Solutions for Low Cost, Near Hermetic Air Cavity Packages

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Topics

• Air Cavity Plastic (ACP) for Macro Cell Base Station

• RQFN Air Cavity Plastic for MIMO Base Station

• B-Stage Epoxy Technology

• Sealing Process
Air Cavity Package for Macro Cell

- **Base** – Cu, CMC, or Super-CMC Heatsink

- **Sidewall** – Pre-applied B-Stage Epoxy
  - Epoxy formulated to be a Moisture Barrier
  - Majority of the solvent removed with Heat allowing epoxy to be “staged”

- **Lid** – Liquid Crystal Polymer (LCP) with Pre-applied B-stage Epoxy
  - LCP is CTE matched to the Cu leadframe
  - LCP has water vapor permeability rate similar to glass
Air Cavity Advantages over Overmold

- Air cavity eliminates signal loss caused by EMC’s (epoxy molding compound) proximity to chip surface
- RF consistency - no wire sweep due to EMC material which leads to easier RF tuning
- Less capacitive feedback enables higher bandwidth
- Lead capacitance is fixed as there is no change due to EMC molding during assembly
Flexible Configuration
Air Cavity Plastic Reliability

- Package qualified by multiple Tier 1 RF customers
- Over 80 million packages in the field
- No reported failures
RQFN Package for MIMO

- Proprietary plastic material used on base with excellent sealing qualities
- B-stage epoxy cup lids that make the air cavity
- Liquid crystal polymer lids
- Injection molding manufacturing process
- Design features for adhesion
- Instrip design for assembly
- Proprietary sealing process
- Matrix lid seals the whole array in one process step using ITS
RQFN

- **High Performance**
  - Air Cavity
  - Near Hermetic
  - LCP and epoxy are low loss dielectric
    - loss tangent of ~.003 @ 10 GHz
    - Dielectric at 3.8 across wide range of temperatures and frequencies
  - 77 GHz capable – A compelling product for mmwave 5G

- **Greater Functionality**
  - EMI Shield Integration option

- **Better Thermal**
  - Cu die Pad
  - AuSn Eutectic Die Attach

- **High Reliability**
  - Leak free - BLT @t0
  - Passes BLT with MSL3 precondition and 3x reflow
  - Passes 1000 TMCL (-40°C - 125°C)

- **Cost Effective**
  - 40% lower cost than equivalent ceramic packages
  - Coupon assembly for fully automatic assembly (cassette-to-cassette)
  - Low NRE for new Package designs=> $6k-10K
Matrix Lid

- LCP Material with B-Stage Epoxy
- Designed for ITS sealing – one coupon sealed per ITS cycle
- Passes BLT
- Custom designs available to fit customer’s 3rd party substrate as long as it meets RJR’s design rules
Power QFN Laminate Product

- 0.5mm coin for higher power applications
- 4-layer
- Cu coin: 20 mils +/- 2
- EM526 material
- VIPPO (via-in pad plated over)
- Solder Resist
- ENEPIG finish (Electroless Nickel Electroless Palladium Immersion Gold)
- Passes gross leak test

8x8 QFN Laminate

Plating
- Electroless Nickel: 3-6 μm
- Electroless Palladium: 0.051 - 0.305μm
- Gold layer: 0.03μm MIN
QFN Options: Leadframe and Laminate

- For a given size, the same matrix lid is used for either option.
- Matrix lid is shipped with RJR's B-stage epoxy.
- High yield sealing can be accomplished with RJR's ITS.
- This solution can be applied to 3rd party substrates if they conform to RJR's matrix lid design rules.
# RQFN Reliability

## Tests Performed

<table>
<thead>
<tr>
<th>Stress</th>
<th>Abbv.</th>
<th>Ref.</th>
<th>Conditions</th>
<th>Duration/Accept</th>
<th>Lot A</th>
<th>Lot B</th>
<th>Lot C</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSL 3</td>
<td>MSL3</td>
<td>J-STD-020D</td>
<td>IR = 260°C</td>
<td>End Point / 0 Fail</td>
<td>0/70</td>
<td>0/70</td>
<td>0/70</td>
</tr>
<tr>
<td>Temperature Cycling</td>
<td>TC</td>
<td>JESD22-A104</td>
<td>Condition G (-40°C to +125°C)</td>
<td>500 cycles / 0 Fail</td>
<td>0/210</td>
<td>0/40</td>
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<tr>
<td>High Temperature Storage</td>
<td>HTSL</td>
<td>JESD22-A103C</td>
<td>Condition A (125°C)</td>
<td>1000 hours / 0 Fail</td>
<td>0/70</td>
<td>0/70</td>
<td></td>
</tr>
<tr>
<td>Low Temperature Storage</td>
<td>LTSL</td>
<td>JESD22-A119</td>
<td>Condition A (-40°C)</td>
<td>1000 hours / 0 Fail</td>
<td>0/70</td>
<td>0/70</td>
<td></td>
</tr>
</tbody>
</table>

* Reports available for 4x4, 5x5 and 6x6

Note: MSL3 pass/fail criteria is BLT after precondition: 24 hours Bake @ 125+5/-0 °C + 192 hours 30°C/60 R.H. + 3 X IR Reflow @ 245 °C + 1 X Flux Immersion + DI Rinse
B-Stage Epoxy Summary

- **B-stage epoxy** is a system wherein the reaction between the resin and the curing agent/hardener is not complete. Due to this, the system is in a partially cured stage. When this system is then reheated at elevated temperatures, the cross-linking is complete, and the system fully cures.

- Eliminates the needs to deal with “wet” materials in their assembly process by supplying a **B-stage** solution for ease of handling.

- Epoxies adhere to – Metals, Composites, Ceramic, Plastic, and Glass

- Epoxy with low chloride contents improve package HAST/UHAST performance

- Solvent free – epoxies have no residual solvent and are more environment friendly

- RJR’s epoxies are RoHS and REACH compliant
B-Stage Epoxy Science

✓ **Proprietary coating process** – provides high speed epoxy application with high throughput

✓ **B-stage control** – through the use of Kinetics, RJR has developed a method to control the quality of the b-staged epoxy and predict shelf life by measuring gel time

![Graph of ln(k) vs 1/T]

\[
\ln(k) = -\frac{E_a}{RT} + \ln(t_0)
\]

<table>
<thead>
<tr>
<th>T, °C</th>
<th>K(T)</th>
<th>Days</th>
<th>Gel time prediction, seconds</th>
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</thead>
<tbody>
<tr>
<td>30</td>
<td>0.38561</td>
<td>28</td>
<td>1740</td>
</tr>
<tr>
<td>8</td>
<td>0.02850</td>
<td>365</td>
<td>1750</td>
</tr>
<tr>
<td>3</td>
<td>0.01488</td>
<td>365</td>
<td>1870</td>
</tr>
</tbody>
</table>

- RJR ships with Gel time: 2000 – 2500 s
- Material Storage Temperature = 3 – 8 °C
Our Value Proposition - B-Stage Epoxies

- We provide the best seal in the industry by formulating our own adhesives from scratch, which allows us to control the sealing process.
- Our epoxies have minimal moisture transmission, low ionics for higher reliability. Our epoxies are designed to work with our ITS sealing system to cure in minutes.
- We have a broad range of standard adhesives that have been used in the semiconductor market for 35 plus years – from nonconductive to thermally and electrically conductive.
- If our standard adhesives do not meet our customers requirements, we can develop a custom formulation that will
Summary

• Air Cavity Plastic packages provide a cost reduction over ceramic packages and a performance advantage over overmold packages. B-stage epoxy enables ease of use in assembly.

• Air Cavity Plastic is available in two platforms
  • **ACP** for Macro Cell base stations - consists of base, sidewall and lid
  • **RQFN** Air Cavity Plastic for MIMO Base Station supports both leadframe and laminate packages

• RJR’s **B-Stage Epoxy** tailored and formulated to support both ACP and RQFN packages

• RJR provides the Total Solution to support Air Cavity Plastic – **Components, B-stage Epoxy, Sealing Process** and **Sealing Equipment** for high-volume Production
THANK YOU