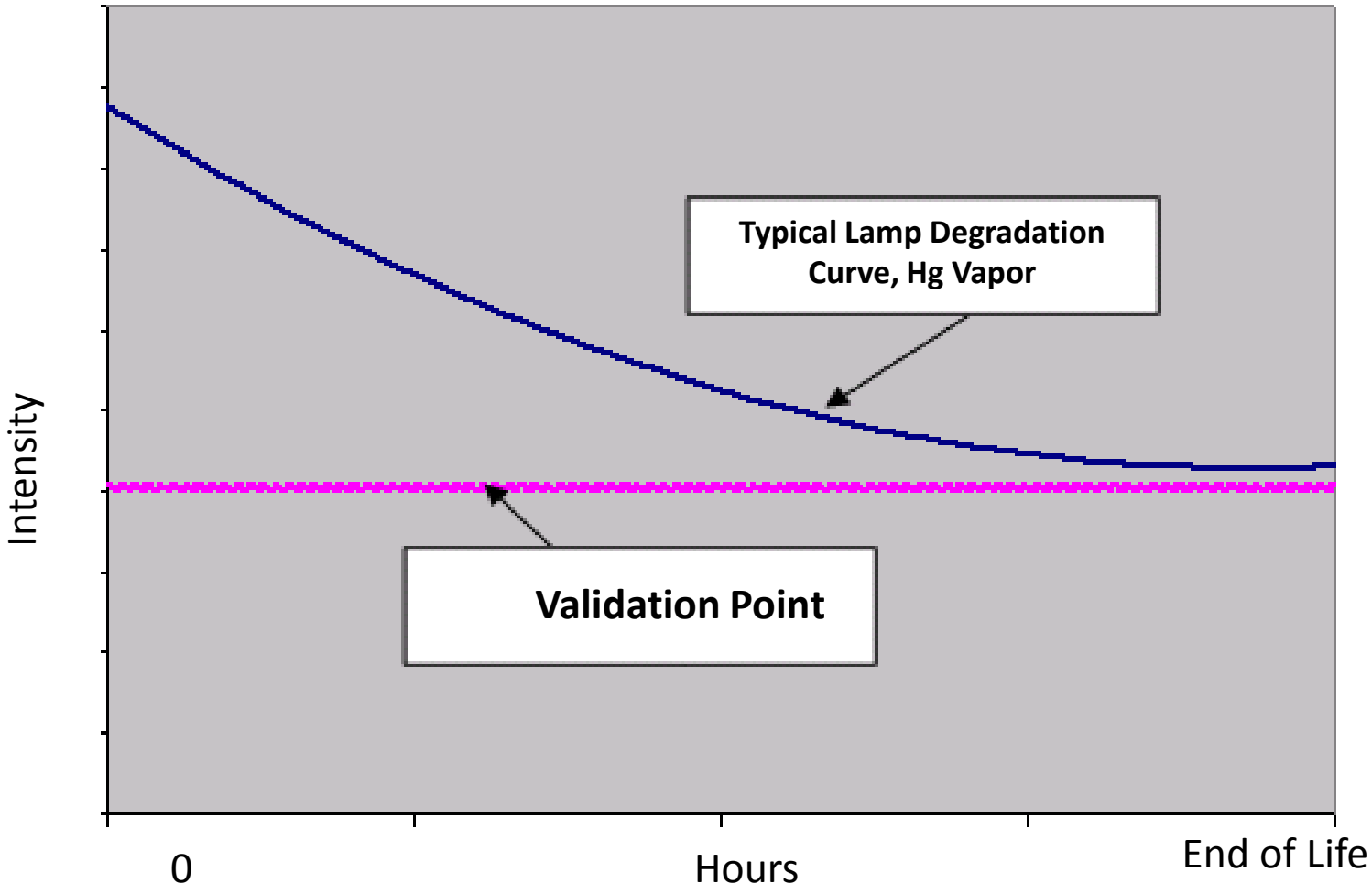
Takeaway – Not the best choice for Conformal Coatings

Curing UV Conformal Coatings

- **Focused beam conveyors generally produce tack-free cures at speeds higher than 1.5 m/min [5 ft/min] – Fusion lamps**
- **Ideal for in-line production**
- **Floods → 30 seconds**
- **Bulb life typically 2,000 or 6,000 hrs**
- **Different spectral outputs available**

Curing Process Validation & Control

(not applicable for Microwave Systems)



FUSION UV SYSTEMS, INC.

- **Microwave systems most commonly used in high speed UV Conformal Coating applications**
- **Most companies supply Fusion UV systems**
- **Highest power**
- **Essentially no bulb degradation**
- **Broad spectral distribution**

Best Practice: Process Control

- All lamps degrade over time (microwave minimally)
- Degradation rate varies by lamp
- Minimum acceptable intensity
  - Minimum lamp intensity (given cure time) required to cure the conformal coating plus safety factor (10-20%)
- Monitor lamps and change lamp when intensity falls below minimum acceptable intensity

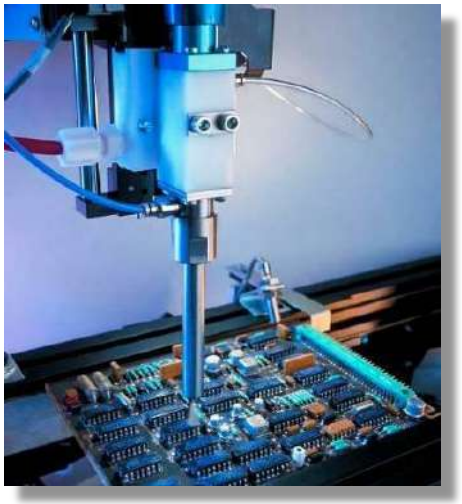
Process Safety

- Employee Training
- Glasses, ANSI Z87.1
- Nitrile Gloves
- UV Safety Seminars

Dispensing Equipment Considerations

- Opaque fluid lines and dispensing tips
- Ambient light & reflection (yellow lights available for extended dwell times)
- Compatible valves and wetted components
- IPA & Butyl Acetate
- Technical bulletins available for guidance
- Selective Spraying recommended

  PVA, Nordson/Asymtek



Summary

- 4th Generation UV/Light Cure conformal coatings offer fastest processing
- New secondary cure mechanism insures shadow curing
- Selective spraying best application method
- Conveyorized curing with microwave or metal halide mercury vapor lamps best
- Continuous improvement by suppliers in areas of adhesion, handling thermal stress, control of cure process.

Special thanks to Dymax, Henkel, and Humiseal for support and information

Acknowledgement of materials from Fusion, Heraeus, Ciba, Asymtek

Questions?