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Development Aspects for Single Pass High Reliability Flip Chip Reflow Encapsulants

IMAPS Flip Chip Technology Workshop

June 25, 2002

Background

- Application
  - Flip Chip on Flex for disk drive (internal)
- Goals
  - Increase productivity
  - Decrease cost
  - Maintain excellent reliability
  - Enable increased product density
- Strategy
  - RE (no-flow underfill) was seen as most desirable process path
  - Strong teamwork embedded in a structured approach was the key to eventual success

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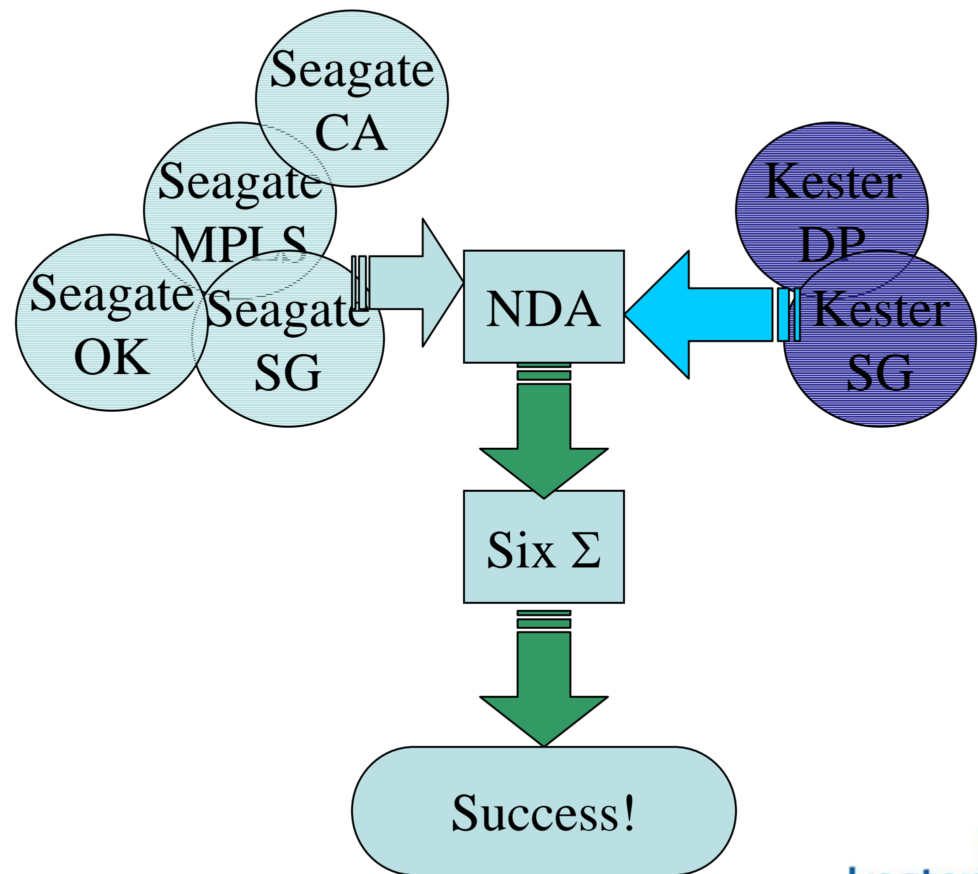
- Multiple “bridges” to build…
  - Between organizations
  - Between functions
  - Between locations



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Project Goals

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

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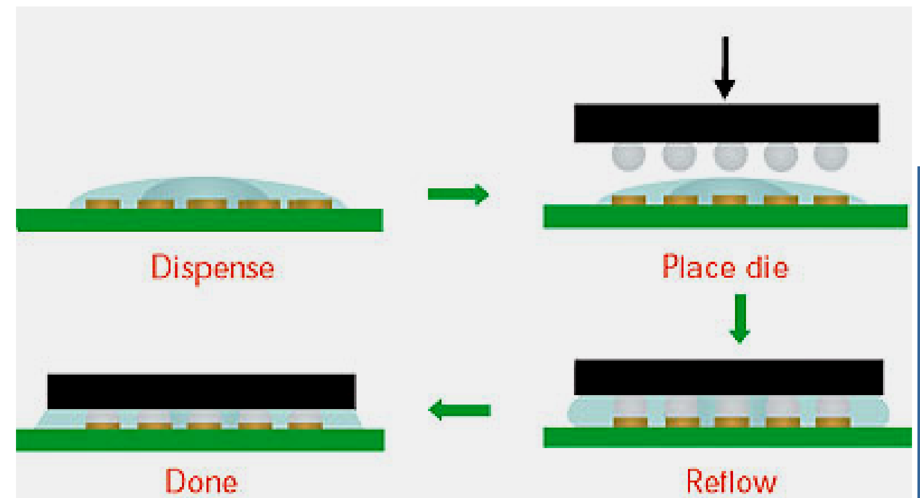
Reflow Encapsulant Process

- Dispense performance is critical to process success
  - Material behavior during & after dispense is important
- Placement tailored to optimize compression flow
- Reflow must take place prior to gel, but material must gel prior to cooling
- Cure must exceed 95% after single reflow pass



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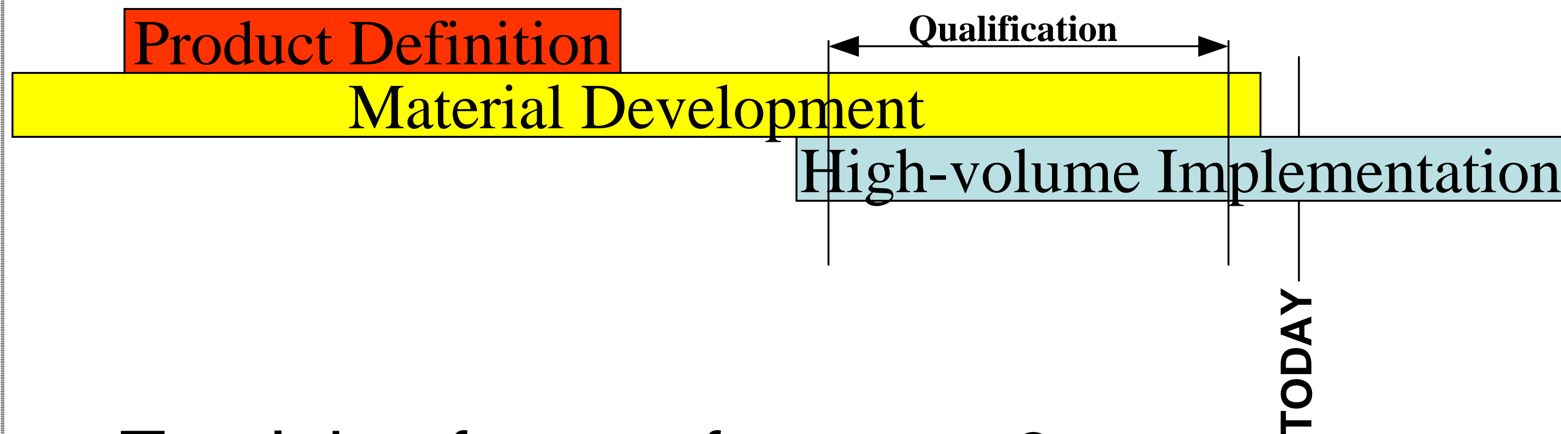
Project Timeline



- Total timeframe of approx. 3 years
- Initial Material development lacked customer-driven aspect
- Multiple paths on development; some failures

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Material Requirements

Requirement	Target/Rationale
Dispensing/viscosity	Repeatably dispensable; preliminary target >10000 cps, ultimately 13000-20000 cps CV < 3% @ 2mg shot size
Pot Life	>8 hours @ 25°C
Storage Life	>6 months @ -40°C
Predictable, Single-pass Reflow and Curing	>95% cure after single reflow pass. Repeatable and robust to processing conditions. Excellent solderability to OSP

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Product Reliability Needs

- Internal Hard Drive Requirements
  - No organometallic catalysts
  - No condensable or reactive volatiles
  - Low extractable ionics
  - No particulate shedding
- Temp Cycling, -55°C to +125°C, 300 cycles
- Temp Shock, -55°C to + 125°C, 500 cycles
- BTH, 500h @ 85°C, 85%RH
- HTOL, 1000h @ 125°C

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Success Through Teamwork

- Initially, material development was not efficient due to:
  - Poor communication
  - Undefined and conflicting expectations
  - Tentative trust

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Success Through Teamwork

- Redefined Cooperative effort:
  - Corporate technical agreement put in place
    - Defined intellectual property issues (Kester, Seagate)
    - Allowed close working relationship to be established
  - Focused two-day meeting
    - Redefined relationships, goals
    - Defined avenues to deal with communication gaps
      - Cross functional, cross-organizational, geographic
    - Reviewed previous activity/knowledge gained
      - Placed in context of new relationship

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Success Through Teamwork

- Six Sigma processes a key to success
  - Improve Time to market for products (increasing DGR)
  - Lead the industry in key objectives (Introducing new and leading technology)
  - Create World class manufacturing Processes
  - Develop Strategic Supplier Relationships

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Success Through Teamwork

Six Sigma Steps: RE Development

Six Sigma Step	Development	Implementation
Measure	Initial Formulations	Introduce technology to product
Analyze	Learning through process & test	Qualified at product level
Improve	Reformulation, improved test structures	Set process keys & WS
Control	Qualify final formulation Manufacturing scale-up	In high volume production

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Success Through Teamwork

- Many material formulation attributes not well understood
  - Initially, needed to deal with basic things
    - Dispensability was initially very poor
  - Once process issues were solved, passing thermal shock was next hurdle
  - Final hurdle was thermal cycle performance
    - More difficult than thermal shock

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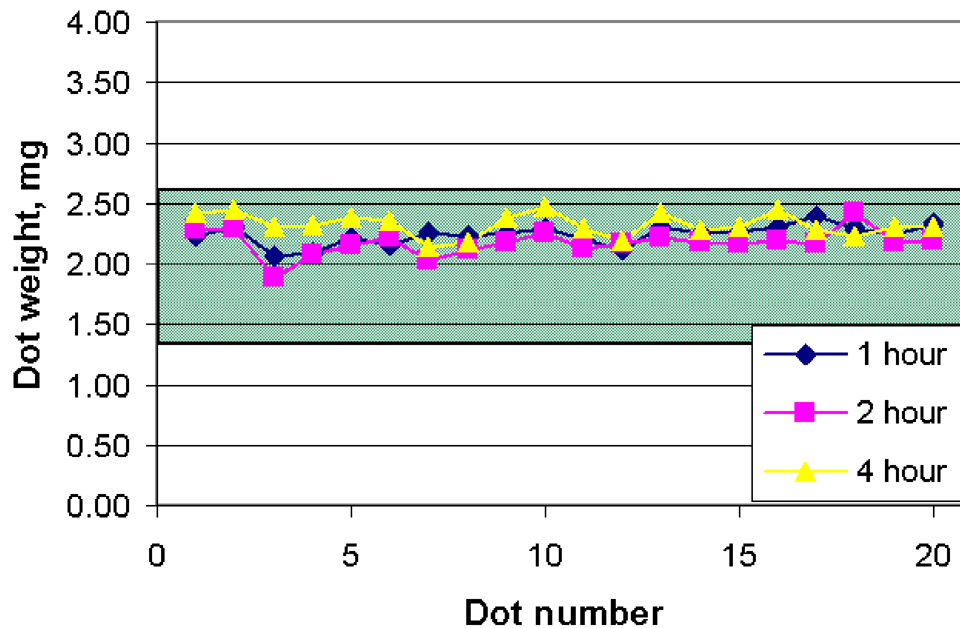
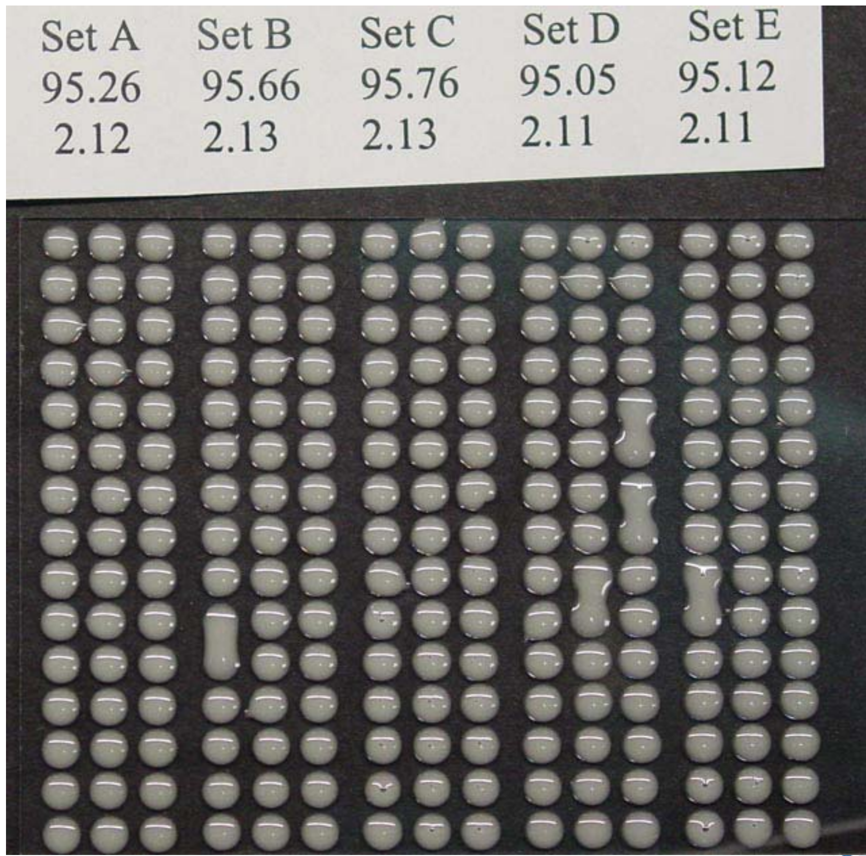
Current Status: Dispensability & Pot Life





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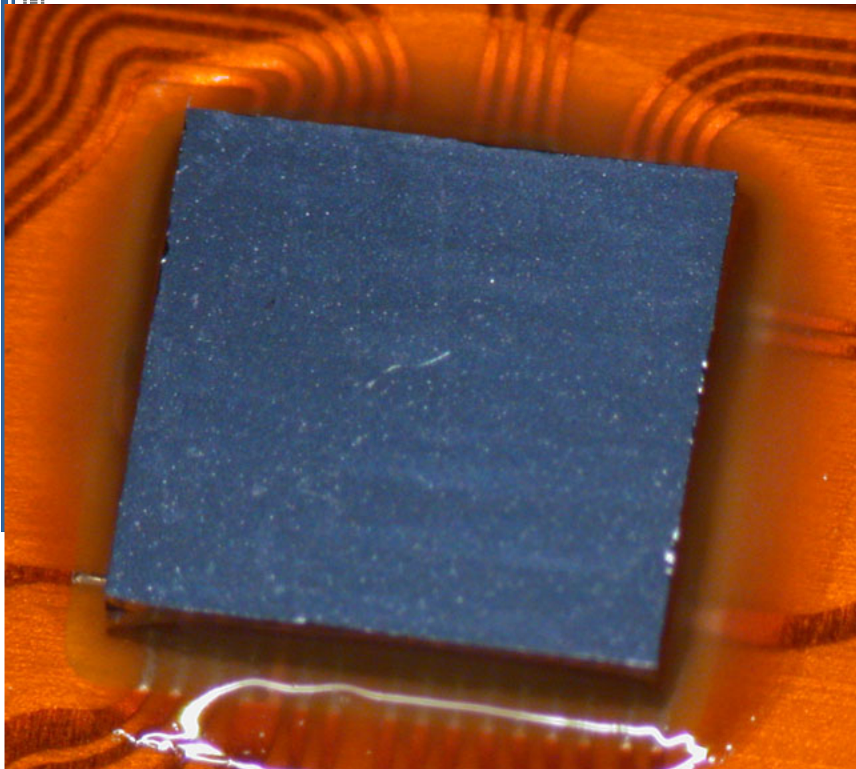
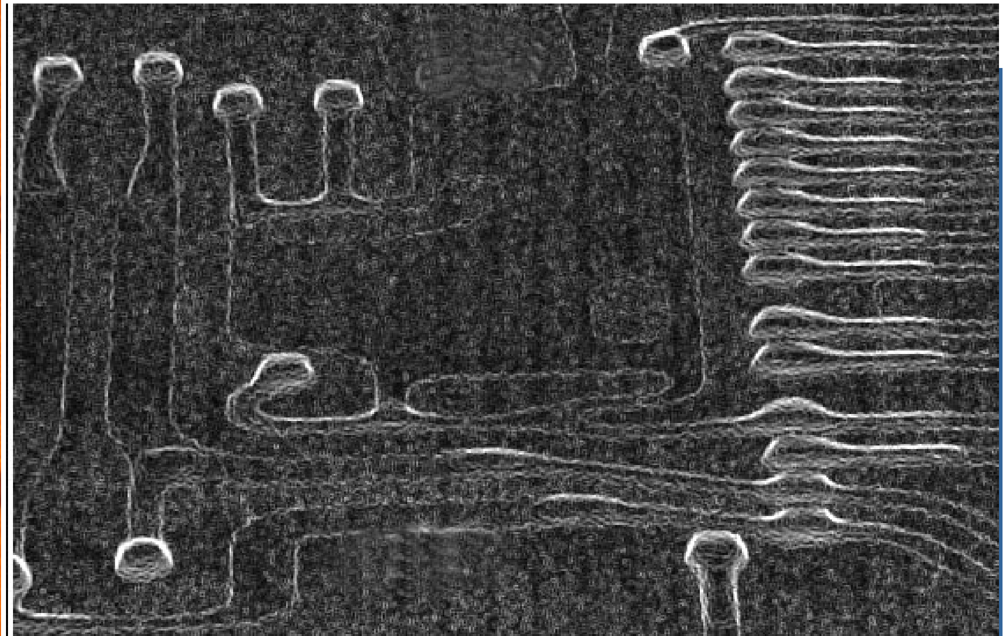
Current Status: Reflow/Curing





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Material Requirements

Material Properties

- Dispense/viscosity
  - CV of 3% at 2mg achieved
- Pot life
  - Greater than 8 hours
- Storage Life
  - 6 months, -40° C
- Cure
  - >95% cure after reflow
  - Excellent solderability, including to OSP

Reliability Goals

- Passes all Seagate tests for:
  - Organometallic catalysts
  - Condensable volatiles
  - Extractable ionics
  - Particulate shedding
- Passes Temp Cycling, -55°C to +125°C, 300 cycles
- Passes Temp Shock, -55°C to + 125°C, 500 cycles
- Passes BTH, 500h @ 85°C, 85%RH
- HTOL >1000h @ 125°C

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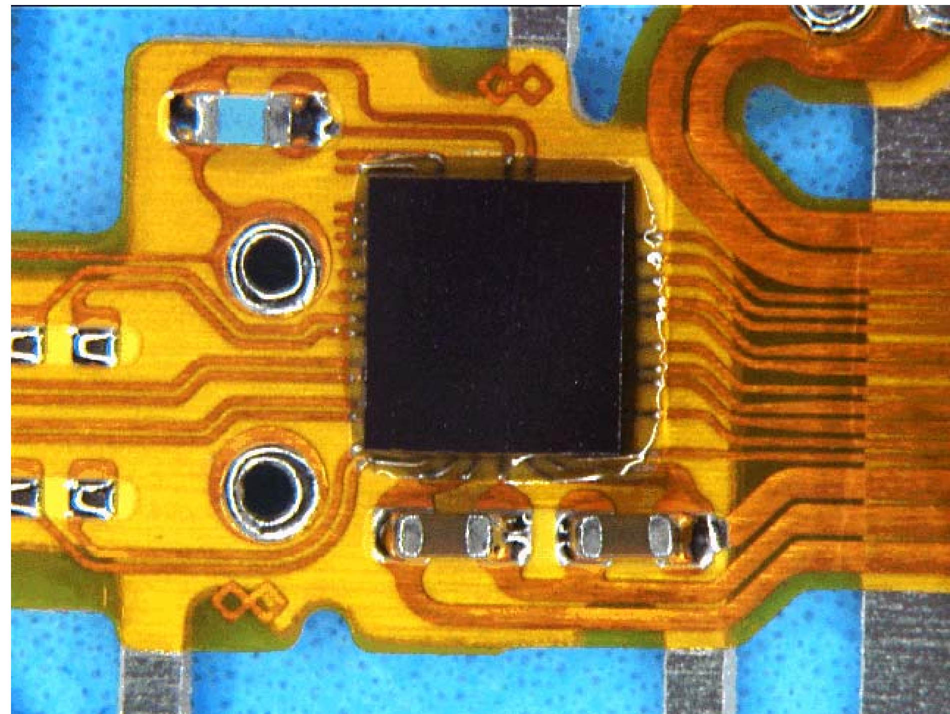
Future Path

- Complete High Volume Ramp
- Advance Dispense Process
  - 1.0 mg shot size
- General Market Availability



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Conclusions

- A unique RE for flip chip on flex has been qualified and is released for production; all key performance goals were met
  - Material will be available to the general market
- A strong OEM-supplier partnership provided path to success
  - Structured, Six-Sigma approach was a key to managing the development process
  - Trust and common viewpoint between organizations took time and significant effort to develop

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