Blue Light (460nm) Fluorescence for the Detection of Organic Contamination in Microelectronic Assemblies

Tristan Baldwin – Senior Process Engineer
Richard Rochford – Senior Principal Process Engineer

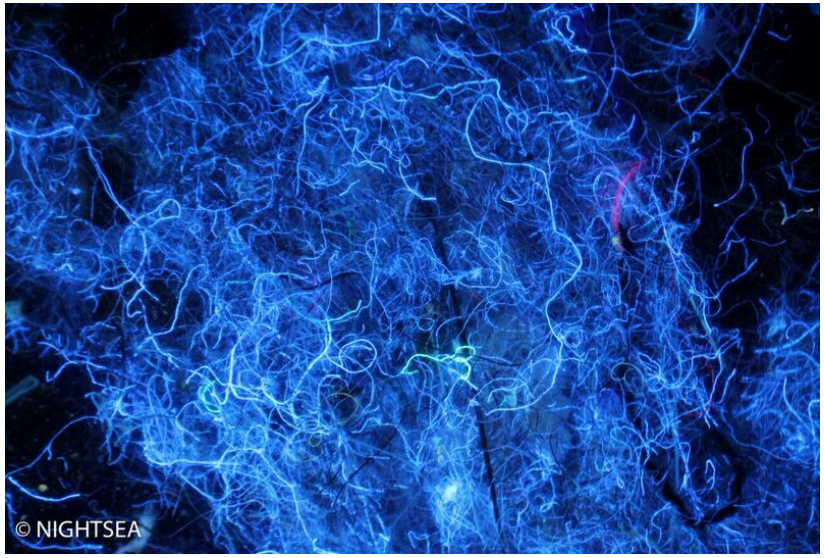
Export Ref. # ES-NHQ-042417-0263

BAE SYSTEMS
INSPIRED WORK

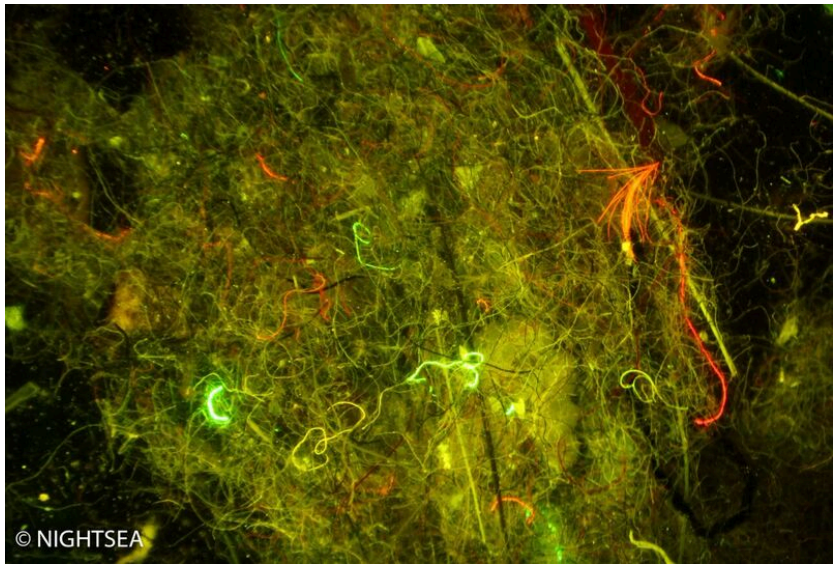
Organic Contamination of Circuitry

- Where does it come from?
- What problems can it cause?
- How can you detect it?
- How do you prevent it?

Sources of Contamination



- Epoxy resin bleed (film and paste epoxy)
- Epoxy resin from film lamination processes
- Soldering Flux
- Dust/Lint



Functional Effects on Product Quality

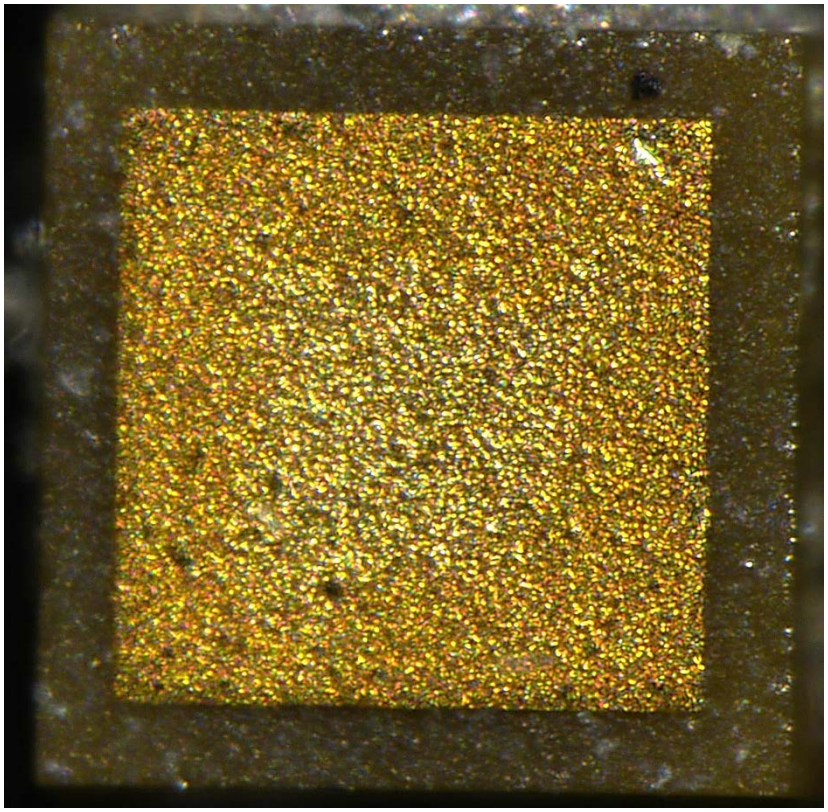
- Wire/Ribbon Bonding
  - Source of “no stick” bonds
  - Successful bonds may have low pull force
- Component Attach
  - Resin can insulate terminations or pads
    - Poor Electrical and RF Grounding
    - Dead Circuit
- Signal Interference
  - Contamination has different permittivity than Air
- Latent Electrical Failures
  - Resin can be conduit for electrostatic migration
    - Causes electrical shorting

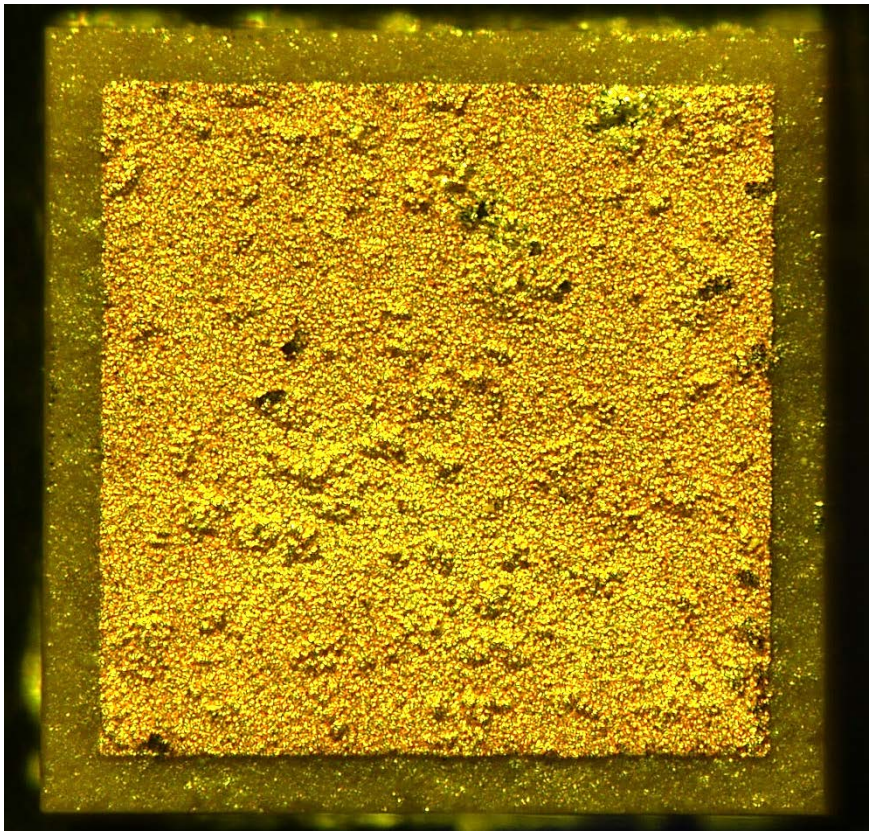
MIL-STD-883K w/ CHANGE 2
Method 2017.12 Section 3.1.5.8

No Device shall be acceptable that exhibits:

- i. Bonds on element attach adhesive or on contamination or foreign material
- m. Polymeric adhesive which may be material or residue as evidenced by discoloration within 0.005” of the outer periphery of a wire bond.
- n. Polymeric adhesive anywhere on a bond wire unless by design.

Contaminated or Clean?





Export Ref. # ES-NHQ-042417-0263

BAE SYSTEMS
INSPIRED WORK

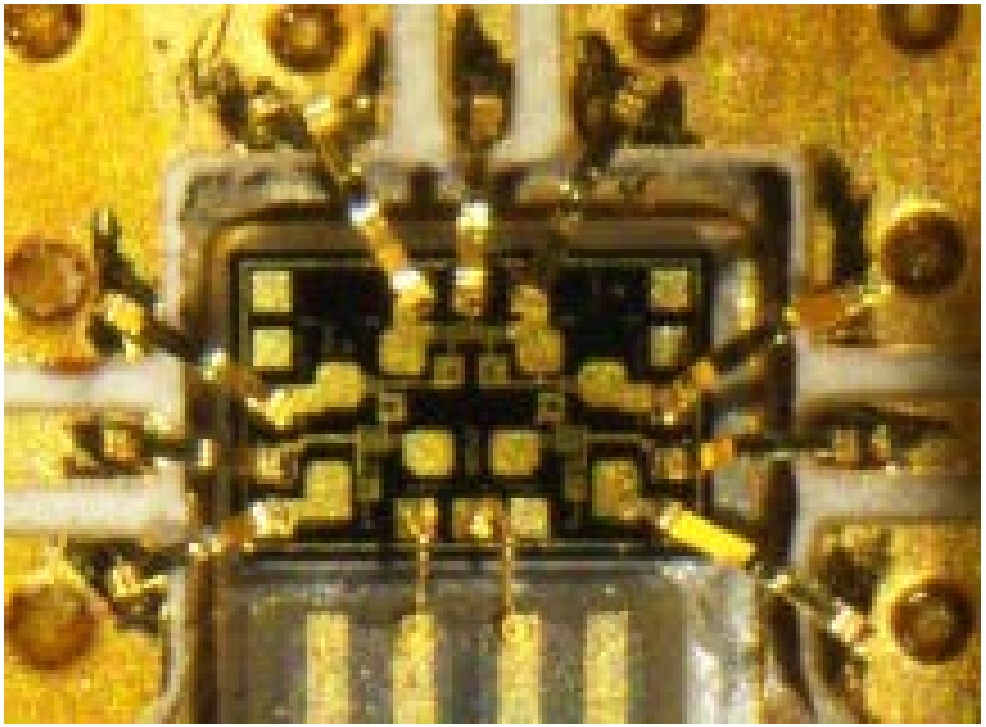
Current Detection Methods

- White light optical inspection
  - White light microscopy alone permits contamination “escapes” to wire/ribbon bond.
- Water break testing
  - Impractical on very small pads, not possible on individual die, always unreliable
- Surface Chemical Analysis
  - EDX and XRF
    - Neither is surface sensitive
  - FTIR
    - Requires a break of operations and not practical on a large area nor on contact sensitive devices
  - XPS (X-Ray Photoelectron Spectroscopy)
    - Highly surface sensitive, $$$$, dimensional limitations, requires UHV compatibility
- UV Fluorescence
  - **Does not work on most epoxies!**

How to Remediate Organic Contamination to Prevent both Immediate and Latent Defects

How can you clean what you don't know is there and cannot determine if it has been removed?

- 100% physical abrasion!
  - Costly
  - FOD generating



Measure Twice Cut Once

Reducing Defects while Reducing HPU

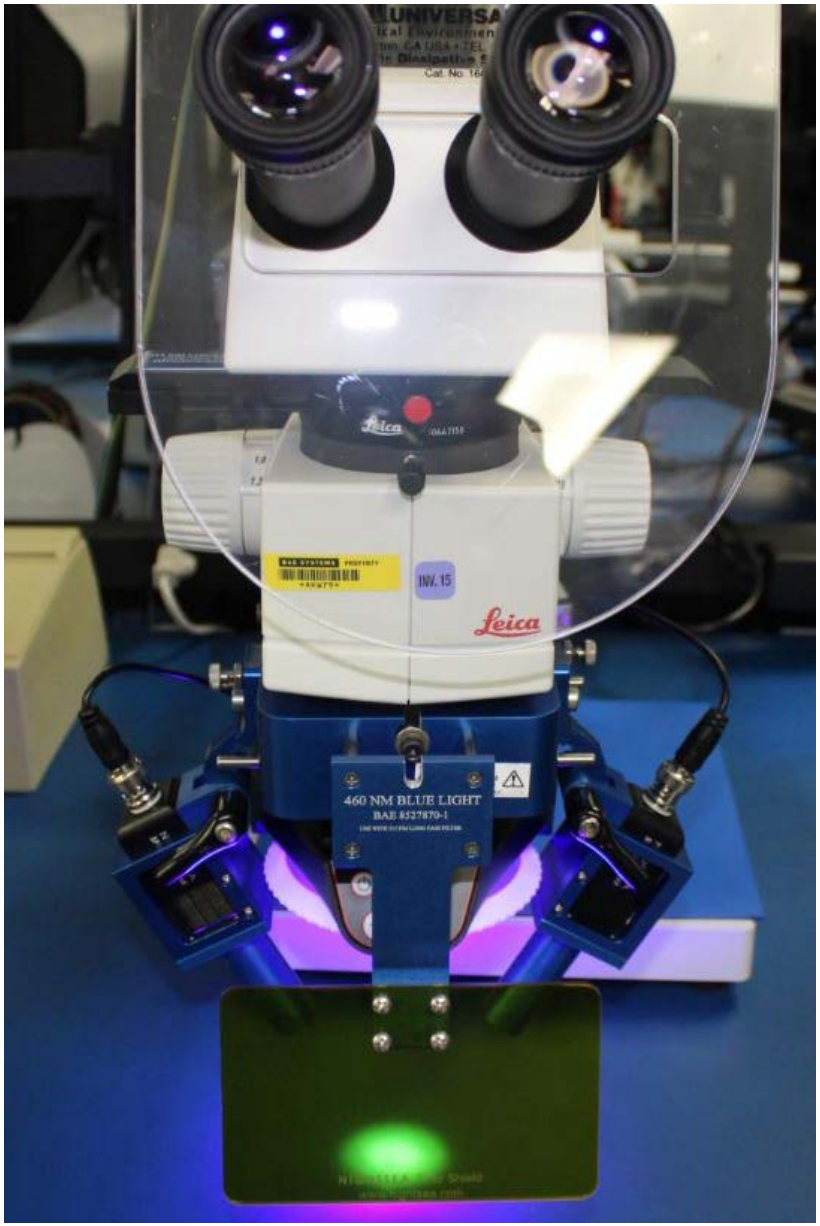
- A continuous challenge for design and process engineers alike!
- Rework can cost upwards of 3 times an initial build
- Preventing or immediate remediation of defects is typically cheaper than detection requiring a disruption of product flow.
- Inspection operations can be reduced once process capability has been successfully proven and sustained.

In Process Fluorescence Inspection

Filtered Blue Light Fluorescence integrated with a bench top stereoscope, LEICA model M80

- Utilizing the inherent visible light fluorescence of typical cured epoxy formulations. BAE Systems in conjunction with Mike Meade of JH Technologies and Charles Mazel PhD of NightSea were able to successfully visualize thin epoxy resin contamination in chip and wire microwave assemblies.

- *Patent Pending*

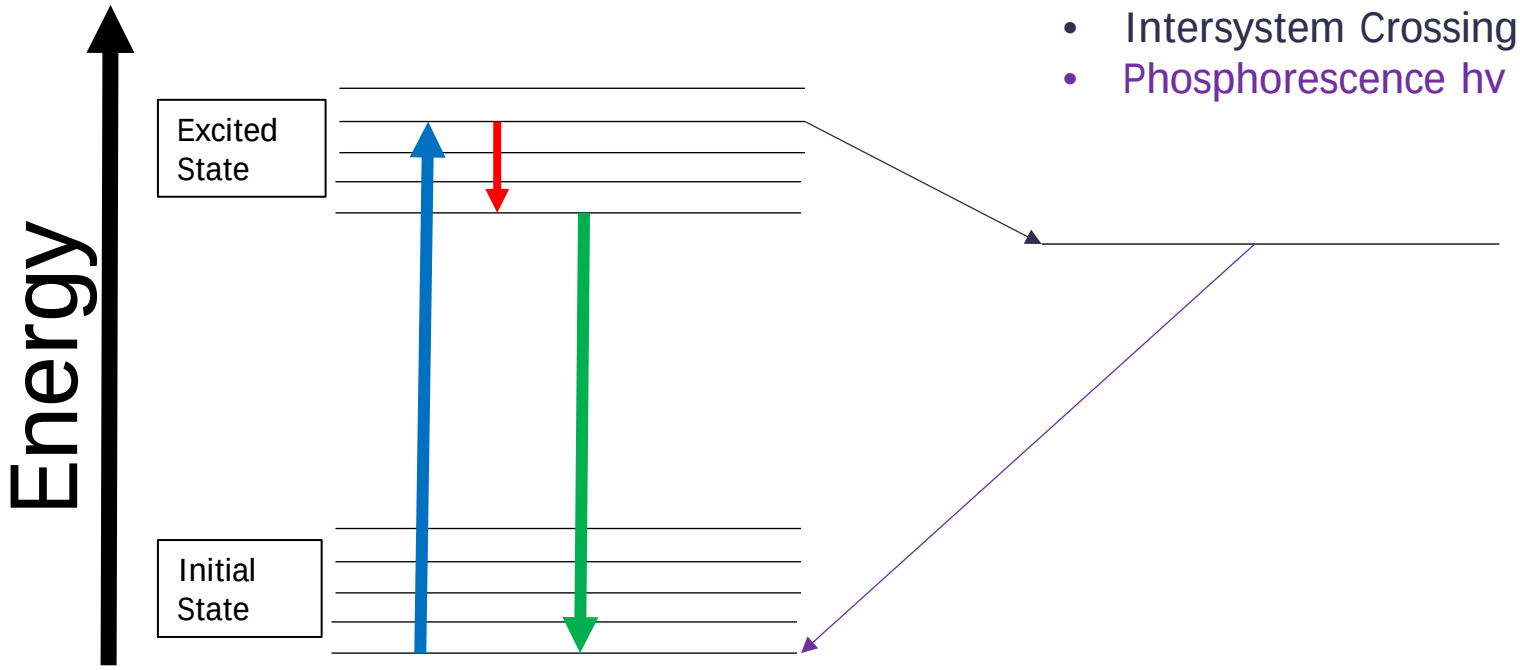


Export Ref. # ES-NHQ-042417-0263

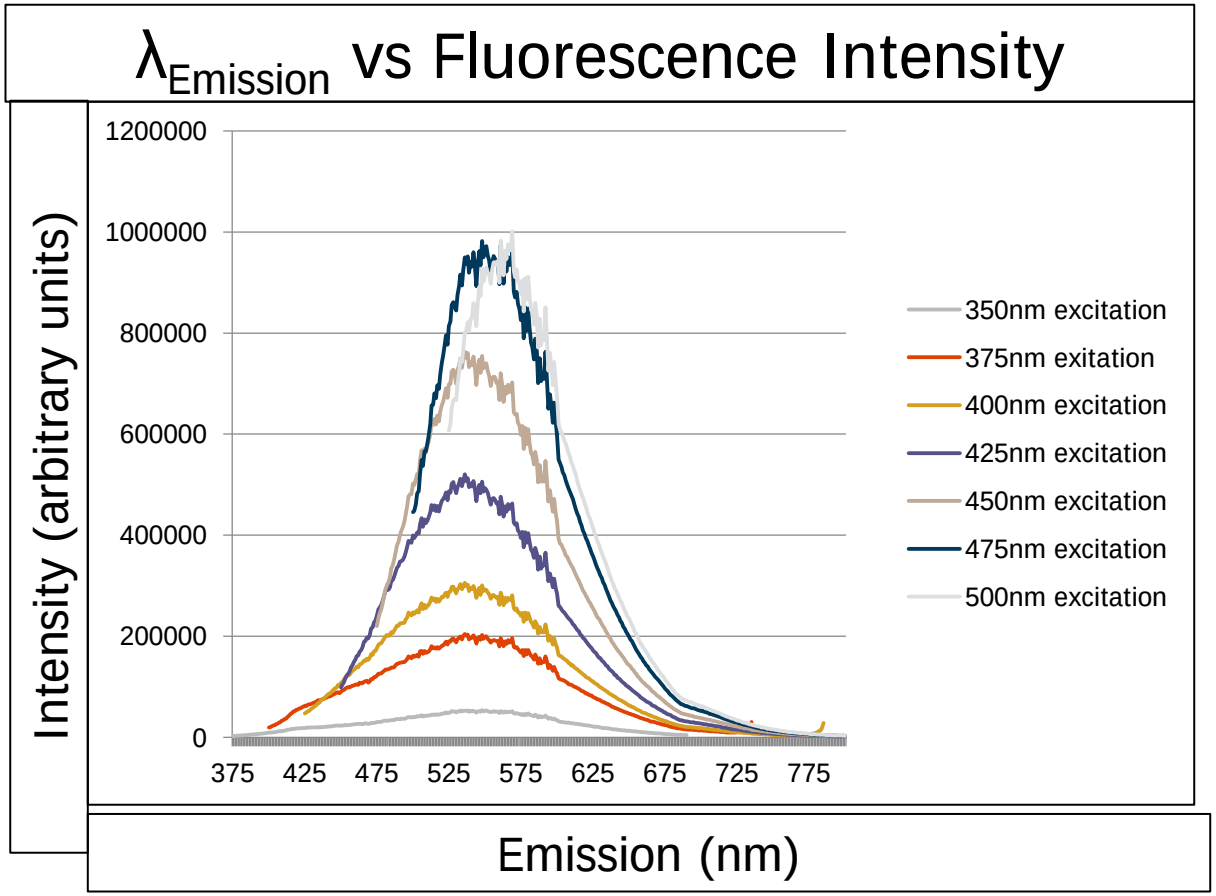
BAE SYSTEMS
INSPIRED WORK

Fundamentals of Fluorescence

- Excitation Energy hv
- Internal Conversion (Stokes Shift)
- Emission Energy hv
- Intersystem Crossing
- Phosphorescence hv



Solid Phase Fluorescence of Epoxy Samples

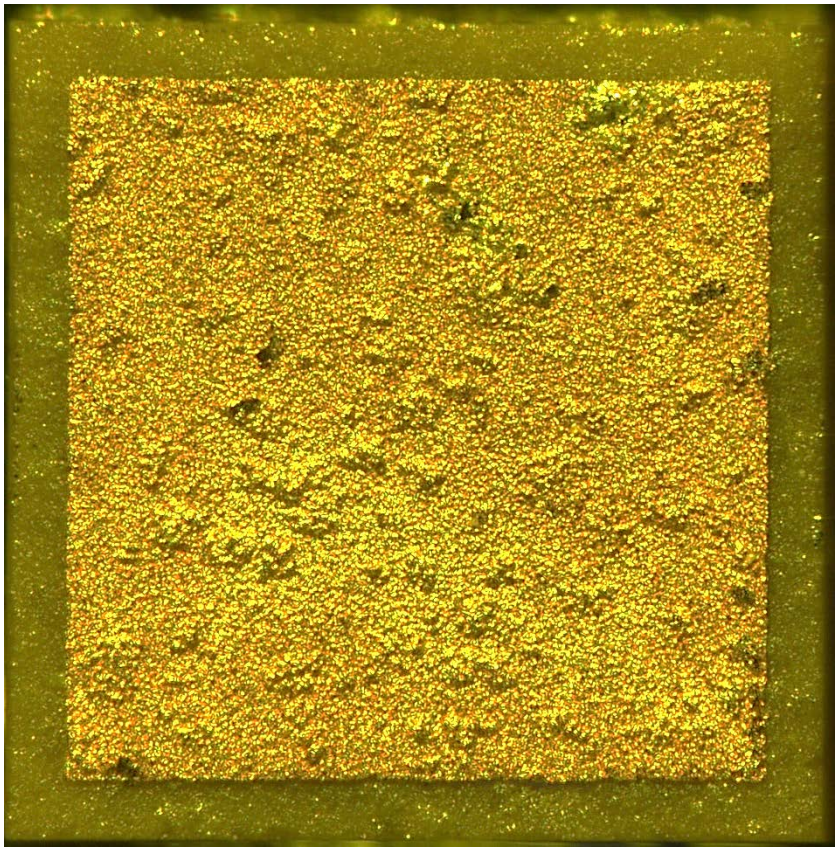


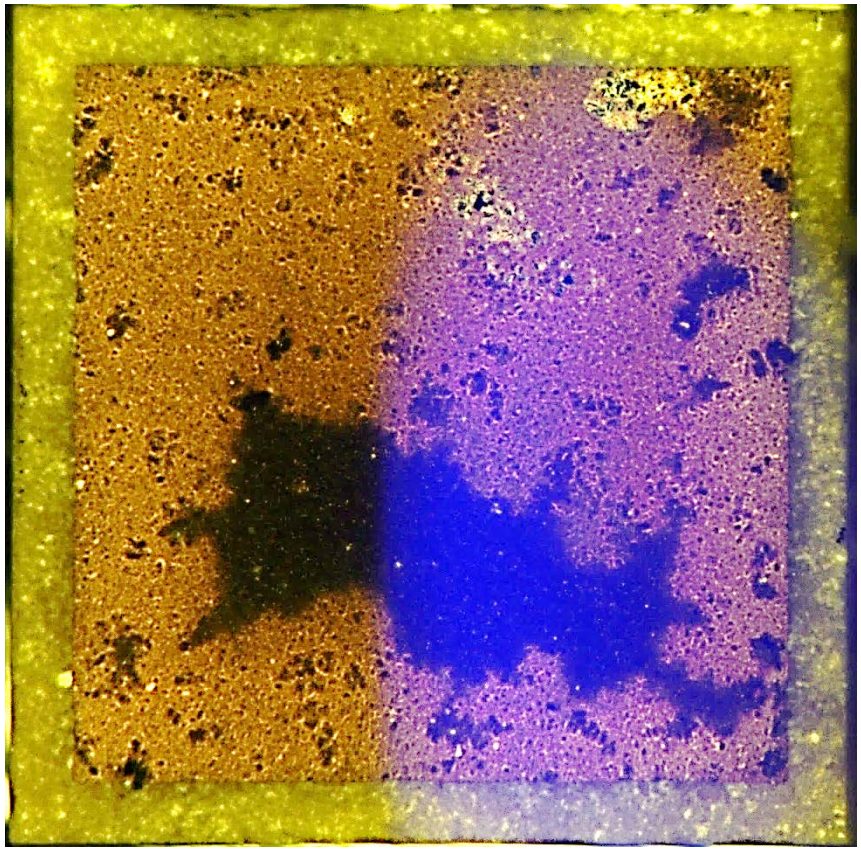
Measured on a cured sample with a Horiba-JY Fluorolog 2 using a low fluorescence glass slide and 2mil (prior to cure) epoxy thickness

Device Design

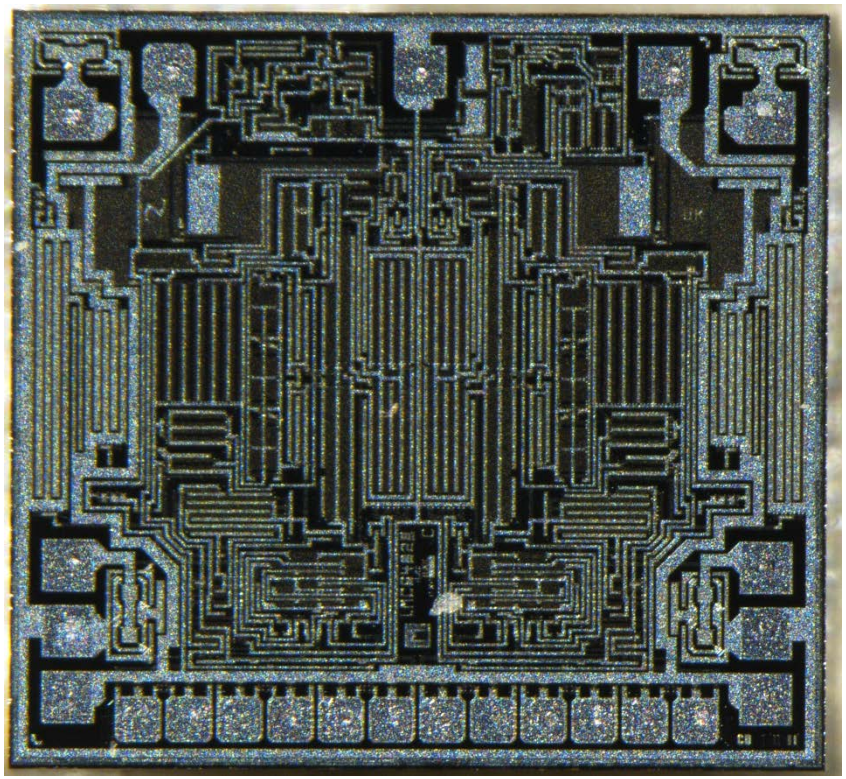
- Our solution uses two 460nm LED lights from NIGHTSEA for illumination and a 515nm Chroma long pass filter, Leica M80 stereo microscope
- Testing performed at the University of Massachusetts Lowell confirmed our anecdotal evidence
- While blue light fluorescence is common in biological systems research we found no evidence that it has been used for in-process assembly and inspection of microelectronics or soldered circuit cards
- Blue light fluorescence can be easily integrated into existing bench top microscopes and stereoscopes
- High power stereoscopes and compound microscopes are readily available from optics brands (eg. Leica)

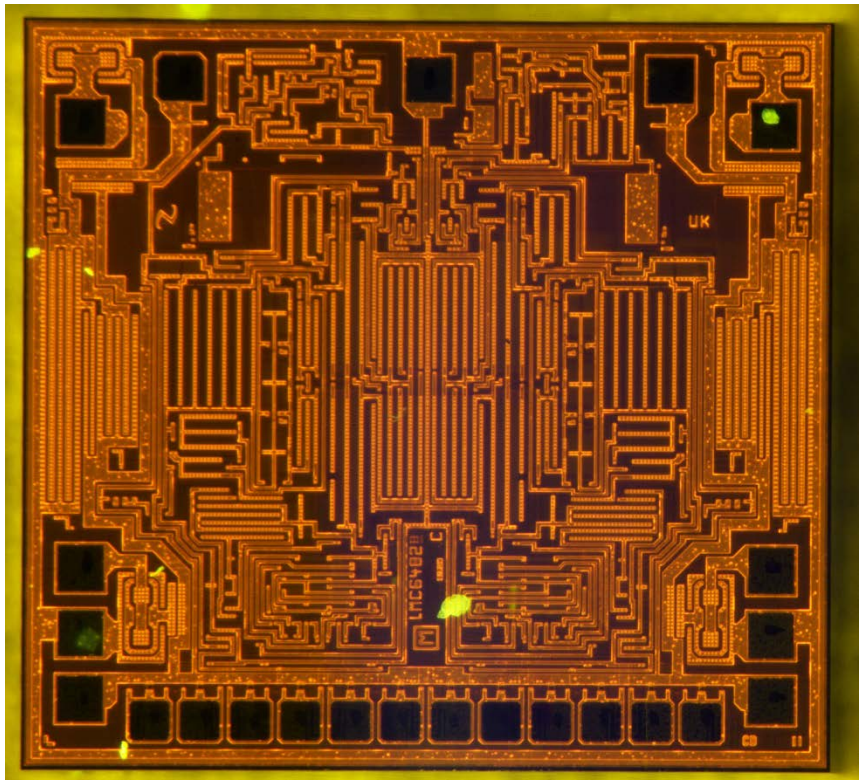
Resin Bleed on Single Layer Ceramic Capacitor





FOD from Wafer Probe

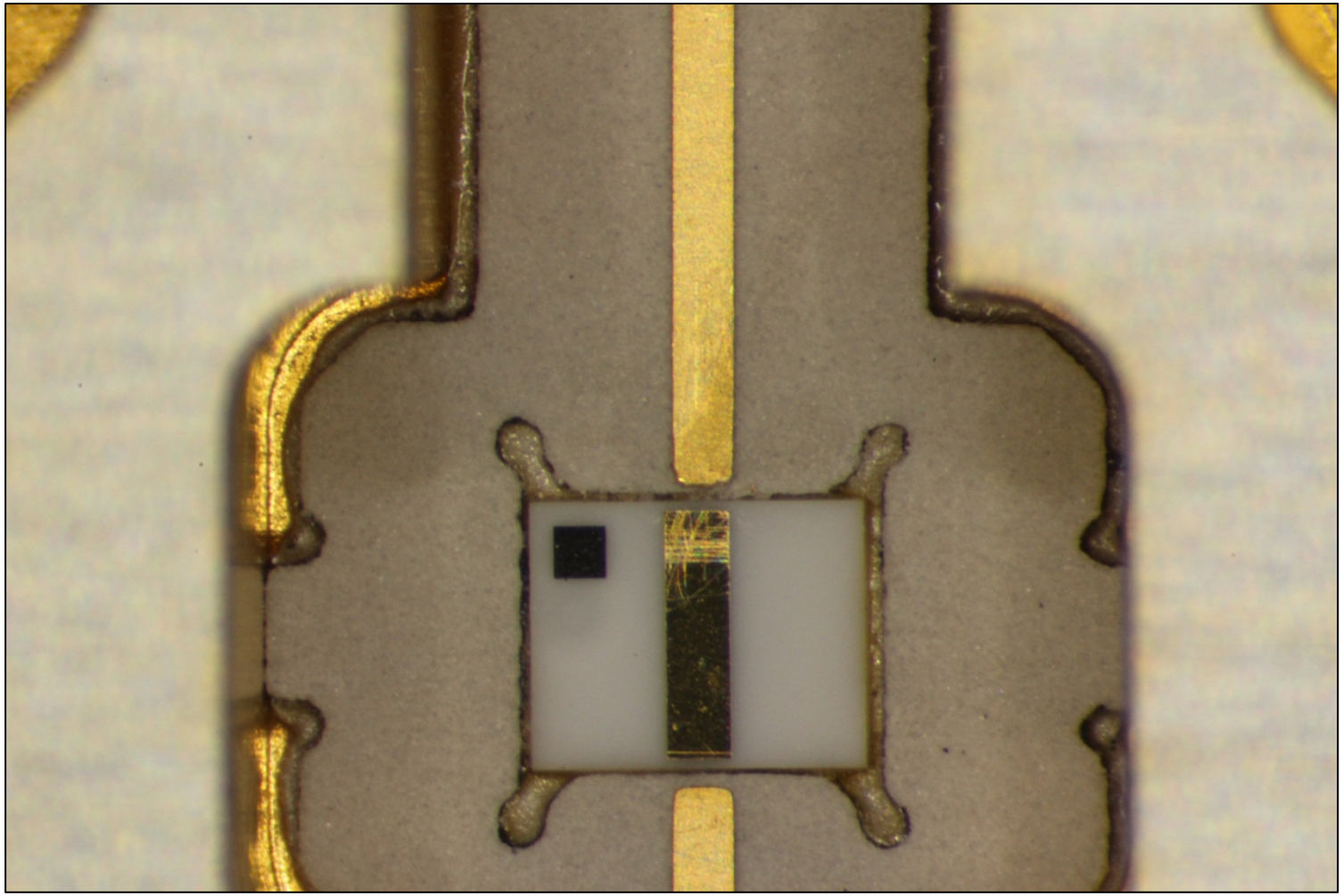




Export Ref. # ES-NHQ-042417-0263

BAE SYSTEMS
INSPIRED WORK

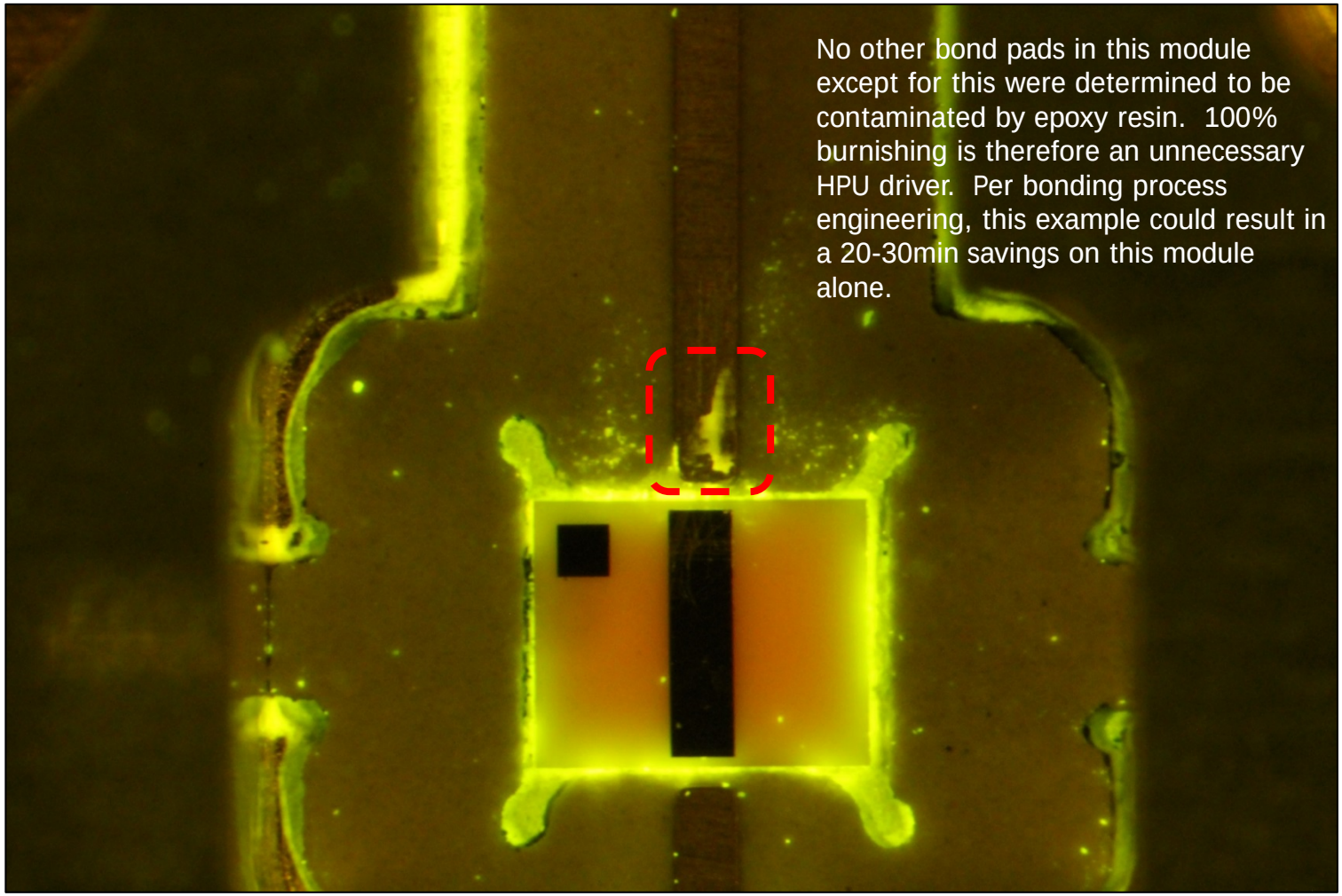
Impossible Wire/Ribbon Bonding (No-Stick)



Export Ref. # ES-NHQ-042417-0263

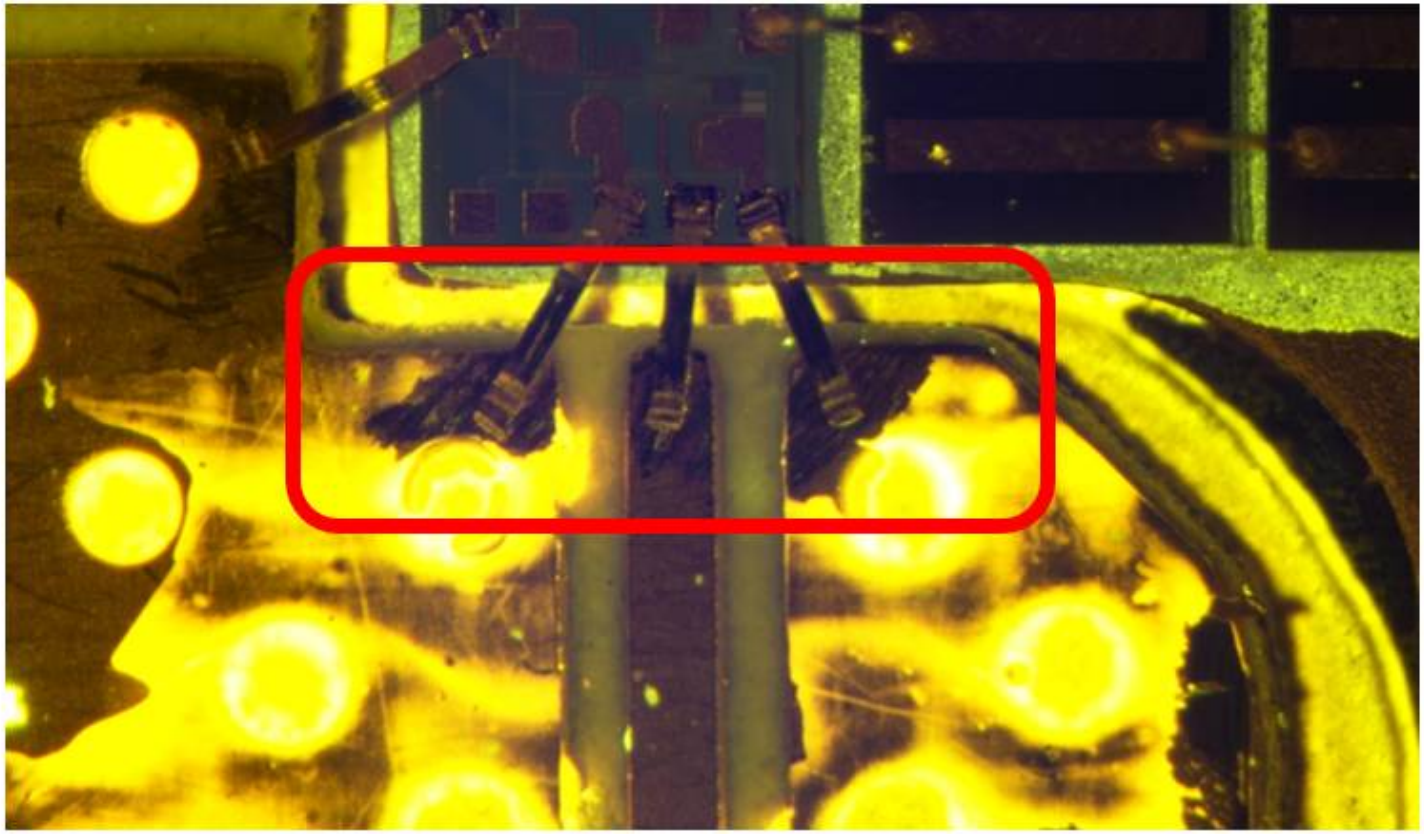
BAE SYSTEMS
INSPIRED WORK

1 out of ~200 Ribbon Locations Required Cleaning

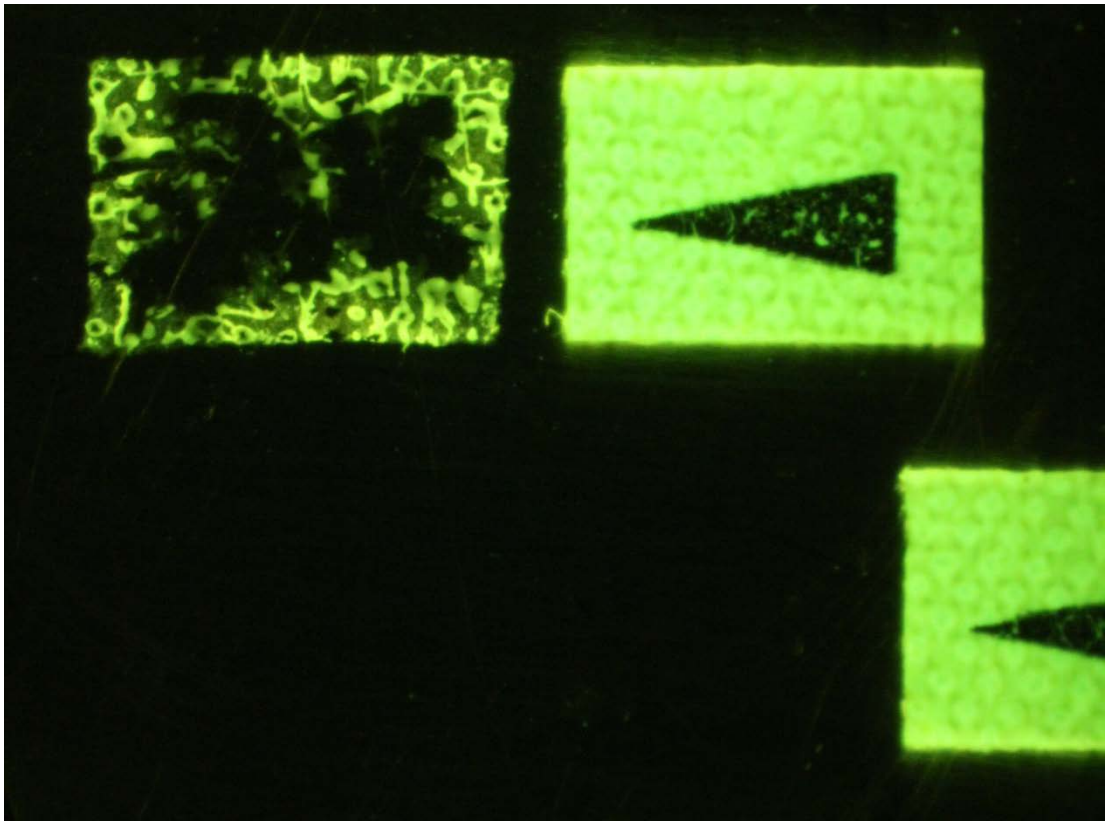


50% Reduction in Burnishing

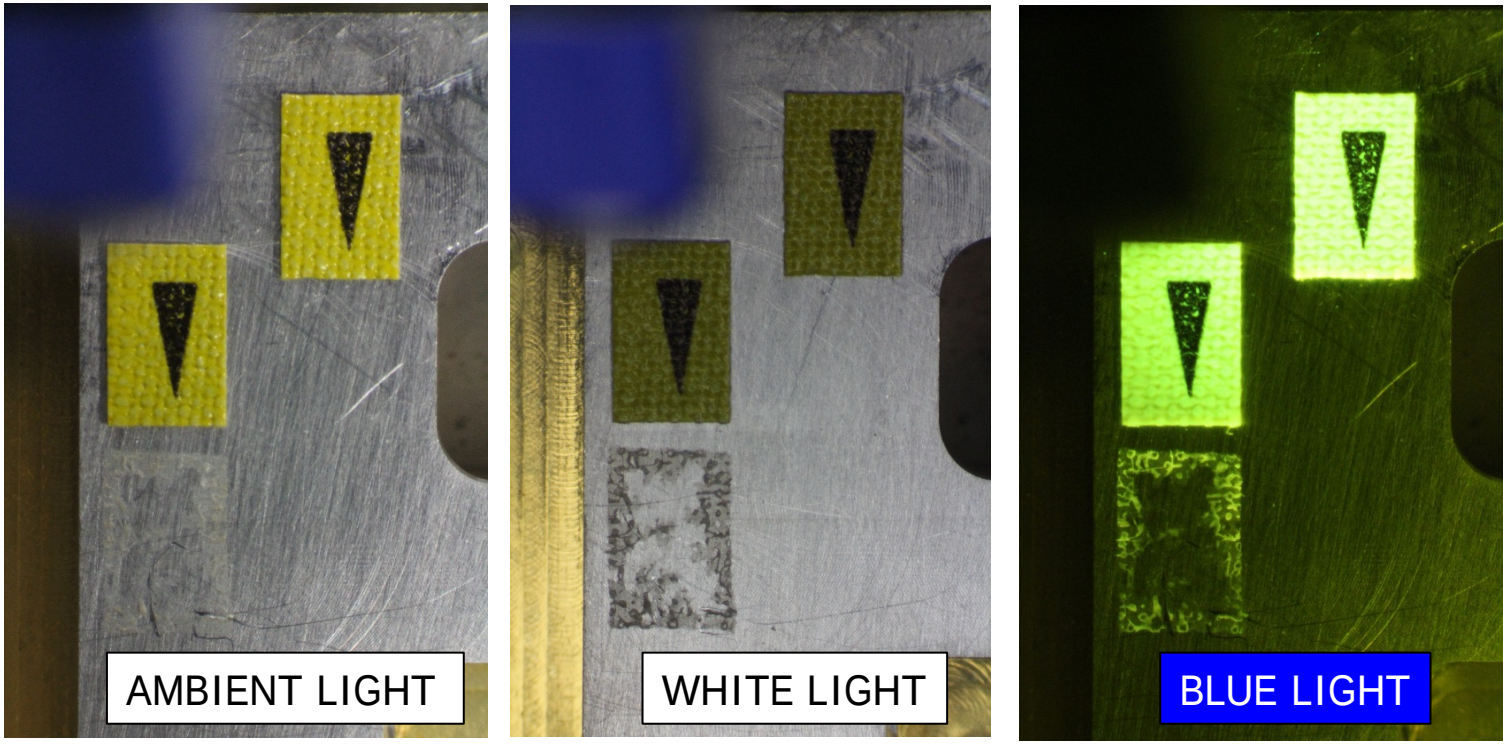
High magnification image reveals the importance and effectiveness of burnishing bonding locations



Adhesive Residue from Pressure Sensitive Adhesive



Tape Residue from Indicator Arrows



Prevention!

- Filled Vias
  - Prevents film epoxy resin from upwelling onto bonding surfaces
- Lamination Cure Profiles
  - Temperature
  - Pressure
  - Dwell
- Avoid Unnecessary Exposure to FOD generators
  - Lint
  - Flux
  - Adhesives
  - FOD generated by scraping/burnishing film epoxy squash-out

Limitations

- Not everything will fluoresce
  - Silicone
  - PTFE
  - Spittle
- Some contaminants can not yet be detected inexpensively

Conclusions

- Visible Light Fluorescence is an inexpensive and highly effective means to inspect microelectronics for contamination
- Most common sources of FOD fluoresce with 460nm blue, visible light
- Minimal health risk for inspectors and bystanders
- Visible light fluorescence offers significant value to all aspects of microelectronics assembly and is not limited to chip-and-wire or circuit card and packaged assembly.

Thank You

- BAE Systems Inc.
  - Brian Cahill
  - Butch Locke
- NIGHTSEA
  - Charles Mazel
- JH TECHNOLOGIES
  - Mike Meade

Export Ref. # ES-NHQ-042417-0263

Questions