Anti-collapse Reflow Encapsulant Technology for FCOF

IMAPS Flip-Chip 2003, Austin TX

Overview

- Background
- Problem Statement
- Development Process
  - Timeline
  - Anti-collapse approaches
- Test Methodology
- Results & Discussion
  - Process and reliability tests
- Conclusions

Background

- 9110S Development overview
  - 3 year process, defined FCOF optimal behaviors
    - Mechanical, dispense, curing, etc.
    - Developed in partnership with Seagate Technology
- Need for Anti-collapse Behavior
  - Make behavior independent of pad definition
  - Driven by economics
- Pb-free transition
  - New resin & catalyst technology
  - Control of voiding
    - From substrate & (sometimes) component

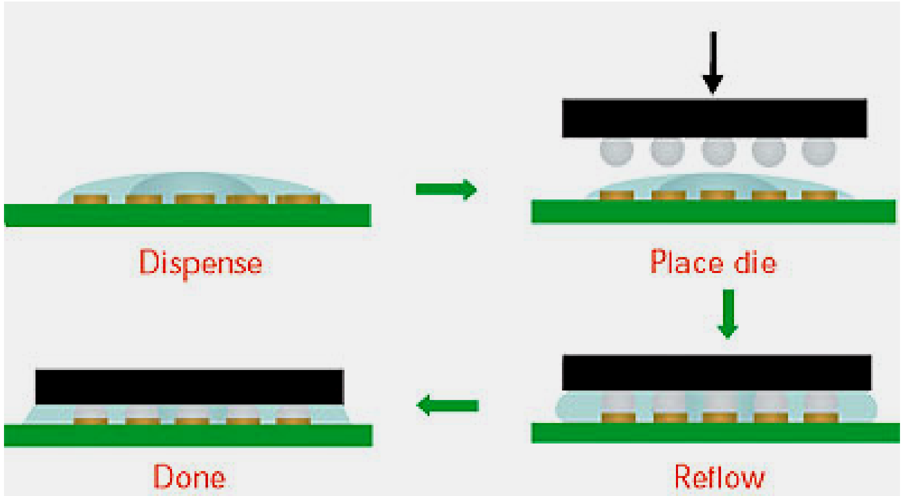
Background

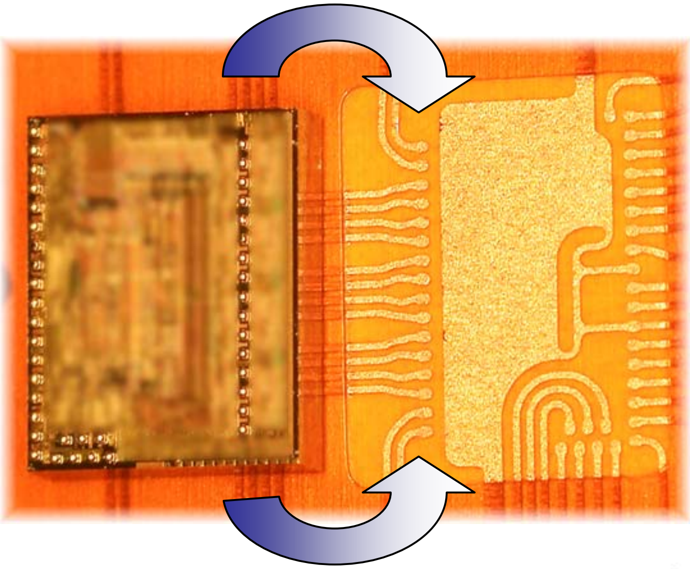
Basic RE Process Targets

Metric	Target/Rationale
Throughput	>30% increase in line throughput Product cost reduction Fewer steps; higher yield
Product Quality	Equal or better reliability with increased product density
Product Density	Reduce space required for capillary underfill
Floor Space & Equipment	Eliminate post-cure Simplify dispensing process

Anti-collapse Problem Definition

- Kapton coverlay opening tolerances
- Chip standoff variations
- Solder alloy variations (Pb-free)





Two Anti-collapse Approaches

Anti-collapse Beads

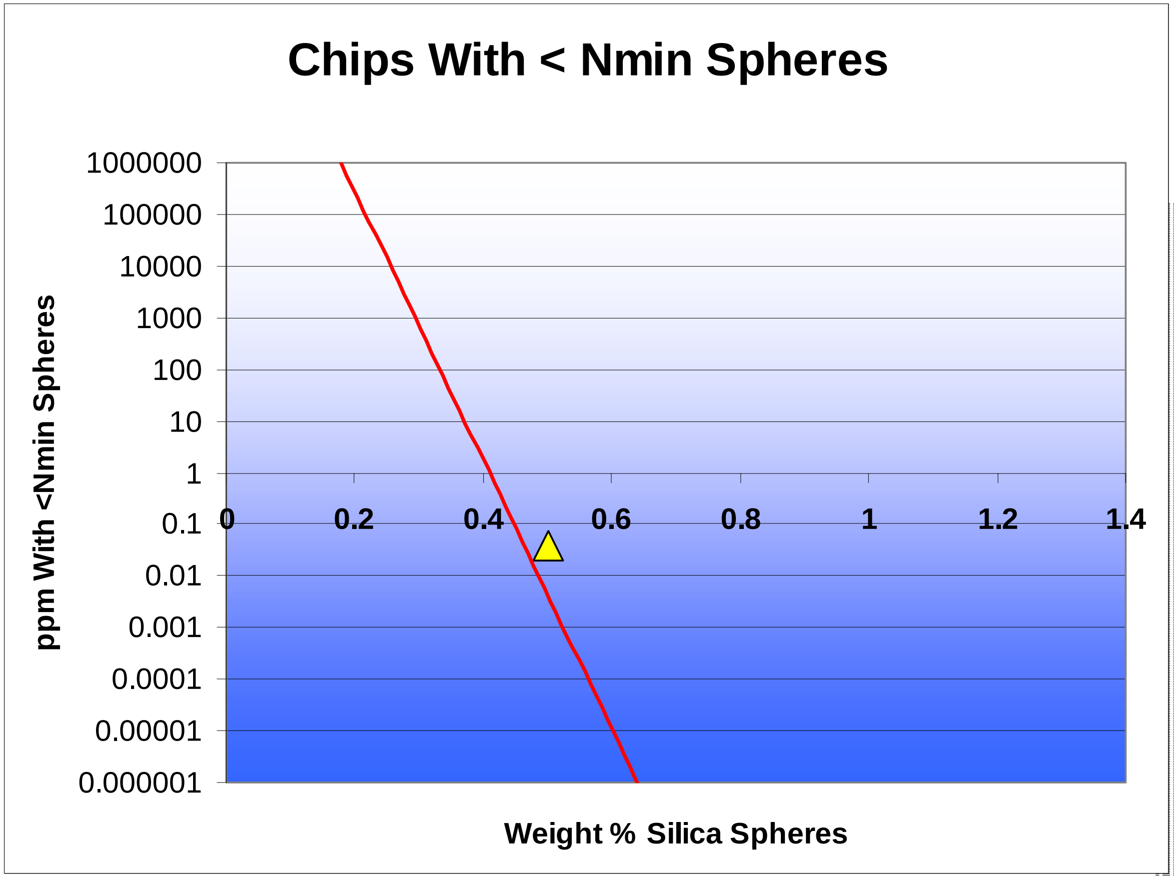
- Proven technology
- Simple implementation
- Requires bead diameter tailored to standoff
- bead dispersion must be well understood
  - Die size dependence!

Rheology Control

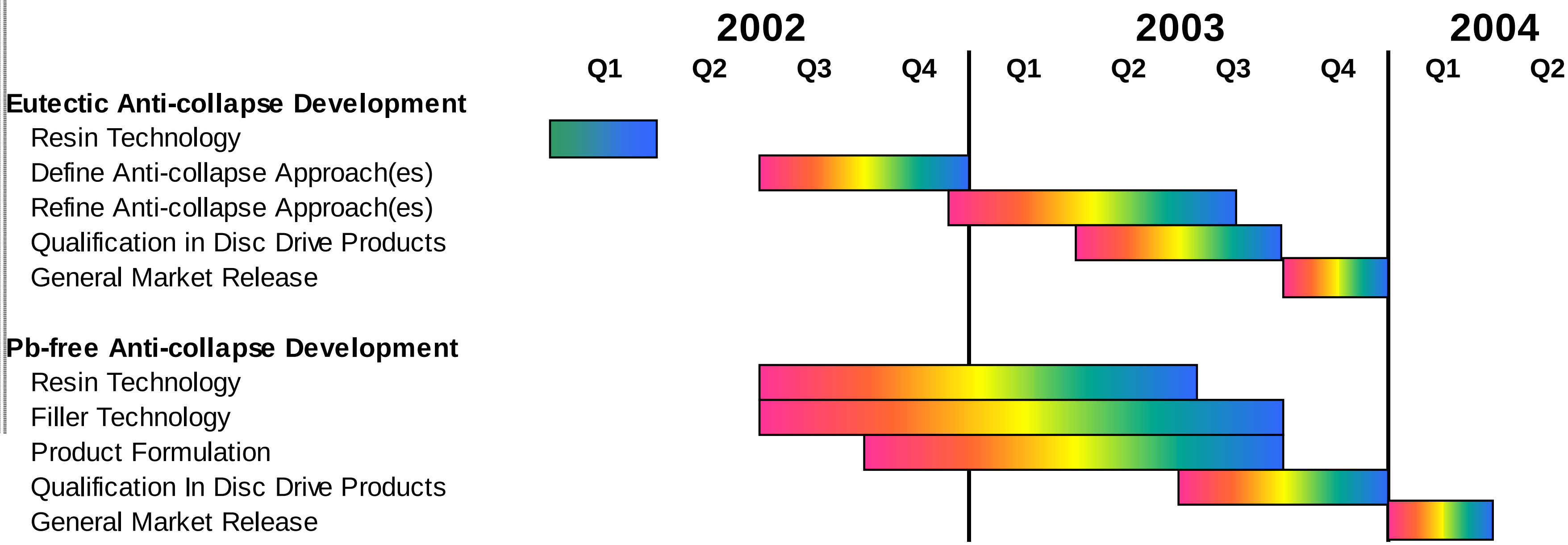
- More than one way to accomplish this
- Kester chose inorganic viscosity modifiers
- Performance independent of standoff
- Some die size dependence is possible

Anti-Collapse via Beads

Chip W:	2.5	mm
Chip L:	2.5	mm
Gap H:	0.1	mm
Fillet Dim:	0.35	mm
Material Density:	1.29	g/cm^3
Silica density:	2.202	g/cm^3
Silica Sphere Dia:	0.045	mm
Sphere Weight:	1.05E-04	mg
Sphere Concentration:	0.50%	
Minimum N:	10	Spheres
Volume in Gap:	0.625	mm^3
Volume in Fillet:	0.856	mm^3
Total Volume:	1.481	mm^3
% of Volume in Fillet:	57.8%	
% of Volume in Gap:	42.2%	
Target Dispense Weight:	1.91	mg
N total:	90	Spheres
N gap:	37	Spheres
P of <= Nmin:	0.00%	
ppm of chips with < Nmin:	0.040	ppm



Timeline for Development



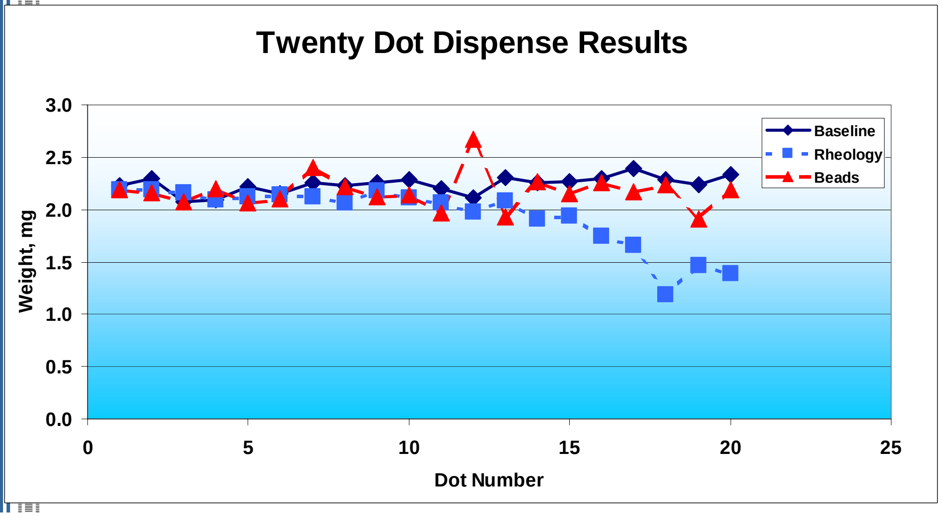
Test Methodology

- Focused on actual process performance
- Dispense testing performed with Cam/Alot 1414 and DL Tech. Pump
- Placement with Universal GSM
- Reflow with Heller 1700 oven
- X-ray with Fein Focus FOX
- Cross section as required

Dispense Testing

- Pattern Repeat Test
  - 45-dot pattern repeated every 5 minutes for one hour
  - Measure average dispensed weight for each pattern
- Twenty-dot test
  - Measure individual dispense weights to measure repeatability
- Measure anti-collapse materials against baseline material

Dispense Testing



- Rheology-controlled material failed twenty dot test
- Baseline & bead-based materials were equivalent
- Slightly higher volume required for bead-based material

Dispense Testing

Baseline

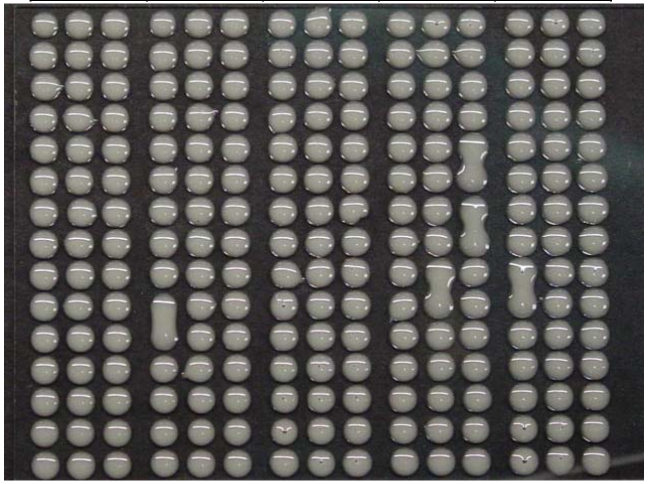
	Set A	Set B	Set C	Set D	Set E
Total Weight (mg)	91.38	89.73	92.38	92.77	92.92
Weight per Dot (mg)	2.03	1.99	2.05	2.06	2.06

Rheology-controlled

	Set A	Set B	Set C	Set D	Set E
Total Weight (mg)	12.48	N/A	N/A	N/A	N/A
Weight per Dot (mg)	0.27	N/A	N/A	N/A	N/A

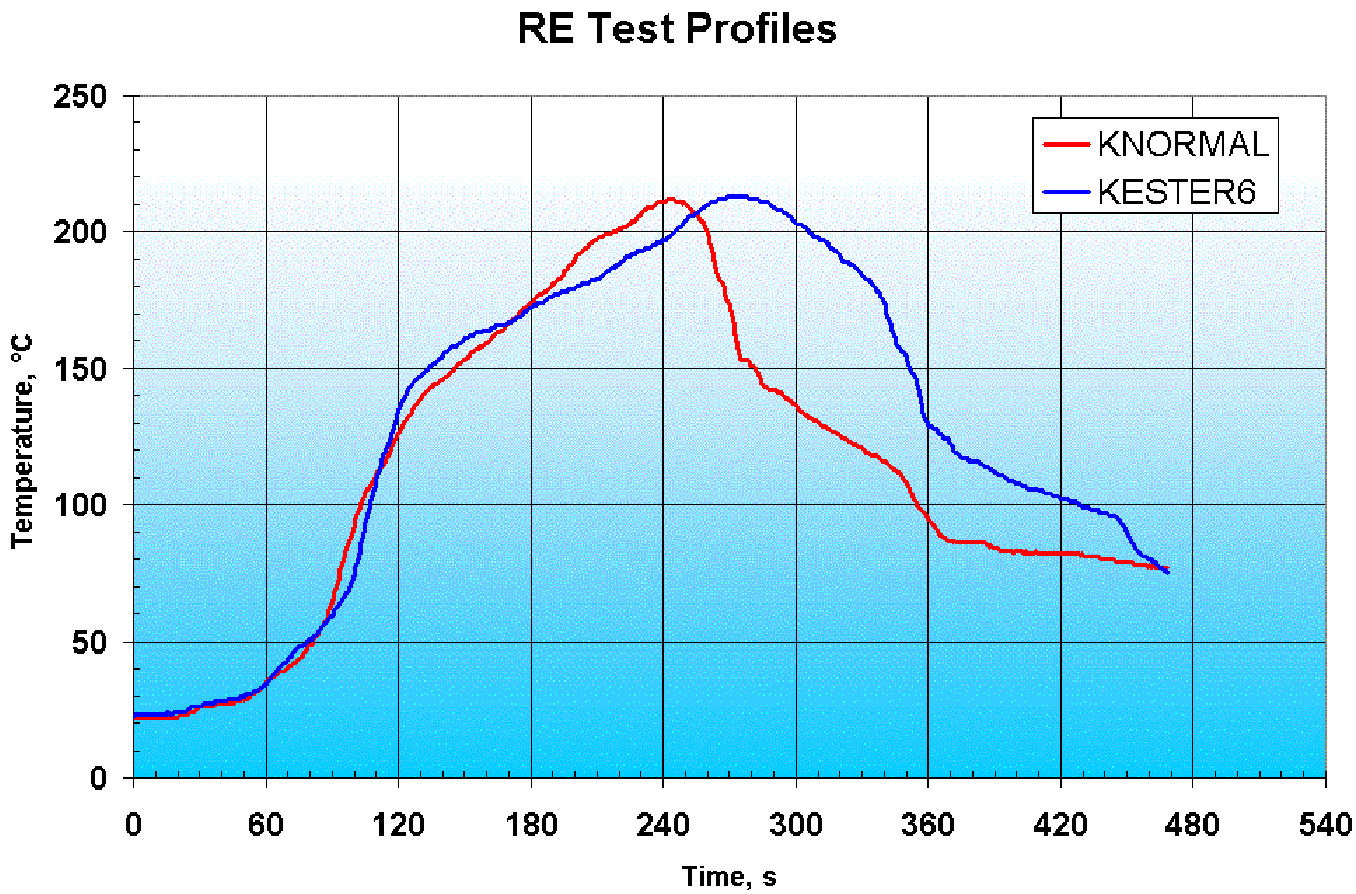
Bead-based

	Set A	Set B	Set C	Set D	Set E
Total Weight (mg)	102.85	102.81	103.11	103.23	103.05
Weight per Dot (mg)	2.29	2.28	2.29	2.29	2.29



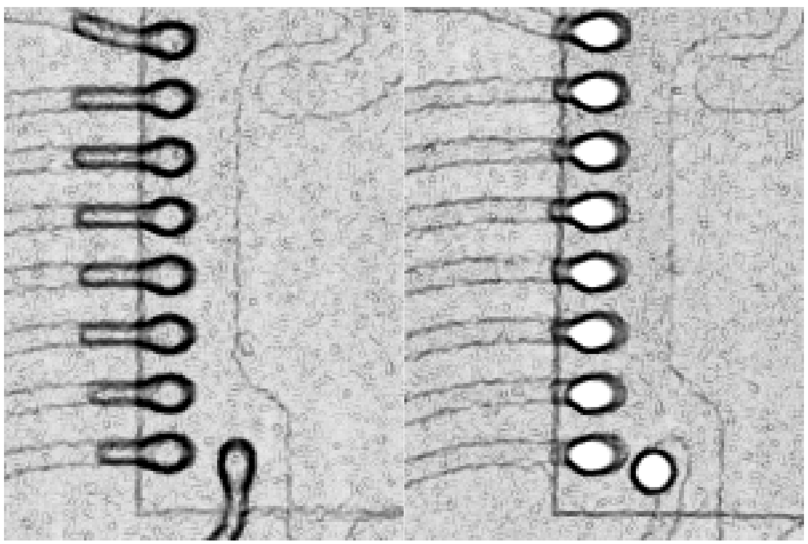
- Rheology-controlled material also failed pattern repeat test
- Again, equivalent performance for baseline vs. bead based material

Soldering Performance



Soldering Performance

X-ray Evaluation Technique

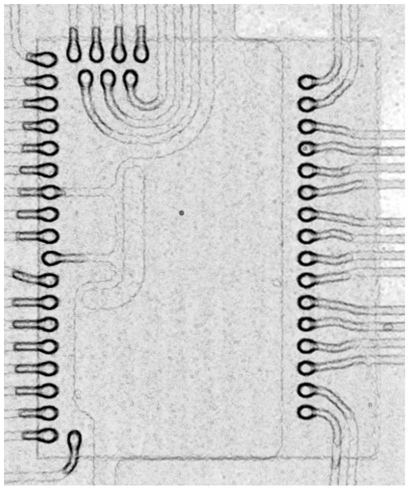


- 2-D x-ray, normal to surface
- Sobel filter applied
- Image inverted
- Normalize background density
- Yields information on wetting and bump mass

Soldering Performance

Baseline Material

KESTER 6



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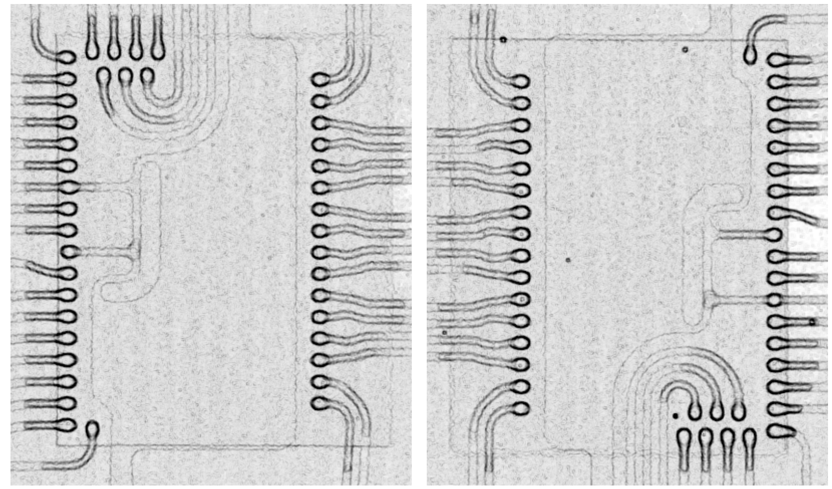

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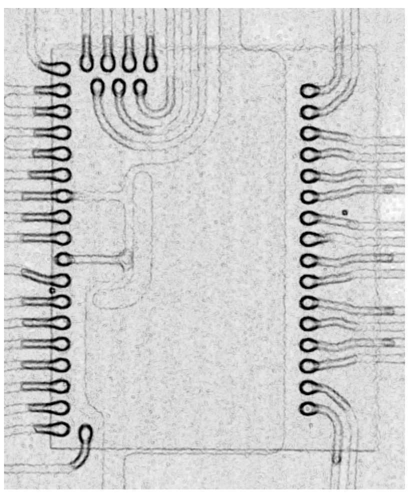

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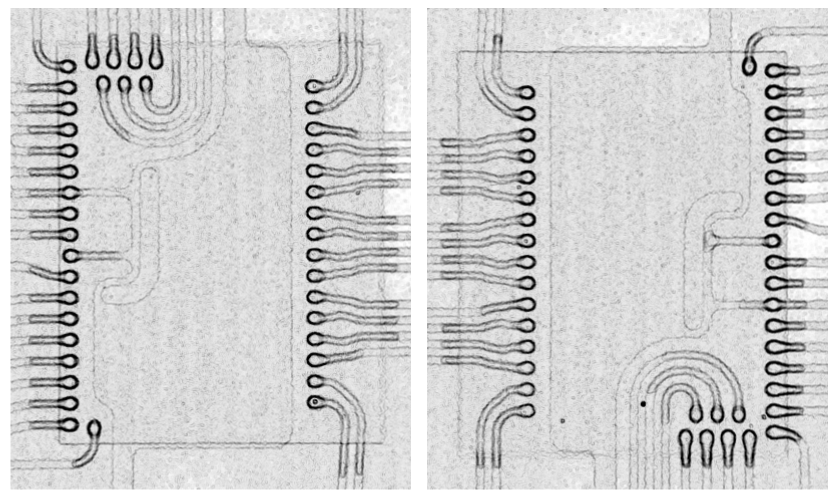

Soldering Performance

Rheology Controlled Material

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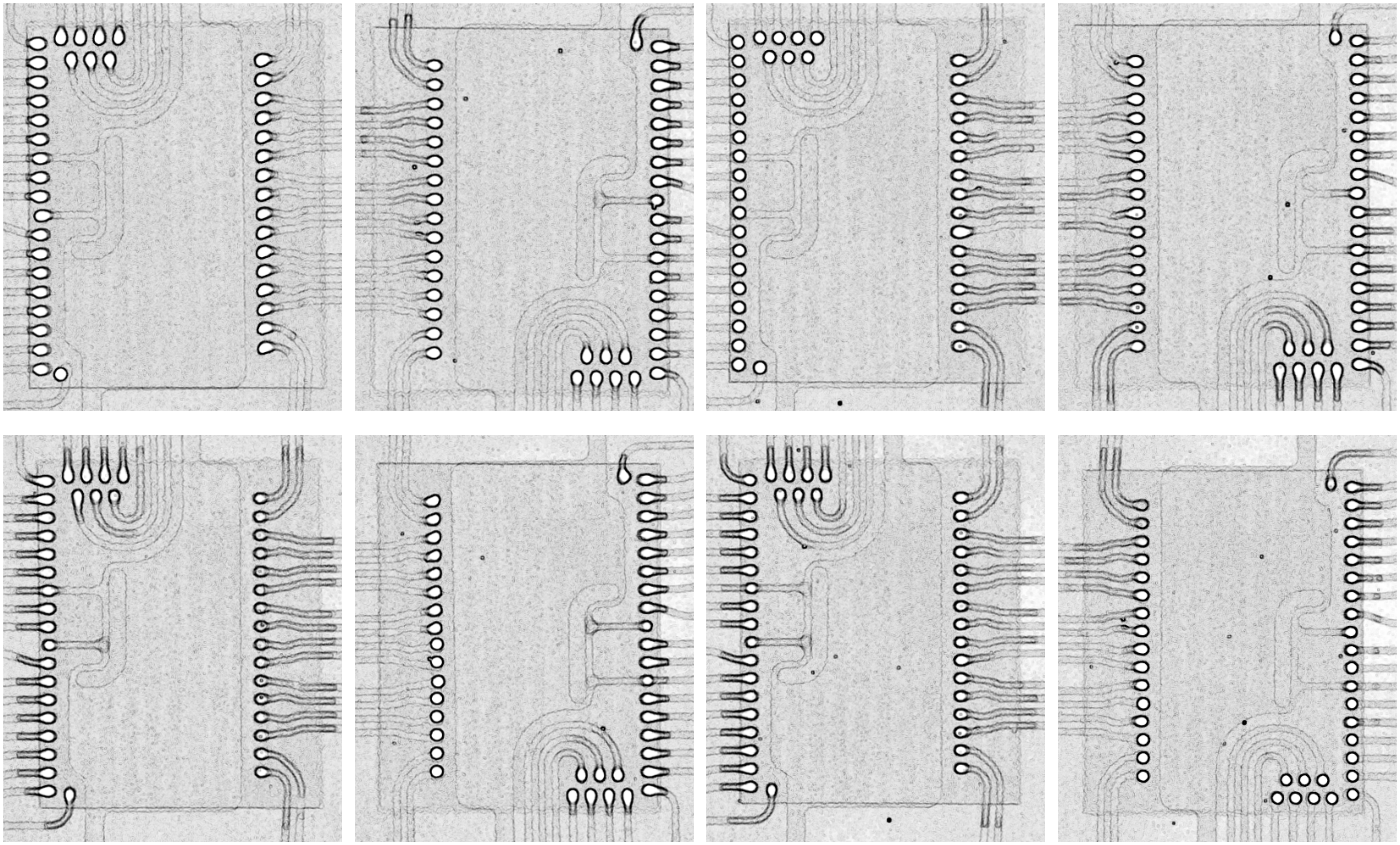
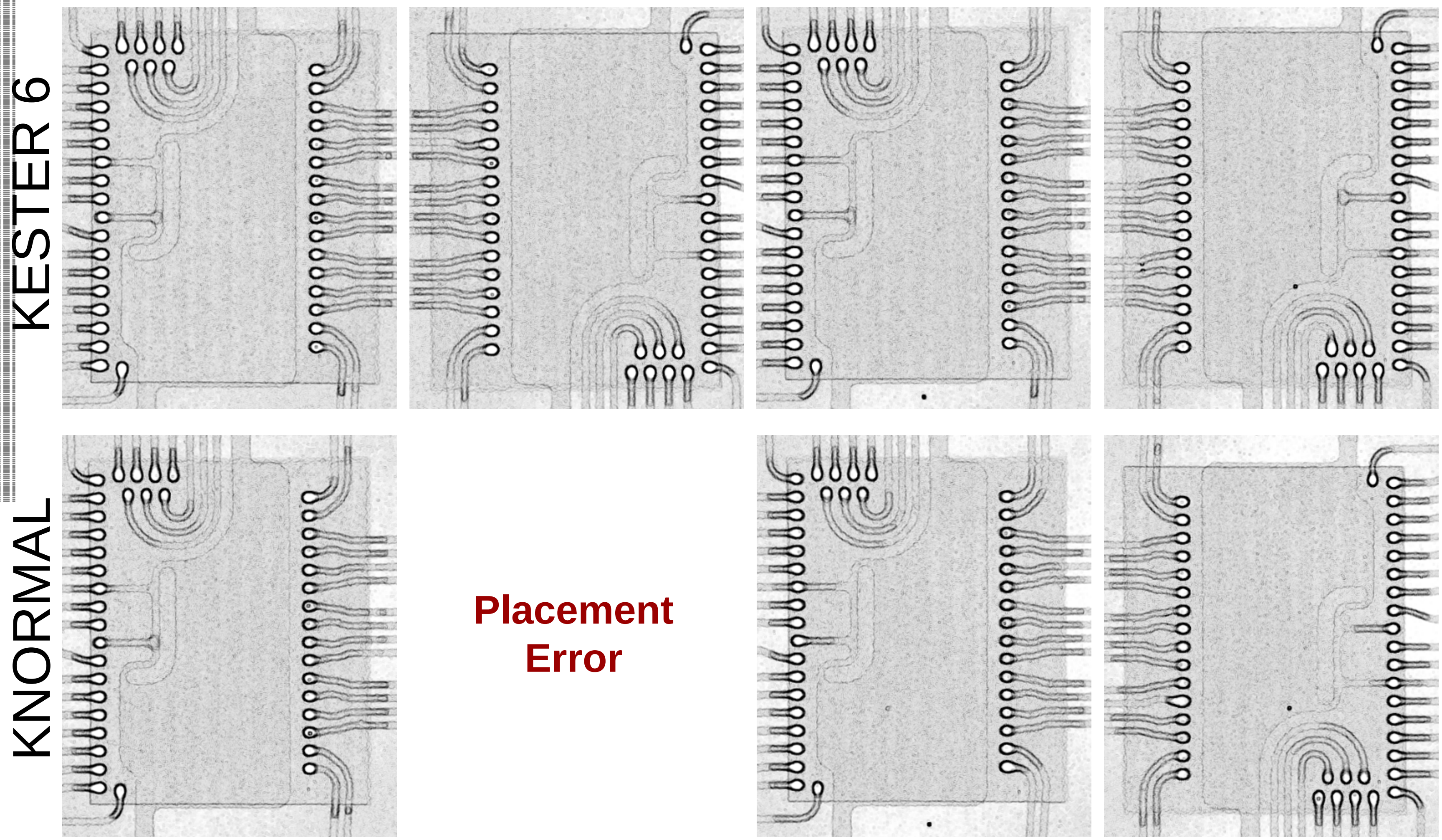


Soldering Performance

Bead Based Material



Reliability

Reliability Test Matrix

TEST	T/C	T/S	BTH	HTOL
Sample Size	45	45	45	45
Temperature	-55 to 125 C	-55 to 125 C	85 C	Ta = 125, Tj 150 C
Humdity	</= 35%	NA	85%	< 25%
Rate of Change	10 deg C/min.	20 deg C/min.	NA	NA
Minimum Dwell	5 minutes	6 minutes	168 Hrs	1000 Hrs
Number of Cycles	300 cycles	500 cycles	1	NA
Read Points	100 / 300	200 / 500	168 HRs	168, 500 Hrs
Bias	NA	NA	Low Power Dissipation, Static or Idle Mode	Read or write mode out puts loaded
Parameter Method	Functional Test	Functional Test	Functional Test	Functional Test
Acceptance	C = 0	C = 0	C = 0	C = 0

Reliability

Summary

- Eutectic, bead-based materials have passed all reliability testing to date
  - Thermal Cycle & Thermal Shock complete
- Awaiting final results…
  - BTH & HTOL tests near completion
  - BTH, HTOL were passed previously using same resin system

Conclusions

- Anti-collapse technology incorporated in RE is most economical approach
  - Eliminate need to incorporate substrate or die features to limit collapse
  - Eliminate need for pad definition
- Two viable approaches to anti-collapse RE for FCOF have been demonstrated
  - Bead-based control
  - Rheology-based control

Conclusions

- Bead-based anti-collapse will be qualified for disc drive applications
  - For Eutectic die, Q3 2003
  - For Pb-free die, Q4 2003
- Rheology-based anti-collapse will also be pursued for the general market.
  - Requires change of filler technology
  - Provides the greatest application flexibility