High Performance Organic Cavity Packaging developed for Hermetic, High Rel Applications

Dr. Mike Zimmerman and Christopher Lee
Quantum Leap Packaging, Inc
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Outline

- Company Background
- Material and Enabling Technologies
- Hermetic Semiconductor Packaging
- Reliability
- Applications
- Summary
Company Background

- Founded December 2002
- Headquartered in Wilmington, Massachusetts
  - 32,000 sq. ft. manufacturing facility in Wilmington, MA
  - 20,000 sq. ft. manufacturing facility in Poway, CA
- Venture Capital:
- Strategic Investor:
- Strategic Partnerships
  - DuPont
  - CMC Interconnect Technologies
  - Customer Joint Development
- Materials Company with first products in semiconductor packaging
High Performance Polymer

New Molecular Structure: QUANTECH™

- Isotropic Properties
- High Temperature Stability (500°C)
- Ability to Manipulate Material Properties
  - Control of Mechanical Properties, CTE
  - Tailored Electrical Properties
- Excellent Adhesion to Metal Leadframes and Flanges
- Hermetic Lid Seal Techniques
- Outstanding Moisture Resistance
Quantech™ Material

High Temperature Stability and Linearity

TGA
(Low Outgassing: Stability to 500°C)

No discernable Tg
DMA (-200°C – 500°C)
# Isotropic and Tailorable CTE

<table>
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<tr>
<th>Product</th>
<th>Mold Direction (ppm/°C)</th>
<th>Transverse Directions (ppm/°C)</th>
<th>Testing</th>
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</table>
Quantech™ Material

Permeability Comparable to Glass

Permeability of Quantech™
Enabling Technology: Lid Seal Process

B-Stage Epoxy Seal

UltraSeal™: Ultrasonic Weld
QFN Cross Section: Lid Interface

8x8 Package
Y-direction
Cross-section plane #1
(longitudinal weld section)
Enabling Technology:
UltraSeal™ Ultrasonic Lid Seal

- Hermetic Lid Seal
- Rapid Cycle Time
- Room Temp Processing
- Elimination of Epoxy Cure and Ovens
- Thin Wall and Package Miniaturization
Traditional LCP Issues: Adhesion and Hermetic Properties

Red Dye Penetrant Test

Dye leakage at Interface

IMAPS MASH 2008
Quantum Leap Packaging, Inc.

Enabling Technology: Adhesion

Red Dye Penetrant Test

- Top View
- No dye leakage @ Interface

- Bottom View
- No Leakage @ Lead Interface

Cross Section: Quantech™/Leadframe Interface

- Package, X-direction Cross-section plane #2 Lead Structures

IMAPS MASH 2008
Process Temperatures

Attachment with AuSn 330°C and higher die attach temperatures

- High Power Packaging: 300 W
- AuSn Die Attach: 320 C
- Higher Die Attach Temperatures
### Reliability Testing of Sealed Military Power Package

#### Customer A

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<tr>
<th>Test Description</th>
<th>Result</th>
<th>Standard</th>
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<tr>
<td>Total Parts</td>
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<tr>
<td>Initial Gross Leak Test</td>
<td>49/49 Pass</td>
<td>MIL-STD-883E</td>
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<tr>
<td>Initial Fine Leak Test (&lt;5 x 10^{-8} atm cc/s)</td>
<td>47/49 Pass*</td>
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<tr>
<td>500 Temp Cycles (-40°C to +125°C)</td>
<td>45/47 Pass*</td>
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<td>1000 Temp Cycles (-40°C to +125°C)</td>
<td>21/21 Pass</td>
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*Leakage @ lid seal due to fixture alignment

#### Customer B

<table>
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<th>Test Description</th>
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<td>Initial Gross Leak Test</td>
<td>40/40 Pass</td>
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<td>Initial Fine Leak Rate Test</td>
<td>40/40 (&lt;1 x 10^{-9} cc-atm/sec)</td>
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<td>250 Temp Cycles (-50°C to +150°C)</td>
<td>5 pcs. (1 x 10^{-11} cc-atm/sec)</td>
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<td>500 Temp Cycles (-50°C to +150°C)</td>
<td>5 pcs (&lt;5 x 10^{-8} cc-atm/sec)</td>
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<td>PIND Test</td>
<td>10/10 Pass</td>
<td>MIL-STD-883E Customer</td>
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Air Cavity Hermetic Package
8x8 QFN Image Sensor

Adhesion to Glass
Image Sensors with Advantages of QLP Technology

- True Hermetic Package
- No Epoxy
- Miniaturization
- Room Temp Lid Assembly
Dew Point Test Method

Pre-Conditioning
120hrs 60C/70%RH
2x260 C Reflow

85C/85%RH Exposure

Nitrogen Box
10s Lid face down

Cooling Plate

- Starting Temp 25 C
- Decrease Temp, 5 C Intervals
- Down to -35 C

LID: Visual Inspection @20-30X Mag

Nitrogen Box

Moisture Condensation or Cloudiness?

NO

YES

Cooling Plate Temp = Dew Point Temp
Image Sensor Packages

- 40 parts: 8x8 QFN Sealed with Glass Lid
- 120 hrs 60°C/70%RH Exposure
- Dew Point Test Method
  - Chill Plate: 10 seconds
  - 30X Visual inspection for condensation
- 40/40 Dew point <5°C (<+25°C requirement)
  - Ceramic QFN’s do not pass this test
- Reflow Simulation:
  - 2 x 260°C, 60 seconds per exposure
  - 30 minutes between exposures
- Gross Leak: 40/40 Pass
- Helium Leak Test Results
  - 40/40 Pass
  - 5x10^-8 to 1x10^-9 cc-atm/sec
Dew Point Test Results

- Exposure 85°C/85RH through 1000hrs
- Precondition: 120 hrs at 60°C/70%RH
- Requirement < +25 °C
- Results < -35 °C
- **EXCEEDS** Ceramic package w glass lid

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**Package Defect:** 0/10 0/10 0/10 0/10 0/10
Temp Cycle & Hermetic Performance

- Condition: -65 °C/150°C 500 cycles
- Precondition:
  - 120 hrs at 60°C/70%RH
  - 2x 260°C Peak Reflow
- Requirement < 1.0E-08 (Pa/s)
- Results: 0 Failure

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Package defect: 0/10 0/10 0/10 0/10
Summary

- Plastic air cavity packages achieve Hermetic performance through QLP Material and Enabling Technologies
- Proven Reliability Performance generated by customer evaluations
- Working with Lead customers for co-development
  - High Rel Applications
  - Image Sensors
  - Military Electronics
- Recognized as Industry’s First Plastic Hermetic Package