

# Reliability Considerations on LCP Air-Cavity Packages for Photonics Integrated Circuits (PICs).

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**Abstract.** RJR previously presented a low-cost package solution that can replace packages used in photonics. The technology is based on existing air cavity plastic (ACP) package technology used in RF power applications. Based on structural similarities between RF packages and a 14-pins butterfly package, we predict in this paper the reliability of a 14-pin butterfly package against an ACP2-0800-6V RF power package.

**Keywords:** reliability, optics, photonics, PIC, packaging, air cavity package, liquid crystal polymer, butterfly package

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## 1 Introduction

In 2005, RJR Technologies pioneered an air-cavity RF-power package using LCP (Liquid Crystal Polymer) insert injection-molding technology. For decades, the semiconductor industry used ceramic packages to provide the benefits of an air-cavity enclosure. RJR's ACP package solution effectively replaced most ceramic packages in the RF Power market by providing customers with increased RF performance, higher thermal capability, reduced costs and faster time-to-market. In 2023, RJR launched a 14-pin and 40-pin butterfly packages designed for photonics integrated circuits (PICs), with plans to expand the portfolio to support a variety of package configurations for ROSA, TOSA, TROSA, VCSEL and Lidar applications. The technology has many advantages over conventional solutions, such as: 1) greater flexibility in package geometry; 2) compatibility with a wide range of lead-frame and heatsink materials; and 3) significantly shorter prototype cycle times.

Packages with the same outer dimensions can be quickly prototyped by implementing a new lead-frame design, which can be modified relatively easily, reducing cycle times from months to just weeks. Also, drop-in heatsinks can be chosen from different materials depending on cost, CTE matching and/or heat conductivity requirements. Most importantly, the technology is highly scalable for volume production and offers cost efficient manufacturing. For more information, see Koelink et al <sup>1</sup>.

This technology provides near-hermetic package performance whereas some other package technologies provide full hermetic performance. Many applications don't require full hermetic performance, especially as volumes increase and costs need to be reduced, as is the case in Photonics. This brings up 2 questions:

1. What level of near-hermeticity can individual applications accept?
2. How to quantify near-hermetic performance?

The first question is very dependent on the individual application. Because all previous package solutions were fully hermetic, many device manufacturers have never determined the specific level of hermeticity required for their applications. As the industry shifts toward technologies that offer high-volume scalability and cost reduction, while still meeting performance and reliability requirements, device manufacturers will need to define the appropriate level of hermeticity for their applications, making solutions like RJR's essential to meeting business objectives. The second challenge will be addressed in this paper. RJR has been active for over 30 years in RF power applications, offering package solutions that have a large degree of structural similarity with the 14-pin butterfly package in terms of design (size and shape), materials and manufacturing processes used. The ACP2-0800-6V package RF power package closely resembles the 14-pin butterfly package on all the attributes previously mentioned (see figure 1A and 1B).

## **2 Structural Similarity**

Structural similarity rules are used in industry to shorten design cycles, reduce the numbers of reliability qualification tests of new products and better predict and understand failure mechanisms. For a more in-depth understanding of the application of structural similarity rules, see Van Driel et al <sup>2</sup>. We will analyze the structural similarity between the ACP2-0800-6V and the 14-pin butterfly package in more detail by looking at the design, materials and manufacturing processes.

### Design

Both the ACP2-0800-6V and the 14-pin butterfly package follow the general "architecture" of RJR's RF air cavity plastic (ACP) power package solutions shown in figure 2. Both packages consist of a flange (thermal base), a sidewall containing the lead frame, and a lid. Overall dimensions are comparable. The ACP2-0800-6V measures approximately 20.27 mm x 9.65 mm (L x W), whereas the 14-pin butterfly measures 20.80 mm x 12.70 mm (L x W), both are outside dimensions. The ACP2-0800-6V package has a wall thickness varying from 1.01-1.14 mm for the sidewall and 1.52 mm for the lid. The 14-pin butterfly package has a wall thickness varying from 0.75-1.87 mm for the sidewall and 1.50 mm for the lid. However, the height of the 14-pin butterfly package is larger than the ACP2-0800-6V package. We will address this separately in paragraph 4 (Discussion). See figure 1A and 1B for detailed drawings of the 14-pin butterfly package and the ACP2-0800-6V package, respectively. The wall thickness affects the hermeticity of the package since it defines the penetration length for water (vapor) and gasses. The walls are typically flat on the top and bottom surface of the sidewall, but hermeticity could be enhanced by designing a step-index in the housing surfaces (making the wall of the housing thicker which creates a wider epoxy interface). This would increase the penetration length at identical internal and external dimensions of the cavity.

A key design difference between the ACP2-0800-6V and the 14-pin butterfly package is the inclusion of an optical feedthrough (ferrule) in the latter. Hermetically sealing a fiber through a ferrule is well-established technology (see Dietz <sup>3</sup>). Traditional glass soldering methods require temperatures of 320° C or higher, which may exceed the melting point of the LCP material used. However, proven alternatives such as hermetic epoxy sealing are available (see

Douglas Electrical Components<sup>4</sup>). As a result, the ferrule does not compromise the hermetic performance of the 14-pin butterfly package. The critical interface between the ferrule and the molded sidewall is comparable in hermetic integrity to the molded interface between the sidewall and the lead frame. Moreover, the ferrule interface length can be extended to further enhance hermeticity or can be replaced with a molded LCP ferrule, thereby eliminating one of the interfaces that would be a moisture path into the package. See figure 3 for an example of a design with a molded LCP ferrule (RJR's 40-pin butterfly package).

## Materials

Typically, the Bill of Materials (BOM) of either an ACP2-0800-6V or the 14-pin butterfly package consists of:

- The flange (or “thermal base”) is typically made from materials such as: CMC, CPC, Cu or other metals with good thermal conductivity. The flange is typically plated with NiAu or NiPdAu to avoid oxidation and provide good wettability for soldering, brazing or sintering. These materials are considered fully hermetic.
- Liquid Crystal Polymer (LCP) for the sidewall and the lid. The sidewall contains the lead frame which is insert injection molded. Compared to other plastics, LCP offers better permeability characteristics for both water, vapor and oxygen. See figure 4: Water Vapor Permeability versus Oxygen Permeability for different LCP materials and plastics. The sidewall and the lid are made from different types of LCP, for instance HTP1280 for the sidewall and HTP1335 for the lid. Some physical parameters for these two LCP's are shown in table 1A/B. Most parameters are similar, with several being identical. The 14-pin butterfly package and the ACP2-0800-6V package use the same LCP materials for the sidewall (HTP1280) and the lid (HTP1335).
- The lead frame is typically made from hardened copper (e.g, C7025 H/H) with NiPdAu plating.
- The epoxies used to seal both the flange-to-sidewall and flange/sidewall-to-lid interfaces are developed and manufactured by RJR. RJR epoxies are recognized for their excellent adhesion and high reliability, making them the choice of major semiconductor companies worldwide. The 14-pin butterfly package and the ACP2-0800-6V package use identical epoxy materials for these, which is the RJ4MB-HT, which has been proven in the assembly process of various types of electronic air cavity packages providing an excellent seal that has passed the most rigorous reliability testing in the semiconductor industry . See table 2 for more data on the RJ4MB-HT epoxy.

## Processes

The processes that are used to manufacture both packages include:

1. (Insert) Injection molding. The sidewalls and the lids of both packages use insert injection molding for the sidewall and injection molding for the lid. During the insert injection molding process, the lead frames are inserted into the mold tool to make the sidewall. LCP typically has a low adhesion to various materials. RJR employs

advanced adhesion-promotion methods to improve interfacial bonding with liquid crystal polymer (LCP) surfaces. For the 14-pin butterfly package, the ferrule is incorporated into the side wall in a similar way.

2. The sealing process. Under controlled temperature and pressure, the sidewall is sealed to the flange, followed by sealing the lid is sealed to the sidewall/flange. The best results were achieved after significant improvement in the epoxy formulation and the sealing process, which is included in its Isothermal sealing (ITS) systems. RJR offers a range of custom formulated B-stage epoxies for various applications, which are applied in-house. They range from proprietary high-temperature, high-performance B-stage epoxy systems to low-temperature co-polymer systems. RJR also provides solvent-free epoxies to meet environmental requirements, as well as non-conductive and conductive epoxies that can be applied to numerous different types of components to seal them for use in various applications, including LCP, ceramic, metal or glass. Die attach can be performed either before or after sealing the sidewall to the flange, depending on the temperature requirements of the selected attachment method. Sealing pressure and sealing temperature may vary slightly depending on the specific epoxy used.

### 3 Reliability results

Pham et al <sup>5</sup> have previously reported on the general reliability of the usage of LCP in RF packaging including a literature study. They report that LCP is an attractive material for making (even) hermetic packages that can provide reliability in a low-cost and lightweight platform. Several authors in the literature study provide data that LCP can be used for hermetic packages with solid long-term reliability. The limiting factor in the total package is the sealing process between the different interfaces, such as LCP-to-lead frame, sidewall-to-flange and sidewall/flange-to-lid. RJR developed its proprietary B-staged epoxy, design features, manufacturing processes and ITS ( Isothermal Sealing) equipment to provide near hermetic high reliability packages. We will address the reliability of the sealing further.

#### *3.1 Moisture Sensitivity Level (MSL) and Temperature Cycling*

The ACP2-0800-6V package has been subjected to Moisture Sensitivity Level and Temperature Cycling testing. The tests were done in 3 batches of 80 pieces each. See table 3 for a detailed description of the test batches. A full description of the tests is given here:

**Stress Test/Specification: Moisture Sensitivity Level Preconditioning 3 (MSL)/J-STD-020D**

**Purpose:** The test was performed to simulate the board mounting process where parts are subjected to a high temperature for a short duration. These tests detect mold compound delamination from lead-frame. Of course, if the package is bolted on to the board, it would not go through a reflow process. This test is just an indication of how robust the RJR package solution would apply to the 14-pin butterfly package.

**Conditions:** (0-hours test) immersion in 125°C liquid (fluorocarbon or water) for 30 seconds, 24hrs Bake@125 °C + 168 hrs at 85 °C and 85% relative humidity +3X Reflow@245°C peak temperature +1X Flux Immersion + DI Rinse. All devices were preconditioned in strip form and then singulated before IR reflow.

**Sample Size:** 3 Lots, 80 units each

**Possible Failure Mechanisms/Modes:** Possible failure mechanisms include on package level, corrosion of leads, epoxy and LCP delamination, deterioration of sealing quality. On functional product level, potential failure modes include corrosion, fractured wire-bonds, passivation cracks.

**Passing Criteria:** Pass 0-hour Leak Testing and Gross Leak Testing after 3X solder reflow passes @ 245°C.

**Stress Test/Specification: Temperature Cycling (TC)/JESD22-A104**

**Conditions:** MSL3 pre-conditioning is done prior TMCL Ta = -65°C to +150°C; unbiased. All devices were tested in strip form. Read Points: 0, 100, 500, and 1000 cycles

**Sample Size:** 3 Lots, 80 units each

**Purpose:** Accelerate failure mechanisms caused by cycling between high and low temperatures.

**Possible Failure Mechanisms/Modes:** Possible failure mechanisms include degradation due to stresses caused by CTE mismatch (Coefficients of Thermal Expansion). On package level, failure mechanisms include deterioration of mechanical integrity, delamination between the package parts (flange, sidewall, lids). On electrically functional products, fatigue and cracking/delamination, broken bonds, cracked dies, resulting to degradation of thermal and electrical characteristics of product and catastrophic failure.

**Passing Criteria:** Conservation of structural integrity

The qualification tests were performed per standard test conditions (JEDEC, AEC-101, MIL-STD-883). Sample sizes were chosen per recommended sizes or per Lot Tolerance Percent Defective (LTPD) Sampling based on the Military Standards (Max % Defective = 5%). All tests passed. See table 4 for detailed results.

### ***3.2 Gross Leak, MSL 3 plus 3x Reflow and Temperature Storage Life***

For Gross Leak, MSL 3 precondition, plus 3x Reflow and Temperature Storage Life testing. RJR used tests performed on the ACP2-1230-6 package, based on structural similarity. The ACP2-1230-6 package is an RF power air cavity package. It is a high performance, low cost, LCP plastic package with a high level of design flexibility. RJR's ACP package platform has many applications in technology fields, such as: RF power, wireless, and sensors. The package has a thermally enhanced flange for microwave and power applications. The structural similarity is due to a design that incorporates the same architecture, materials, and manufacturing processes, with the ACP2-1230-6 featuring larger dimensions. Because of the larger dimensions, the ACP2-1230-6 is considered more prone to failure than the ACP2-0800-6V package. If it passes the tests, so should the ACP2-0800-6V package. See figure 5 for a drawing of the ACP2-1230-6 package.

The qualification consisted of three production lots. Each production lot is defined by material produced on a single day, where a process set up/qualification occurred. All lots were fabricated and assembled at RJR's Oakland facility. The reliability stress tests were performed per industry standards (MIL STD-202). All tests passed. See table 5 for detailed results.

A full description of the tests is given here:

**Stress Test/Specification:** Gross Leak Test/MIL-STD-202D

**Purpose:** The test was performed to detect any gross leaks in the package.

**Sample Size:** 3 Lots, 80 units each

**Conditions:** 125°C±3 in Fluorocarbon Liquid

**Possible Failure Mechanisms/Modes:** Cracks, holes, or bonding delamination at the interface in the package.

**Passing Criteria:** Pass Bubble Leak Testing after MSL3 + 3 x reflow (245°C)

**Stress Test/Specification:** Moisture Sensitivity Level (MSL3): JEDEC J-STD-020C

**Purpose:** The test was performed to simulate the package assembly process where parts are subjected to a high temperature for a short duration

**Conditions:** 24 hrs Bake @ 125°C + 40 hrs soak @ 60°C/60% RH + 3X Reflow @ 245°C

**Possible Failure Mechanisms/Modes:** Cracks or holes in the package or bonding delamination at interface

**Passing Criteria:** Pass Bubble Leak Testing after MSL3 precondition + 3 x reflow (245°C)

**Stress Test/Specification:** High Temperature Storage Life (HTSL)/JESD22-A103D

**Purpose:** Failure mechanisms which are thermally activated through the application of extreme temperature

**Condition:** 150°C Sample Size: 3 Lots, 77 units each

**Possible Failure Mechanisms:** : Creep or deformation, fatigue (cracks and delamination), corrosion, material degradation, and other mechanisms which are activated due to exposure to extremely high temperature.

**Passing Criteria:** Pass gross leak test per MIL-STD-202G Method 112E Condition D

The qualification consisted of production lots fabricated at RJR's Hayward facility. The reliability stress tests were performed per industry standards (JEDEC, AEC, and MIL-STD-883). The devices used were mechanical samples. The ACP2-1230-6 packages used for qualification consisted of RJR's SW1230-6-A (side wall), L1230-A (lid), and a flange manufactured by Sumitomo. All tests passed. See table 6 for detailed results.

## 4 Discussion

Based on structural similarities between the 14-pin butterfly package and the ACP2-0800-6V package, we postulate that the 14-pin butterfly package will pass Moisture Sensitivity Level (MSL3) and Temperature Cycling. These tests were performed on the ACP2-0800-6V package and all devices passed.

For Gross Leak testing of the ACP2-0800-6V package, RJR used tests performed on the ACP2-1230-8R package, based on structural similarity with the ACP2-0800-6V package. The ACP2-1230-8R package is considered more prone to failure than the ACP2-0800-6V package due to its larger size. If it passes the tests, so should the ACP2-0800-6V package and in turn also the 14-pin butterfly package. These tests were performed on the ACP2-1230-8R packages and all devices passed.

Finally, for High Temperature Storage Life Test of the ACP2-0800-6V package, RJR used tests performed on the LD803 package, based on structural similarity with the ACP2-0800-6V package. The LD803 package is considered more prone to failure than the ACP2-0800-6V package due to its size. If it passes the tests, so should the ACP2-0800-6V package and in turn also the 14-pin butterfly package. These tests were performed on the LD803 packages and all devices passed.

We should analyze the MSL3 test a bit further. In the late 2000's, when RJR was releasing the packages into the RF power market, the plastic air-cavity packaging technology was designed to replace ceramic packages. RJR's customer wanted to determine how robust the package could perform. There were concerns as to what degree this new plastic technology could negate the rate at which moisture would migrate into or out of a package. Moisture ingress is also influenced by whether the package is under power. The degree to which moisture penetrates the package is highest when the device inside the package is powered down. When a package is under power, the internal (thermally induced) pressure typically exceeds the external ambient pressure. This positive pressure differential helps drive moisture out of the package or prevents it from entering. Therefore, the MSL 3 test was selected, designed, typically used to test over-molded package for its structural integrity. Additionally the reliability performance requirement for the MSL 3 test were raised by adding the requirement that the package has to pass gross leak after three reflows. MSL testing was not applied as a standard industry test for Ceramic packages. They only had to pass zero hour gross lead. The fact that the MSL tests were performed on unpowered packages, submerged, baked under humid conditions and subjected to 3 times reflow without failures is a testament to the ruggedness of the ACP package technology. This has led to the expression that the performance of ACP package technology is "near-hermetic".

The next key point to address is the significant difference between the 14-pin butterfly package and the ACP2-0800-6V package: the optical feedthrough in the 14-pin design. In the 14-pin butterfly package, the ferrule is insert injection molded directly into the sidewall of the package, similar to the insert molding of the lead frame. The ferrule is molded into a significantly thicker wall thickness than the lead-frame: (3 mm versus 1.0-1.87 mm, see figure 1A). that means that there is a significantly larger diffusion barrier along the surface of the ferrule than along the surface of the lead-frame. The ferrule does create a larger surface

area along which diffusion can take place, but since also a much larger RF package like the LD803 with a much larger lead-frame surface area all together still passes these tests, we postulate that the 14-pin butterfly package will also pass the test with the ferrule (at least due to diffusion along the outside surface of the ferrule molded into the sidewall).

As we have mentioned before, the height of the 14-pin butterfly package is larger than any of the referenced RF packages. The height of the 14-pin package is 9.15 mm versus 3.76 mm and 4.37 mm for the ACP2-0800-6V and the ACP2-1230-8R package respectively. We need to assess to what degree this creates a new failure mode and/or increases the risk of failures. Only one part of the 14-pin butterfly package has significantly deviating (height) dimensions: the side-wall. The side-wall is made of LCP, a material from which we noted that in literature it is labeled as “practically hermetic” (Dietz <sup>3</sup>). Moreover, the increased height of the side-wall increases the distance between the flange and lid and will therefore most likely reduce stress in the package (due to CTE mismatch of the flange and lid, since the side-wall will not absorb much stress due to its shape). As a result, we expect a decrease in the risk of failure compared to the RF packages.

Then the hermeticity of the inside of the ferrule needs to be addressed. As we discussed already in section 2, the hermetic sealing of a fiber through a ferrule is known technology (see Dietz <sup>3</sup>). But since the traditional process of glass soldering does require temperatures of 320° C or higher, which exceed the melting point of the LCP material used, this technology cannot be used. At present low temperature and reliable alternatives exist using hermetic epoxy seals. (see Douglas Electrical Components <sup>4</sup>). We have reasons to believe that the moisture barrier epoxy that is used to seal the lid (see section 3) could in principle also be used to seal the optical feedthrough.

Taking all tests and results into consideration, we have confidence that the 14-pin butterfly package will pass all tests that have been presented based on structural similarity with existing air-cavity plastic RF packages and known processes in literature.

It’s worthwhile to discuss a little bit the difference between the Telcordia and the JEDEC standards. Telcordia and JEDEC are both organizations that develop standards, but they focus on different areas of the electronics industry. Telcordia standards are primarily used in telecommunications and network equipment, while JEDEC standards are focused on semiconductor devices and related technologies. Telcordia has thus a much smaller application area than JEDEC. Furthermore, the number of samples specified in the Telcordia standard, particularly for GR-468-CORE testing, is 15. Whereas JEDEC standards often recommend using 77 samples per lot, with a minimum of three lots, for a total of 231 samples. For a technology that is derived from the semiconductor industry and provides a high-volume solution, we believe that the JEDEC standard is more appropriate.

## 5 Conclusions

This paper provides a study into the structural similarity of a 14-pin butterfly package and an ACP2-0800-6V package RF power package based on design, materials and processes. Based on structural similarities we postulate that prior reliability testing according to JEDEC, AEC and MIL standards, - including Moisture Sensitivity Level (MSL3), Temperature Cycling, 0-hour Gross Leak Test, Gross Leak Test after MSL, High Temperature Storage and Low Temperature Storage - performed for the ACP2-0800-6V RF power package will also apply to the 14-pin butterfly package. All these tests passed for the ACP2-0800-6V package RF power package without failures.

A significant difference in design between the ACP2-0800-6V and the 14-pin butterfly package is the presence of the optical feedthrough (ferrule) in the 14-pin butterfly package. But it's known and referenced in literature that these feedthroughs can be near hermetically and reliably sealed using epoxies. Additionally, the metal ferrule can be replaced with a molded LCP ferrule to lower costs and eliminate an extra bond line, reducing potential moisture ingress.

The air-cavity plastic packages are tested mostly according to JEDEC standards. Because JEDEC is defined for a much larger application area than Telcordia and provides a high-volume solution, we feel the JEDEC standards is more appropriate than the Telcordia standard for RJR's air cavity plastic package technology use in Photonics applications.

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**Gai van Straten** holds a degree in Electronics and Communications Engineering and a Business Management diploma. She joined RJR Technologies in 2019 as a technical specialist. Prior to this, she worked for Semiconductors companies in Western Europe in the field of program/project management, RF product design, assembly and package development, Quality and Reliability, and Quality Management System implementation. Before moving to Europe, she worked in Philips Semiconductors Philippines as Sr. Manager working on new product/technology introduction, new assembly platform and line industrialization, product engineering and cost reduction programs.



**Wil Salhuana** is the CEO of RJR Technologies, Inc. He received his B.S. in Electrical Engineering from the University of Colorado in the USA. Wil has led several industry breakthroughs in the semiconductor industry that resulted in commercial success, such as 2.4GHz wireless personal area network (PAN) for handheld gaming, fully integrated cable set top box system-on-a-chip device, tape-automated (TAB) packaging, and ball grid array (BGA) and air cavity plastic (ACP) packages, amongst others.

Photograph not available.

**Raymond Bregante** is the co-founder and Executive Chairman of RJR Technologies, Inc. He has been the technical lead for many of RJR's advanced technologies, such as fully automatic sealing systems, high reliability air cavity QFN package, and air cavity plastic packages for oscillators, LiDAR and Photonics applications. In addition, Ray has been the patent holder for RJR's key innovations that resulted in commercial success, such as, US6511866B1 – "Use of diverse materials in air-cavity packaging of electronic devices", amongst others.

Photograph not available.

**Sven Knippscheer** is Managing Director of planSeven Consulting and Director of Sales at RJR Technologies. With over 25 years of experience in innovation management, and international business development, he has held leadership roles at QSIL, H.C. Starck, Plansee, and Tecnisco. He holds a PhD in engineering and is certified as Chief Technology Manager. His expertise spans high-performance materials, semiconductor packaging, and global OEM partnerships across medical, industrial, and aerospace applications.



Figure 1A Drawing of the RJR 14-pin butterfly package.

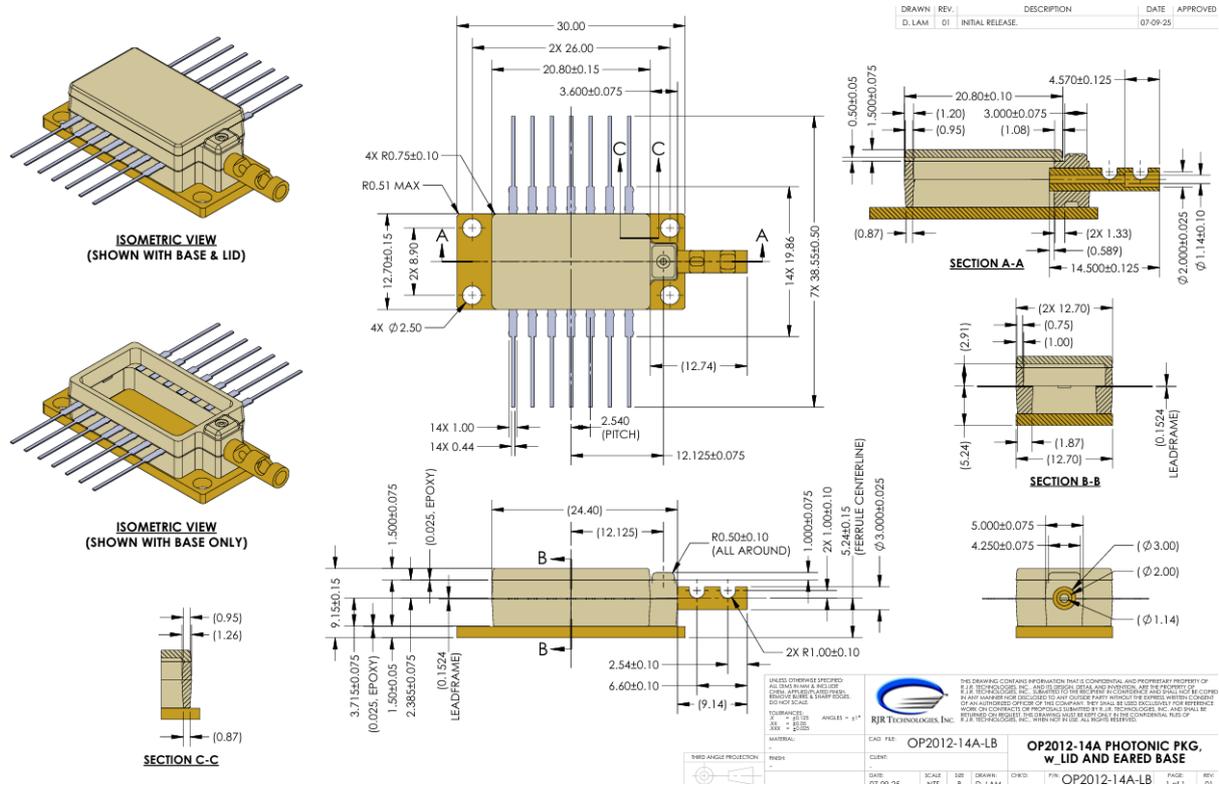
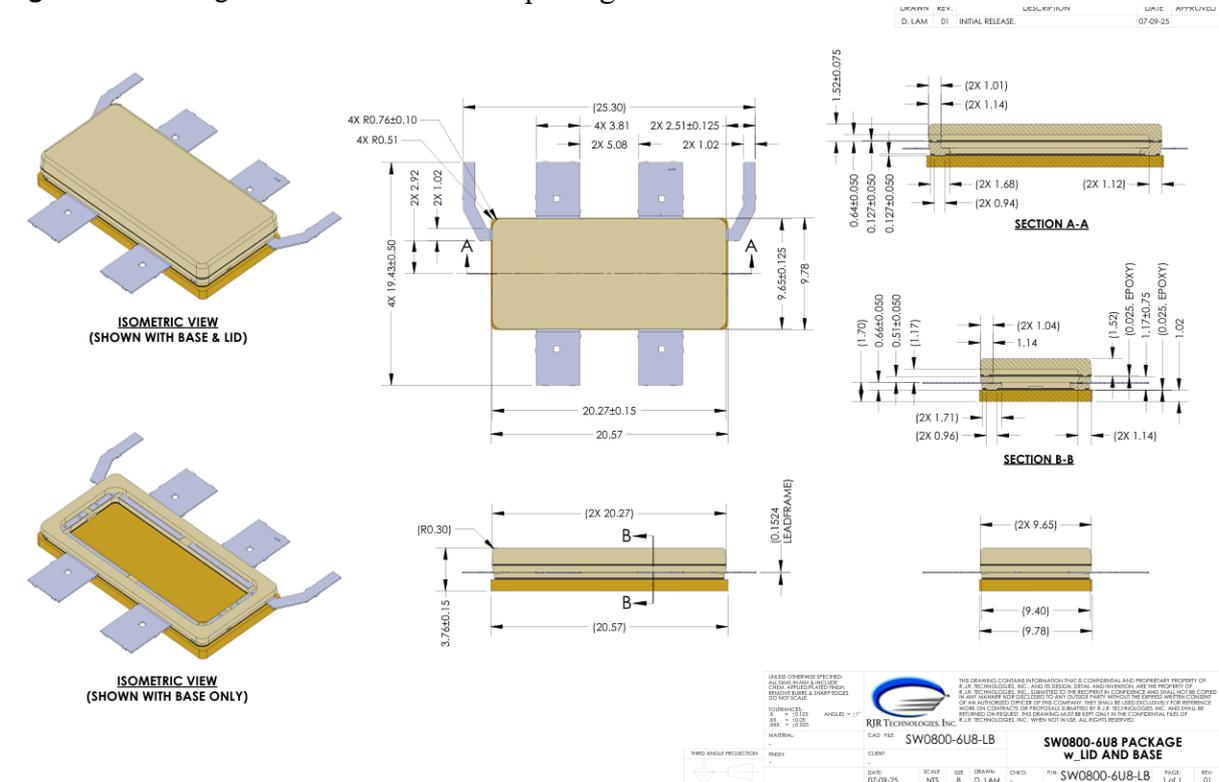
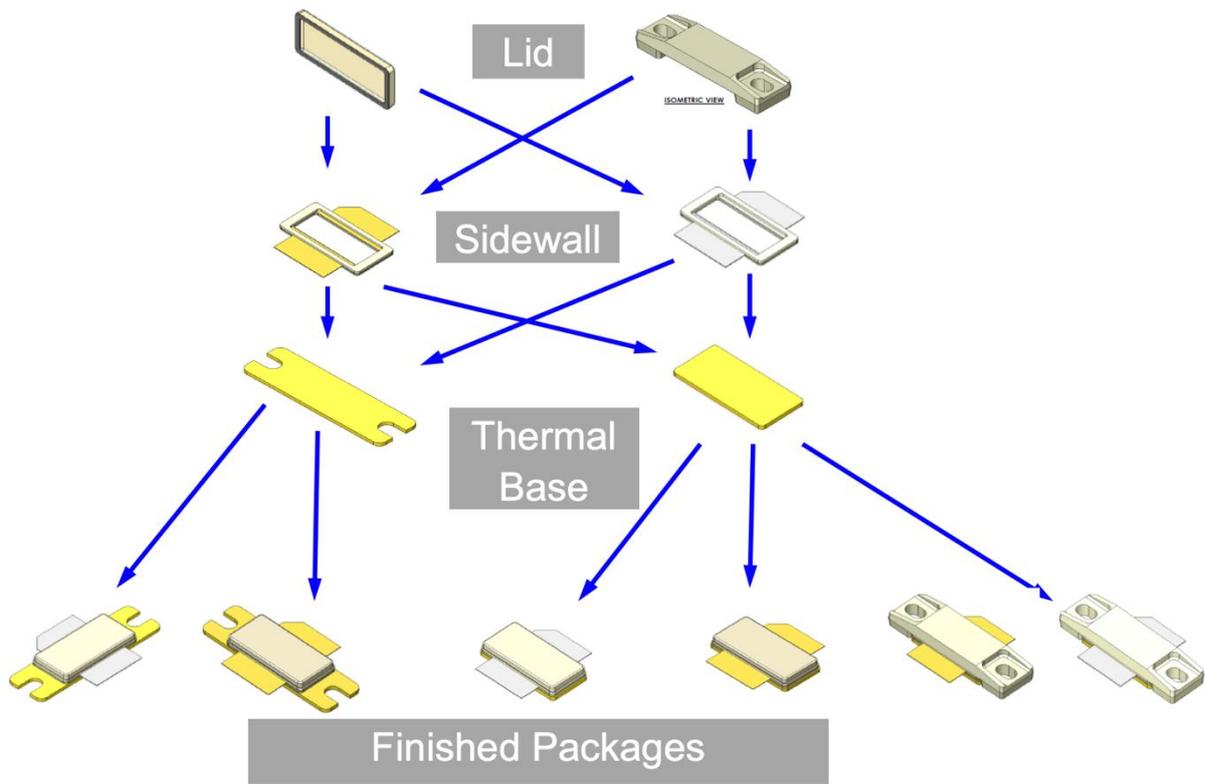


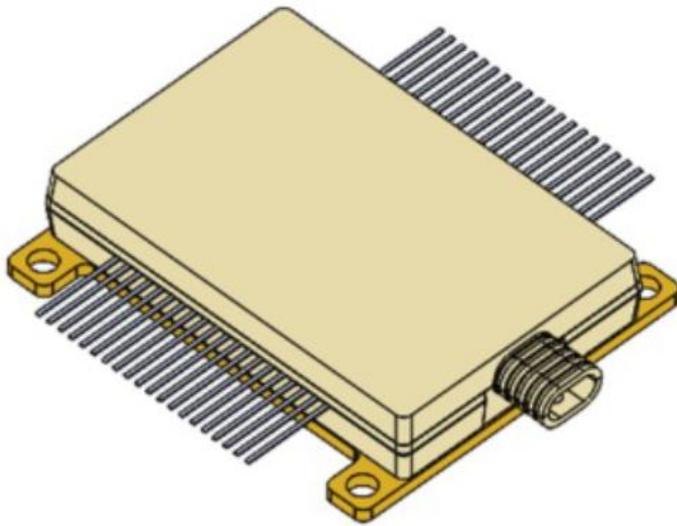
Figure 1B Drawing of the ACP2-0800-6V package.



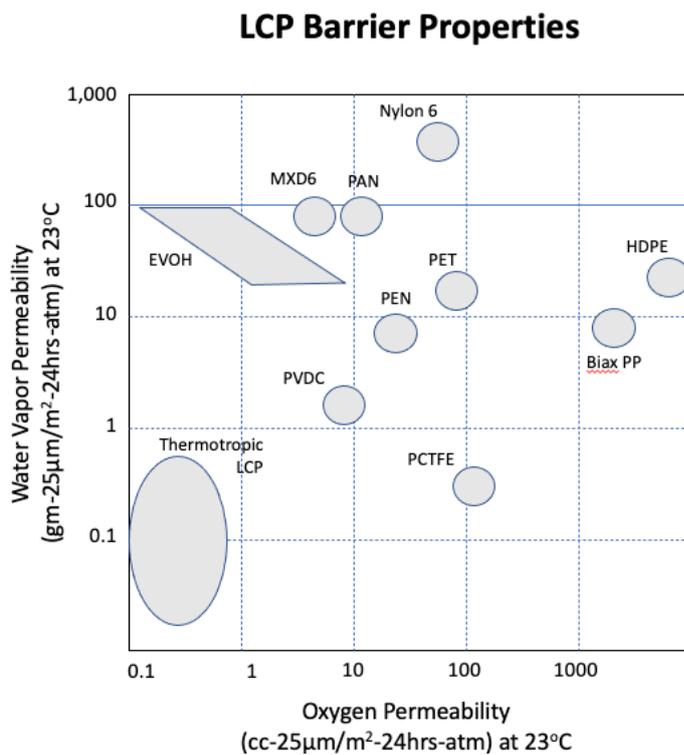
**Figure 2** The Architecture of LCP Package Configurations as shown for RF Power Solution



**Figure 3** RJR 40-pin butterfly package, an example of a package with integrated molded ferrule.



**Figure 4** Water Vapor Permeability versus Oxygen Permeability for different LCP materials and plastics.



**Table 1A** Physical properties of HTP1280 LCP material



## HTP 1280 PLASTIC BODY COMPOUND

This custom thermoplastic compound is used in RJR injection molded, plastic body packages. The material is available in five colors (Black, White, Grey, Blue, and Nature), allowing for color coding of package styles or configurations. The molded compounds are resistant to typical chemicals used in the manufacture and processing of electronic components. Typical properties are as follows:

<b>Physical:</b>		
Density	1.67 gm/cc	ASTM D792
Water Absorption	0.02%	ASTM D570

<b>Mechanical @ 23C:</b>		
Tensile Strength	21,000 PSI	ASTM D638
Tensile Modulus	$2.5 \times 10^6$ PSI	ASTM D638
Elongation @ Break	1.2%	ASTM D638
Flexural Strength	31,000 PSI	ASTM D790
Flexural Modulus	$2.4 \times 10^6$ PSI	ASTM D790
IZOD Impact Strength Notched	1.6 ftlb/in	ASTM D256

<b>Thermal:</b>		
Melting Point	280°C (536°F)	ASTM D3418
DTUL @ 1.8 Mpa (264 PSI)	270°C (518°F)	ASTM D648
Vertical Flammability at 0.79mm	V0	UL 94
CTE (parallel to flow), 0-150°C	12-18 ppm	ASTM E228
Thermal conductivity	0.32W/mK	ASTM C177

<b>Electrical:</b>		
Volume Resistivity	10 <sup>12</sup> ohm-cm	ASTM D275
Surface Resistivity	10 <sup>12</sup> ohm	IEC 93
Dielectric Strength	766 V/mil	IEC 93
Dielectric Constant	3.8 @ 1 kHz	ASTM D150
	3.7 @ 100 kHz	
	3.7 @ 10 MHz	
Dissipation Factor	0.007 @ 100 kHz	ASTM D150
	0.003 @ 10 MHz	ASTM D150
Arc Resistance	165 Sec.	ASTM D495
Comparative Tracking Index	175 volts	ASTM D3638

**Notice:**

- This Material is RoHS Compliant and will withstand Lead Free Solder Re-Flow up to 270°C**  
**his information is provided as a general guideline and is based on laboratory specimens and test procedures. No expressed or implied warranty is made on any specific use. Customers should perform their own tests.**

**Table 1B** Physical properties of HTP1335 LCP material

**HTP 1335**  
**R-Pak™ Plastic Lid Compound**

This custom thermoplastic compound is used in RJR R-Pak™ injection molded, plastic body package. It is RoHS compliant. The material is available in two colors (Black and Natural), allowing for color coding of package styles or configurations. The molded compounds are resistant to typical chemicals used in the manufacture and processing of electronic components. Typical properties are as follows:

Physical properties	Value	Units	Method
Density	1.67	g/cm <sup>3</sup>	ISO 1183
Water absorption after 24 hours @ 23°C	0.004	%	ISO 62
Moisture absorption (23°C/50%RH) sat	0.007	%	ISO 62
Molding shrinkage, parallel	0.1	%	ISO 294
Molding shrinkage, normal	0.4	%	ISO 294
Mechanical properties @ 23°C	Value	Units	Method
Tensile strength	140	MPa	ISO 572-2/1A
Tensile modulus	15500	MPa	ISO 572-2/1A
Elongation @ break	1.3	%	ISO 572-2/1A
Flexural strength	230	MPa	ISO 178
Flexural modulus	14500	MPa	ISO 178
IZOD Impact strength notched	12	KJ/m <sup>2</sup>	ISO 180/1A
Thermal properties	Value	Units	Method
Melting point	350	°C	ISO 11357
DTUL @ 1.8 MPa	340	°C	ISO 75-1, -2
DTUL @ 8.0 MPa	267	°C	ISO 75-1, -2
CTE, parallel	1	ppm/°C	ISO 11359-2
CTE, normal	23	ppm/°C	ISO 11359-2
Flammability at thickness h	V-0	Class	UL 94
Electrical properties	Value	Units	Method
Volume Resistivity	10 <sup>15</sup>	Ohm*m	IEC 60093
Surface Resistivity	10 <sup>17</sup>	Ohm	IEC 60093
Dielectric Strength	37	KV/mm	IEC 60243-1
Dielectric Constant, 1MHz	3.5	-	IEC 60250
Dissipation Factor, 1MHz	90	E-4	IEC 60250

Notice: This information is provided as a general guideline and is based on laboratory specimens and test procedures. No expressed or implied warranty is made on any specified use. Customers should perform their own tests.

**Table 2** Physical properties of RJ4MB-HT epoxy adhesive/sealant

**PACKAGING ADHESIVE/SEALANT MOISTURE BARRIER FORMULATION RJ4MB-HT/RJ4MB-V2**

RJ4MB-HT/RJ4MB-V2 is a Beta stage adhesive/sealant for general-purpose use in sealing electronic packages. It is ideal for use in mechanized sealing systems or manual clipping processes. It is a high flow, low viscosity system for use on ceramic, plastic, and metal IC covers.

**TYPICAL PROPERTIES**

Max operating temperature (continuous), °C	160-165 °C
Outgassing	0.7%TML, 0.04%CVCM
Moisture absorption (24 hr. soak in water @ 100°C)	0.1%
Total ionic content (specific electrical conductance), mS/m	NA
Extractable Ions, ppm	<10
Hydrolysable chloride content, ppm (MIL-STD 883H Method 5011.5)	NA
Ultimate Tg by DSC, °C	180 °C
Modulus, psi	380,000
CTE, ppm/°C	29
Dielectric constant (@ 1MHz)	3.2
Volume resistivity, Ohm-cm	3 x 10 <sup>16</sup>
Thermal conductivity, W/m-k	0.3 – 0.5

**TYPICAL SEALED PACKAGE PERFORMANCE PROPERTIES**

Reflow temperature, °C	260 °C
Lap shear strength (gold/epoxy @ 25°C), psi	1800
Lap shear strength (LCP (HTP1335) @ 25°C), psi	1700
Lap shear strength (LCP (HTP1280) @ 25°C), psi	1700

**Table 3** Detailed device description of the ACP2-0800-6V test batch for MSL and Temperature Cycling. For more details see the text.

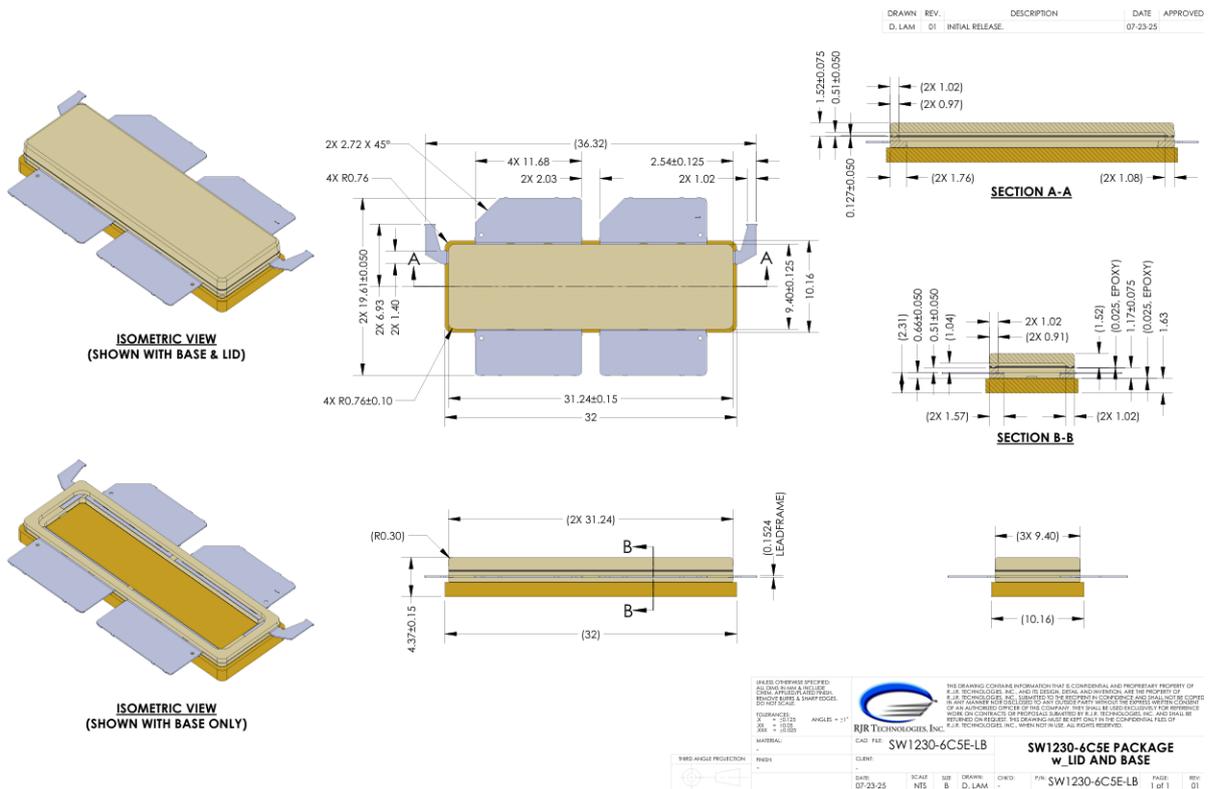
Package	ACP2-0800-6V			
Assembly Site	Oakland, California			
Package Size	800 x 396 mil			
		Lot #1	Lot #2	Lot #3
Lid	L0800A	51200	51200	51200
Assembly Lot #		WYC1817A	WYC1817B	WYC1817C
Base	Sumitomo			
Reliability Lab	RJR Polymers, Inc.			

**Table 4** Detailed results of the MSL and temperature cycling tests of the ACP2-0800-6V package. For further details see the text.

	Stress	Abbv.	Ref.	Conditions	Duration/Accept	Lot A	Lot B	Lot C
1	MSL 3	MSL3	J-STD-020D	Reflow = 245°C	0 Fail	0/80	0/80	0/80
2	Temperature Cycling*	TC	JESD22-A104	-65°C to +150°C	500 cycles / 0 Fail	0/80	0/80	0/80

\*Temperature Cycling passed 1000 cycles with 0 failures.

**Figure 5** Package drawing and data of the ACP2-1230-6 package.



**Table 5** Detailed results of the Gross Leak tests of the ACP2-1230-8R package.

	<b>Stress</b>	<b>Abbv.</b>	<b>Conditions</b>	<b>Duration/Accept</b>	<b>Lot A</b>	<b>Lot B</b>	<b>Lot C</b>
1	Gross Leak Test, t = 0	GLT	Fluorocarbon Liquid	0 Fail	0/80	0/80	0/80

**Table 6** Detailed results of the Gross (bubble) Leak tests, MSL 3 plus 3x Reflow tests, Temperature cycling tests and Temperature Storage Life tests of the ACP2-1230-6 package.

<b>No</b>	<b>Test</b>	<b>Abbv.</b>	<b>Reference</b>	<b>Conditions</b>	<b>Lot 1</b>	<b>Lot 2</b>	<b>Lot 3</b>	<b>Result</b>
1	Bubble Leak Test, t = 0	BLT	MIL-STD-833-G	Fluorocarbon Liquid 125°C +/-3	Qual Lot 1	Qual Lot 2	Qual Lot 3	Pass
					0/80	0/80	0/80	
2	MSL 3 + 3 x Reflow	MSL3	JEDEC J-STD-020C	Reflow =245°C	Qual Lot 1	Qual Lot 2	Qual Lot 3	Pass
					0/80	0/80	0/80	
3	Temperature Cycle	TMCL	JESD22-A104-B	Range -65°C to 150°C for 1000 cycles	Qual Lot 1	Qual Lot 2	Qual Lot 3	pass
					April 16	April 16	April 16	
4	Temperature Storage Life	TMSL	JESD22-A103-D	-150°C for 1000 hrs.	Qual Lot 1	Qual Lot 2	Qual Lot 3	pass
					May 10	May 10	May 10	