No-Clean Assembly Process Conditions – Effects on Flip-Chip/Underfill Reliability

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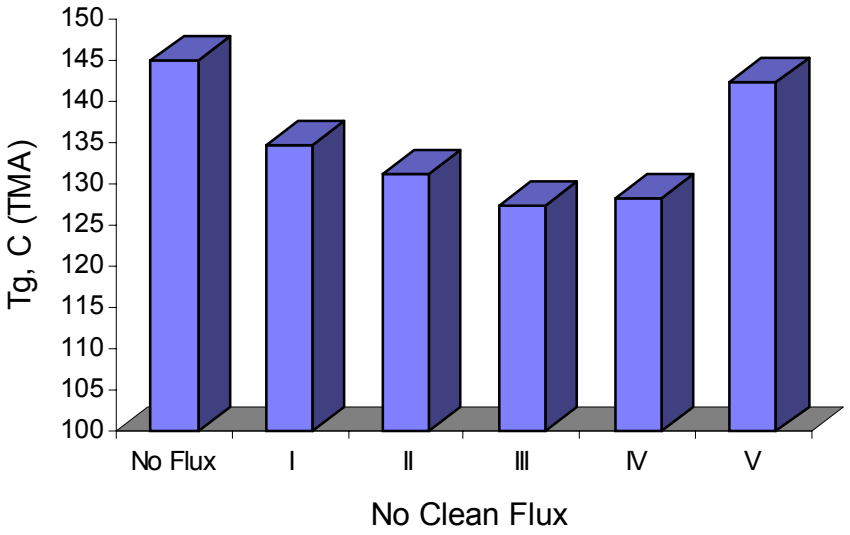
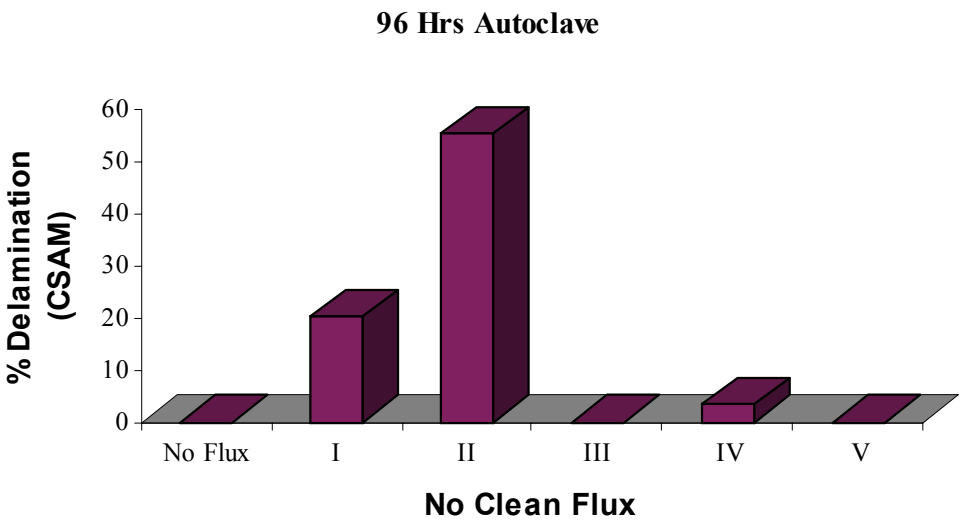
IMAPS SoCal‘ 01 Conference

Background

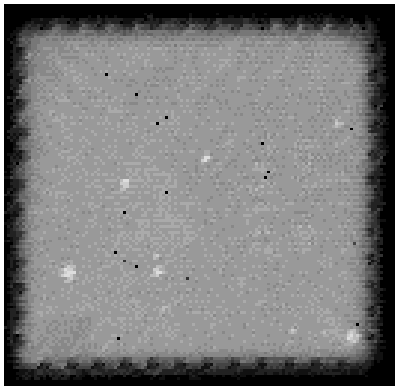
- **Effects of Flux Residues on Underfill Properties**
  - Tg Reduction
  - Flux induced voiding and flow striations
  - Reduction of interfacial adhesive strength



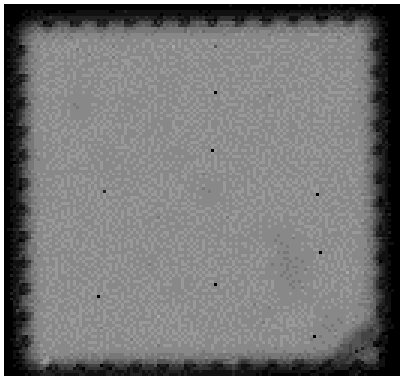


Background

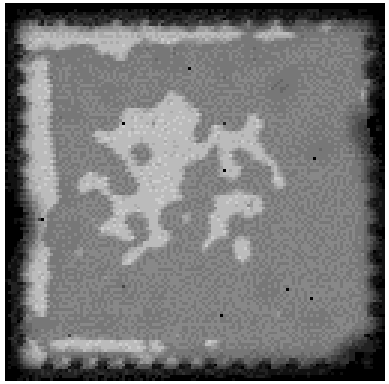
- **Optimum package performance is dependent upon underfill chemistry and flux chemistry –**



Underfill A



Underfill B



Underfill C

- **What processing parameters influence performance?**

Experiment Goals

- **Evaluate Effects of No-Clean Assembly Process Conditions on Flip-Chip Reliability**
  - **Process Variations**
    - Effect of No-Clean Flux Chemistry
    - Effect of Peak Assembly Reflow Temperature
    - Effect of Underfill Dispense Temperature
  - **Reliability Test Criteria**
    - JEDEC Level 3 / 220°C Reflow

Experimental Design

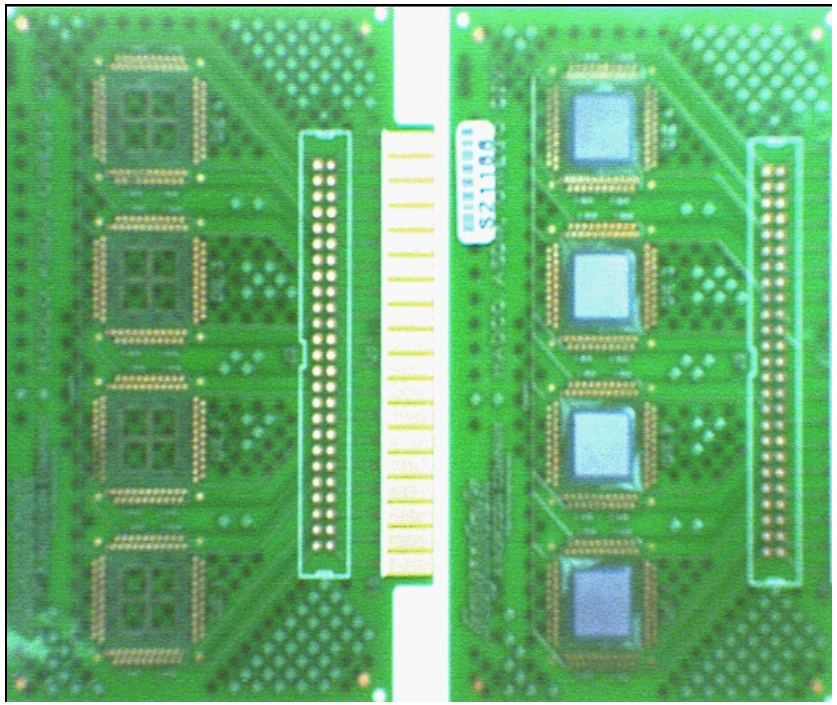
- 3 x 2 x 2 Full Factorial Design
  - Three Commercial No-Clean Fluxes
  - Two SMD Reflow Profiles
    - Peak 220°C and Peak 260°C
  - Two Underfill Dispense Temperatures
    - 90°C Preheat and 130°C Preheat

- Four Test Assemblies per Condition
  (Screening Evaluation Only)

Material Sets Evaluated

Flux Formulation	Chemistry	Viscosity (cps)	Residue
A	Synthetic	110,000	4%
B	Not Reported	10,000	Medium
C	Synthetic	30,000	Very Low
Underfill	Epoxy-Anhydride	5,000	

Test Vehicle



- 10mm x 10mm Die
- Silicon Nitride Passivation
- Perimeter and Internal I/O

- 0.79mm Thick FR4 Laminate
- Cu/Ni/Au Plating
- 4 Die / Substrate

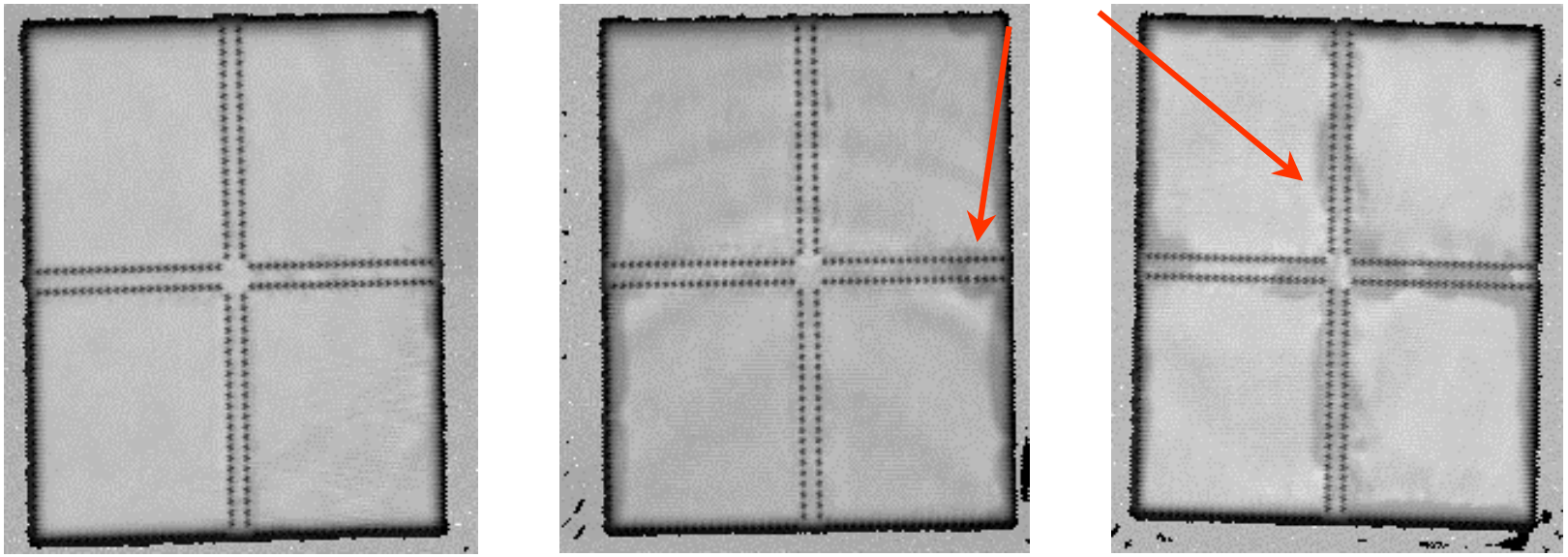
Assembly Process

- Prebake Substrate at 125°C
- Die dip-fluxed at 0.0015” thickness
- Die placed onto substrate
- Die reflow soldered using 220°C or 260°C SMD Profile
- (No cleaning operation)
- Underfill dispensed at 90°C or 130°C
- Underfill cured 30 Minutes at 165°C

Evaluation Process

- CSAM Immediately Following Underfill Process
- Expose Parts to JEDEC L3 Preconditioning
  - 30°C/85% RH/192 Hours
  - 3X Reflow Cycles (Peak Temp = 220°C)
- CSAM

Results - Initial Observations
Effect of Flux Composition

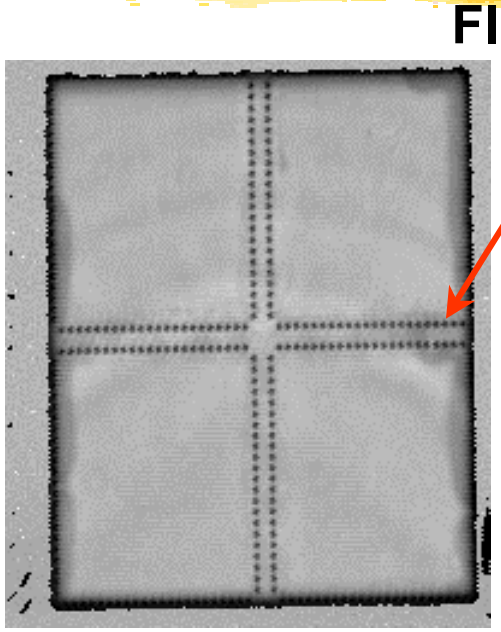


Flux A **Flux B** **Flux C**

220°C Reflow Process

90°C Underfill Dispense Temperature

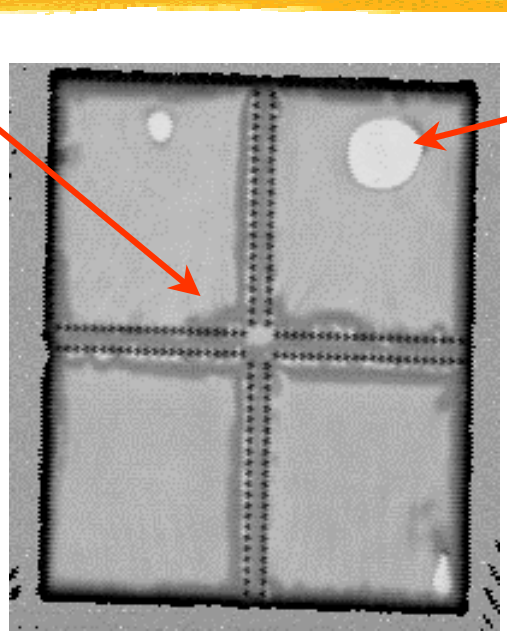
Results - Initial Observations
Effect of Reflow Temperature



Flux B

220°C Reflow Process

90°C Underfill Dispense Temperature



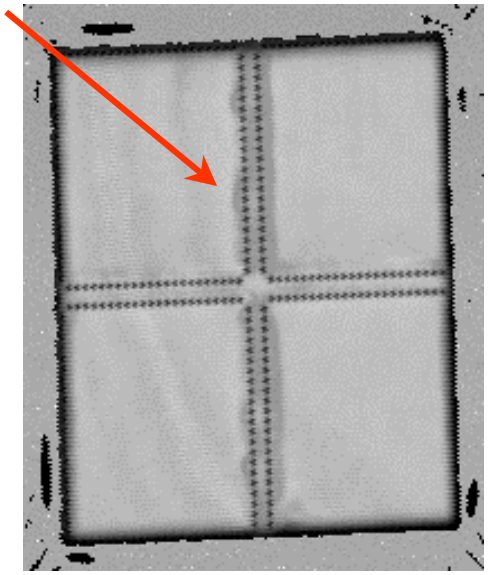
Flux B

260°C Reflow Process

90°C Underfill Dispense Temperature

Results - Initial Observations
Effect of Underfill Dispense Temperature

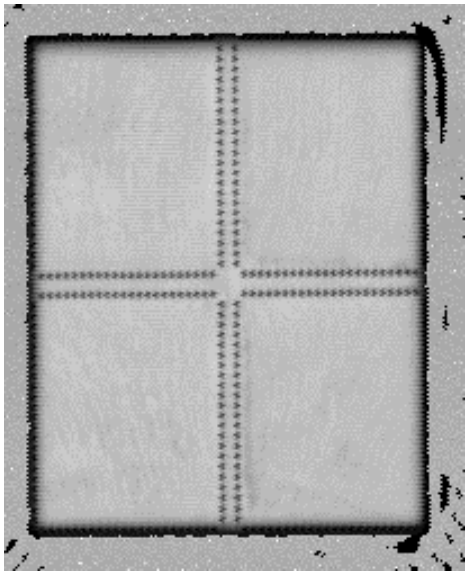
Flux Residue "Shadow"



Flux C

260°C Reflow Process

90°C Underfill Dispense

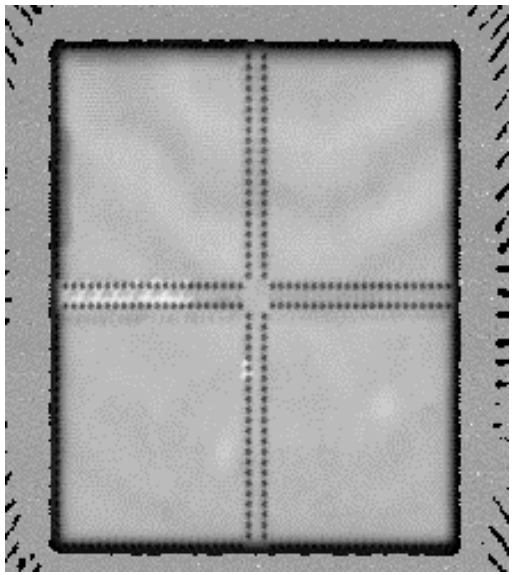


Flux C

260°C Reflow Process

130°C Underfill Dispense

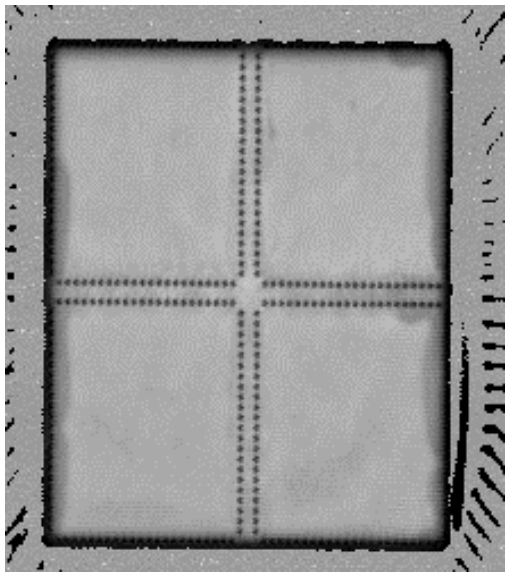
Results - Post JEDEC L3
220°C Assembly Reflow Temperature



Flux A

220°C Reflow Process

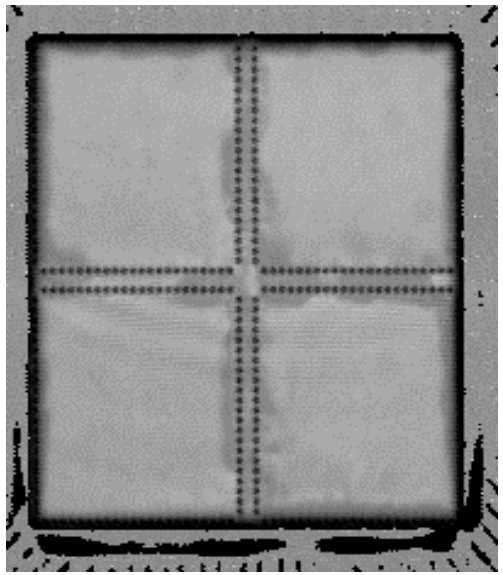
90°C Underfill Dispense



Flux B

220°C Reflow Process

90°C Underfill Dispense

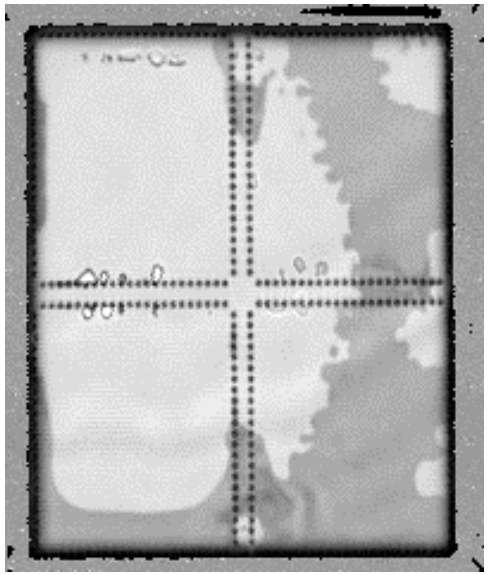


Flux C

220°C Reflow Process

90°C Underfill Dispense

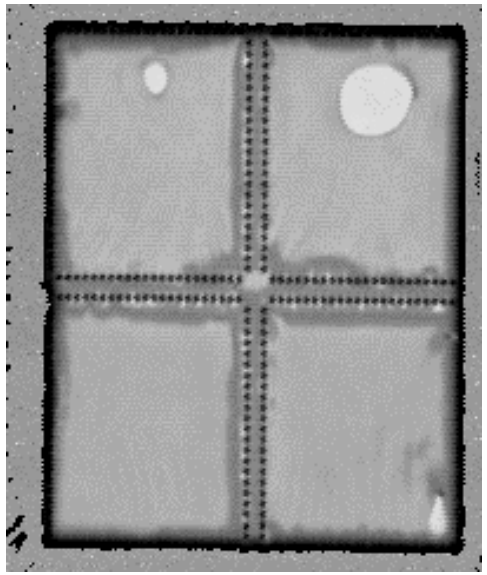
Results - Post JEDEC L3
260°C Assembly Reflow Temperature



Flux A

260°C Reflow Process

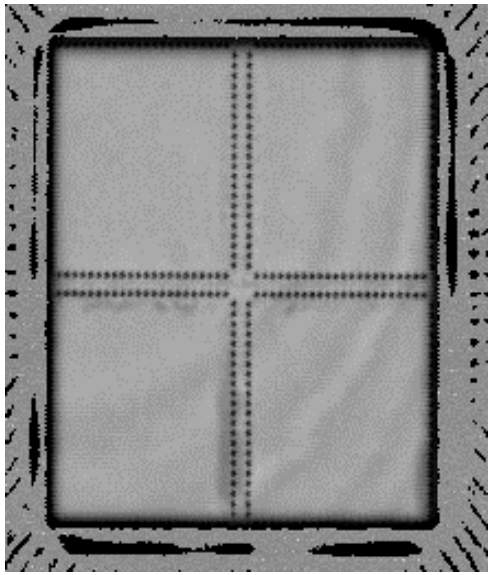
90°C Underfill Dispense



Flux B

260°C Reflow Process

90°C Underfill Dispense



Flux C

260°C Reflow Process

90°C Underfill Dispense

Experiment Conclusions

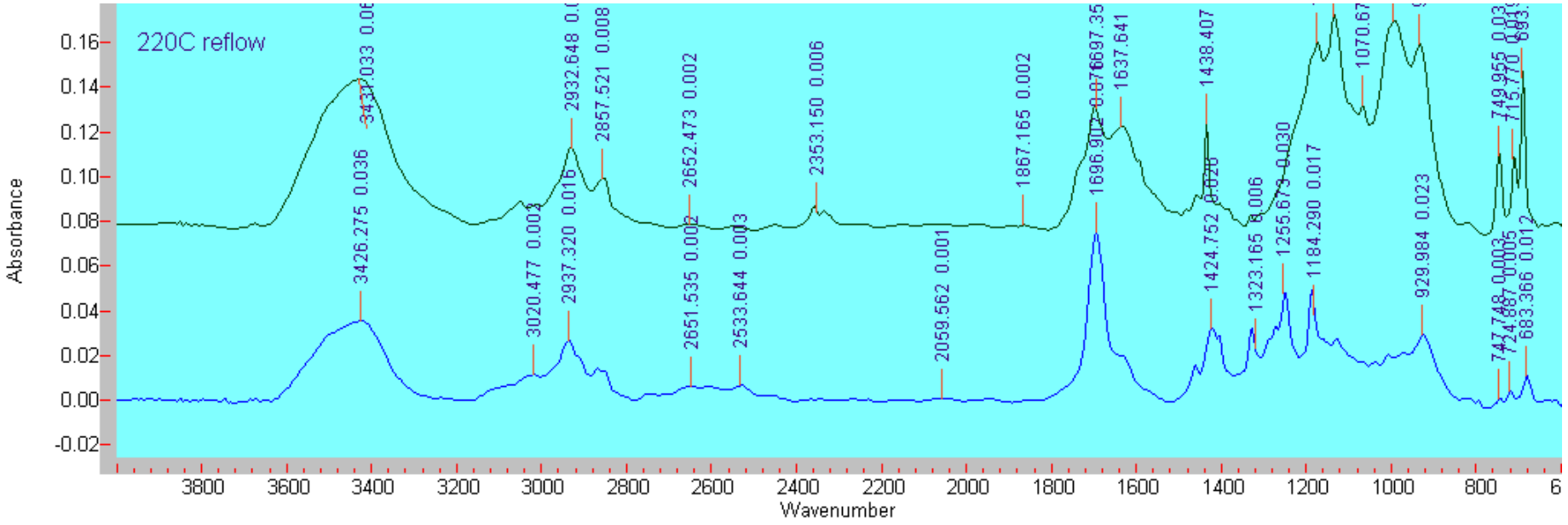
- Effects of Flux Residue
  - Shadow Images of Flux Residue Observed by CSAM Analysis
- Effects of Reflow Process
  - Flow Voids Caused by Higher Residue Flux after 260°C Reflow Process
  - All Samples Passed JEDEC L3 after 220°C Assembly Reflow Process
  - Only One Flux Sample Passed JEDEC L3 after 260°C Assembly Reflow Process

Experiment Conclusions

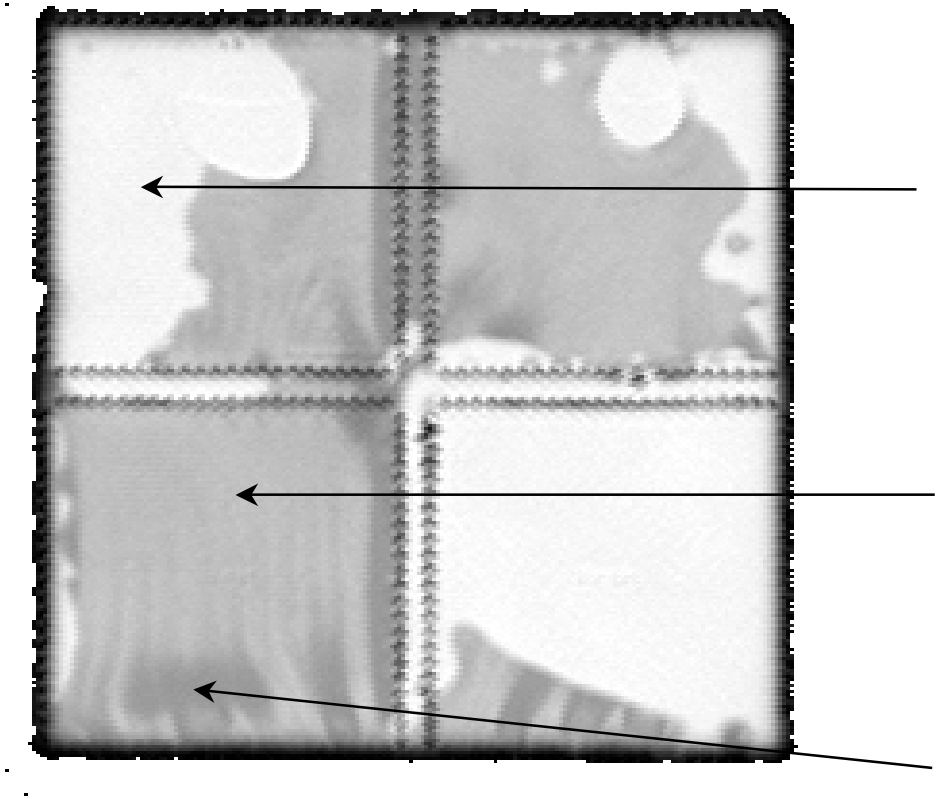
- Effects of Dispense Temperature
  - Higher Dispense Temperature Reduced Flux Shadowing Only on One Flux Chemistry
  - No Impact on Most Flux Chemistries

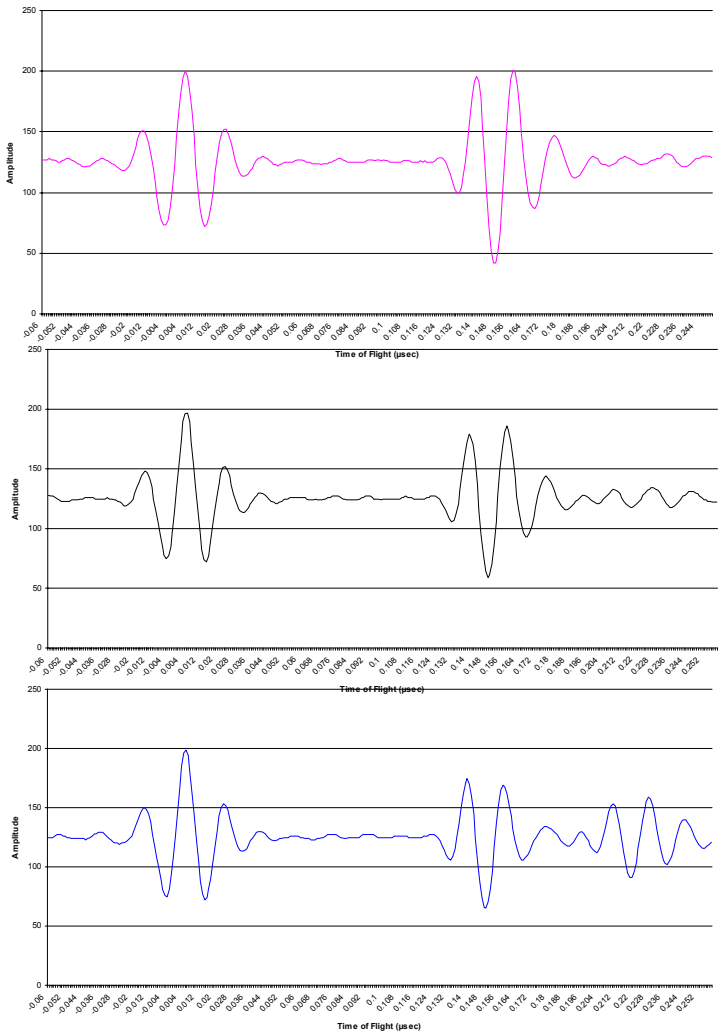
Follow-Up Evaluations

- FTIR Evaluation of the Effects of Reflow Temperature on Flux Residue



Evaluation of “Shadow” Regions





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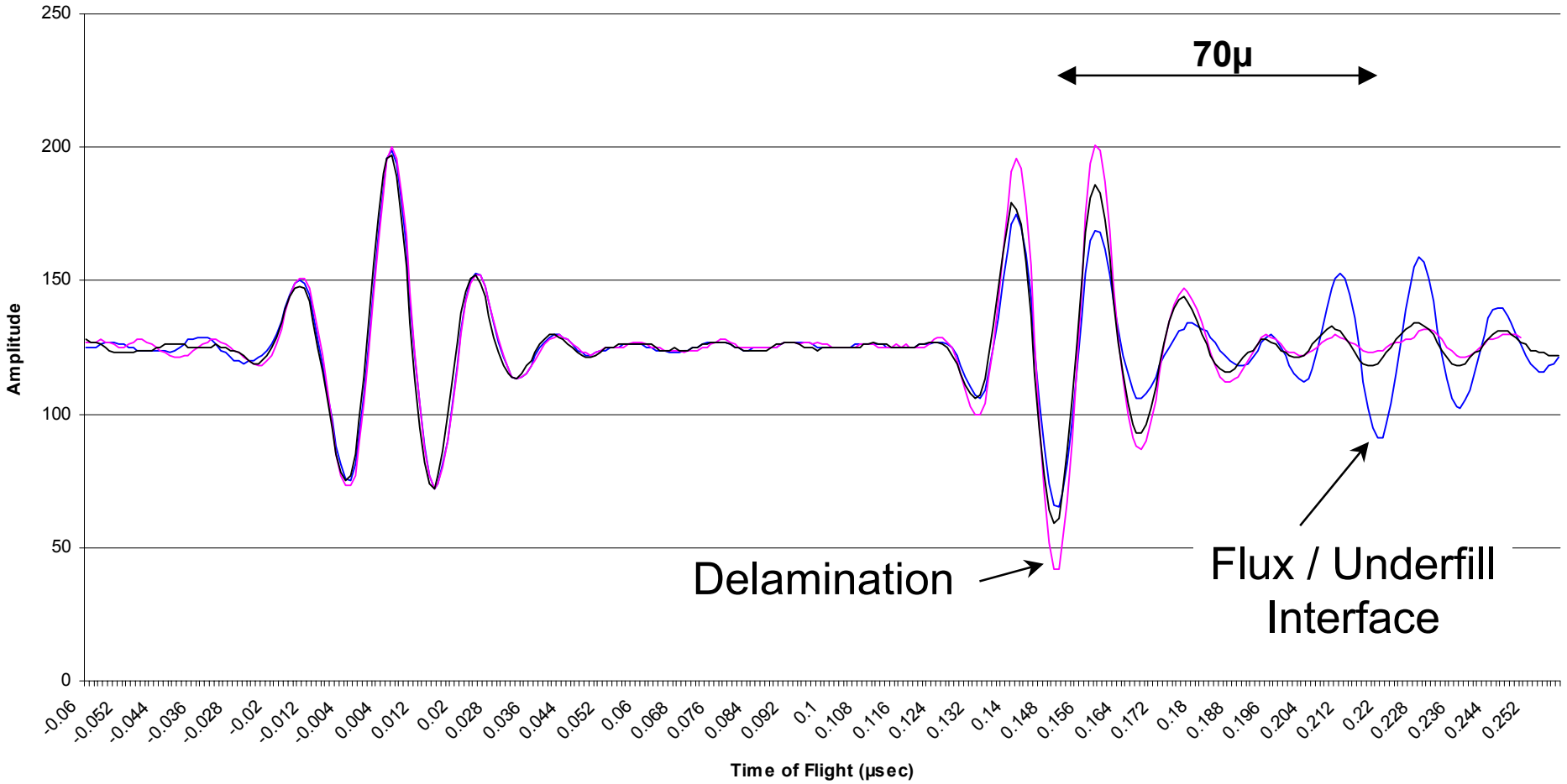
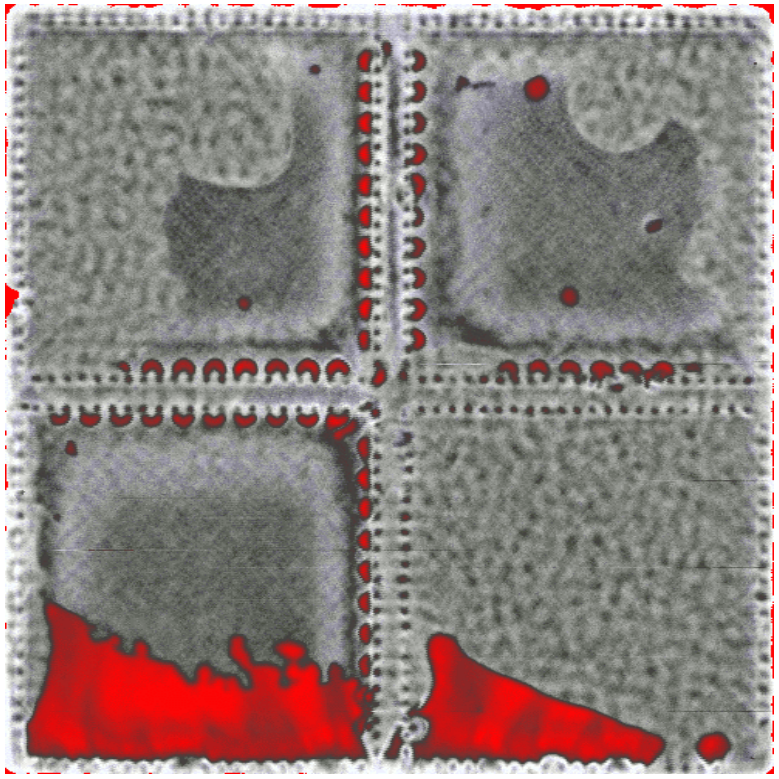
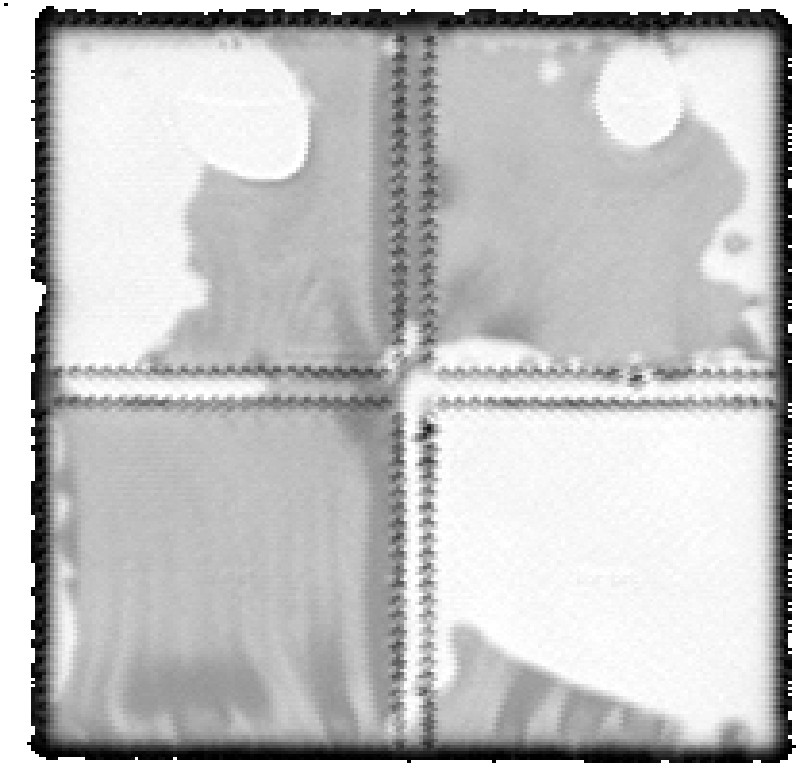


Evaluation of “Shadow” Regions



Flux Level Gate



Underfill Level Gate