GENERAL ASSEMBLY AND MOUNTING RECOMMENDATIONS FOR ACP PACKAGE

REVISION HISTORY

Revision	Description	ECR Number	Date	Owner
A	Initial Release	ECR 202006-01	**June 3, 2020**	JI R&D
B	Reviewed and made minor edits as required	ECR 202208-17	**October 18, 2022**	Jeremy Incomio

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1.0 PURPOSE

1.1 This document is intended to guide customers how to assemble RJR Air Cavity Plastic package on small scale prototyping, and mass production.

1.2 The document provides recommendations on how to mount RJR Air Cavity Plastic on demo boards and/or application boards.

2.0 INTRODUCTION

2.1 RJR Air Cavity Plastic package:

The package consists of heatsink flange, an LCP sidewall and LCP lids. The transistor (active) and capacitor (passive) dies are attached typically thru eutectic solder directly on the flange. Gold wire or Aluminum wires are used as interconnection die to die, and to I/O leads of the package. The package is then is closed or sealed with lid or cap:

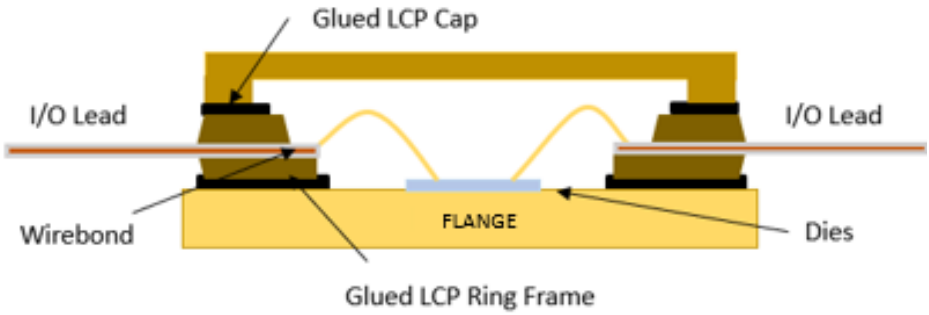

Figure 1. Artist Sketch of ACP Product Cross-Section

2.2 Board Level Soldering:
ACP products application started with LDMOS transistors, followed by GaN transistors. Hence, the board level soldering process specification have been derived on the same application.
Customers who choose their products to be reflow soldered on PCB application boards will be recommended based on the information available by RJR Technologies, Inc.

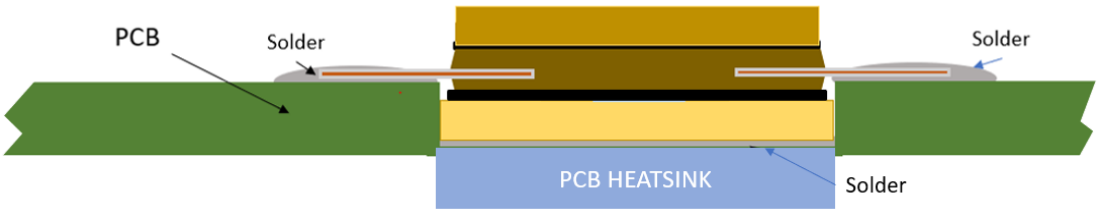

Figure 2. Artist Sketch of ACP Product Soldered on Printed Circuit Board

2.2.1 Demo boards:
Demo boards are usually referred to as dummy boards to simulate the board level soldering process of RJR ACP to an application board. These are customer specific design replicating and studying the end user assembly environment.

2.2.2 Application Boards:

Application boards are full functional circuit boards designed for the ACP product or device.

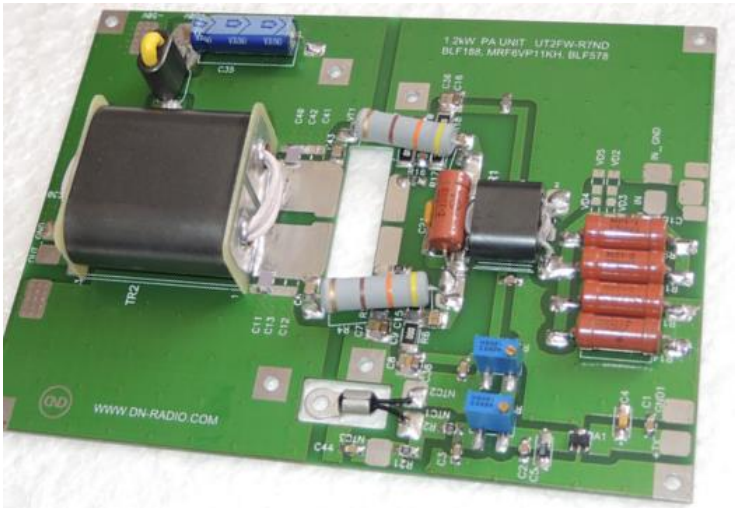

Figure 3. Application board Example: 1kW, 1.8-35MHz, 700W 50MHz Power Amplifier Board with ACP Packaged LDMOS

2.3 Definitions

- Heat sink: refers to the heatsink of the PCB, or as described - the application board heat sink.
- Flange: (also a heat spreader) is the heatsink of ACP devices.
- Ringframe: leadframe molded with LCP ring or pedestal for I/O connection of ACP package.
- Lids: LCP molded cap with b-staged glue.
- B-Staging: partially reacted stage and solid at ambient temperature of the glue (epoxy) that is pre-applied to ringframe and lids
- Solder land: used to define the area on which to solder.

3.0 RJR AIR CAVITY PLASTIC PACKAGE ASSEMBLY:

3.1 Small Scale Prototyping: Using CLIP-BAKE Process

3.1.1 **Step 1:** Perform the die attach on heatsink according to product requirement.
Note: If the die attach process requires heat less than 200°C, it is considerable to do this step after Step 2 and Step 3.

3.1.2 **Step 2:** Place the heatsink on hot plate with 60 °C heat and wait for 10 secs.
Note: The flange is recommended to undergo RJR surface treatment, please contact RJR Technologies, Inc for the details and/or inquiries.

3.1.3 **Step 3:** Place the ring frame on the top of the heatsink, making sure that they are aligned.
Note: If the dies are placed on the heatsink (as Step 1, make sure that the glue will not touch the surface of the die.

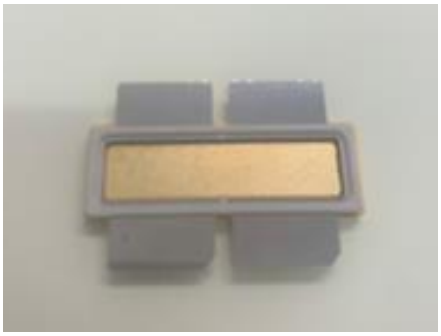

Figure 4. Flange and Ringframe Placed on Hot Plate

3.1.4 **Step 4**: Unload the heatsink and ringframe assembly from the hot plate. Make sure that during unloading, the package is being held from base and not on the ringframe because the glue is still soft.

3.1.5 **Step 5:** Using a conner clip (1 lb. specified) and a glass slide, carefully clip the heatsink and ringframe assembly. Note that the glass slide is on top of the ringframe, protecting the die and/or the die attach area.

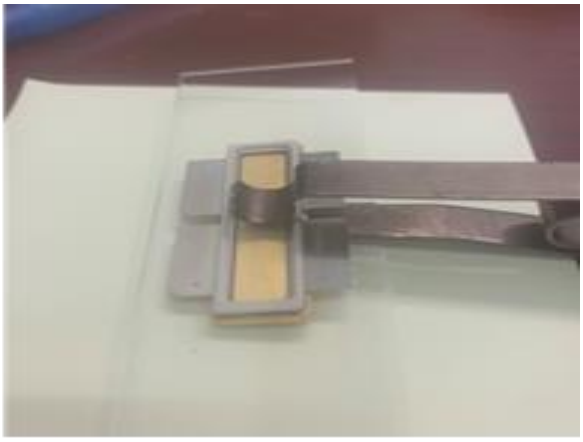

Figure 5. Flange and Ringframe Clipped Together Before Loading to pre-cure Oven

3.1.6 **Step 6:** Place in an oven to pre-cure; 125°C for 30 minutes, and then 160°C for 15 to 60 minutes.
Note That the 15 to 60minutes in 160°C is customer defined in reference to product downstream processes, e.g. wirebonding.

3.1.7 **Step 7:** perform wirebond process or any other component interconnecting processes inside the product

3.1.8 **Step 8:** After step 7, is sealing. To seal the ACP package, place and align the cap or lid on top of the ring frame. Place a glass slide on the lid and clip the heatsink-ringframe assembly to the cap using conner clip (1 lb. specified)

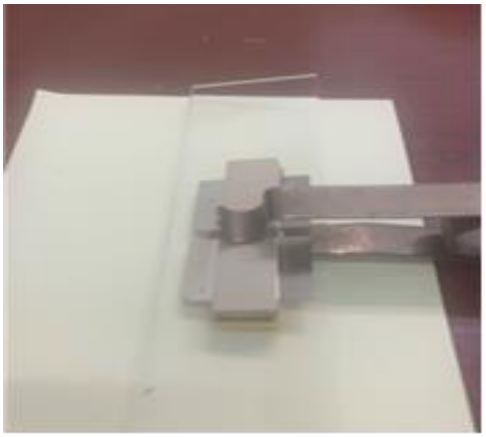

Figure 6. Flange and Ringframe Assembly Clipped with Lids Before Loading to pre-cure and Post cure Oven

3.1.9 **Step 9:** Place in an oven to pre-cure; 125°C for 30 minutes, and then post cure at 180°C for 60 minutes

3.2 Mass Production Using RJR ITS Machine:

3.2.1 For fully functional and consistent ACP assembly, RJR ITS Machine is recommended to warrant a high yield and reliable process.

3.2.2 For full information of ITS machine, set-up and operation contact RJR Technologies, Inc.

4.0 MATERIAL STORAGE SPECIFICATIONS:

LCP ringframe and LCP Lids are packed in separate trays. They are both with pre-applied epoxy, B-staged, therefore, ample attention on the storage conditions must be given to ensure reliable package assembly builds.

4.1 Customer Samples:

4.1.1 Samples are packed in ESD Bags with desiccants, they are sealed from dust and particles.

4.1.2 The ESD bags are normally contained in small boxes.

4.1.3 Upon delivery, the samples must be refrigerated between 3°C and 8°C

4.1.4 When the parts are to be used, place the parts still sealed ESD bag, for 2 hours to acclimatize.

4.1.5 Pull out parts that will be used for assembly and testing, then re-seal the remaining parts back in the ESD bag.

- Parts to be used can be stored in ambient condition not more than 16 hours. Beyond 16 hours, the parts must be scrapped.
- Remaining parts that are resealed, must be refrigerated again between 3°C and 8°C.

4.2 Mass Production Materials:

Please see storage recommendation details in Specification ICP-075-002

5.0 MOUNTING RECOMMENDATIONS FOR ACP PACKAGE:

ACP products application started with LDMOS transistors followed by GaN transistors, and hence the board level soldering process specification have been derived on the same application. Primarily reflow soldering, the customers will be recommended with information how to design the PCB board soldering areas for the ACP package leads and heatsink (aperture or cavity design specifications).

5.1 Recommended Design Rules for PCB design

5.1.1 Solder Land of the ACP Leads:

The solder land is recommended to be 250 µm larger than the package lead. This value is relatively large, so that placement accuracy of the package on the PCB will not be critical.

5.1.2 PCB with Solder Mask Defined Solder Land:

The package solder land is defined by the solder mask as illustrated in figure 6. The minimum overlap for the copper layer of the PCB to the solder mask is recommended to around 75um. This considers the manufacturing of the PCB, placement accuracy of ACP package, and intended control of the solder outflow.

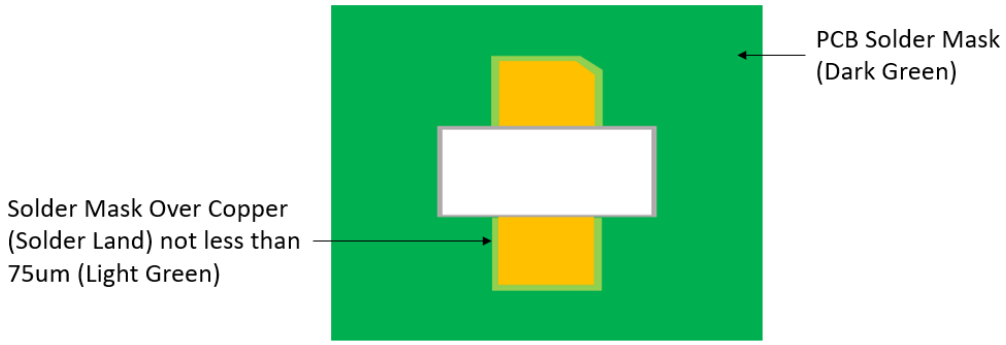

Figure 7. Solder Mask Overlap on Copper Solder Land

5.1.3 PCB (without solder mask) Solder Pads:

Some application board designs don't require the solder mask on the ACP package's leads.

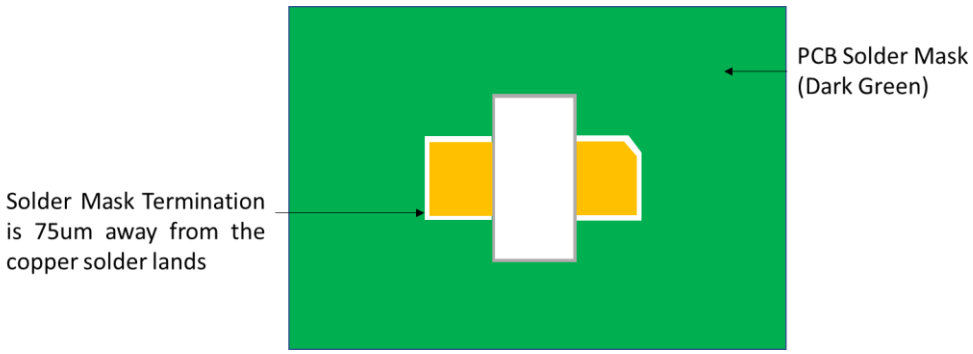

Figure 8. Solder Mask Away from Copper Solder Land

The design of the solder land is equal to the copper area; hence the solder mask must terminate at least 75um away from the copper or solder lands. This is to ensure that the mask will not overlap on the copper solder land, given the inaccuracy of PCB manufacturing.

5.1.4 Package Footprint Consideration for Soldering on PCB:

Below are the most relevant dimensions for soldering the ACP package in PCB board

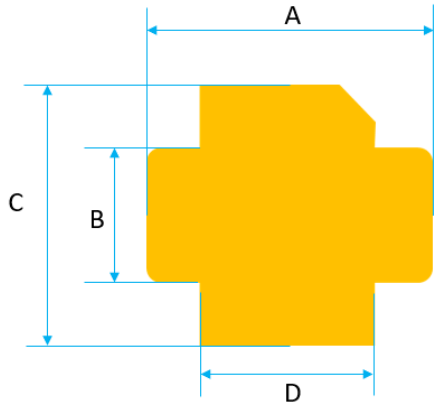

Figure 9. Relevant Dimensions for Soldering ACP on PCB Board

5.1.5 PCB Cavity for ACP Flange to Heatsink Soldering:

The size of the cavity in the heat sink is primarily specified based on the outline of the ACP flange. To insert the flange with ease but not compromising the positional accuracy, the cavity width and length is recommended to be 100um to 150um larger than the ACP flange width and length:

It is essential that, after mounting, the package leads make good contact with the PCB pads, and that at the same time the bottom of the flange makes good contact with the heat sink. The main considerations are:

1. The PCB thicknesses
2. The thickness of the solder between the PCB and the heat sink.
3. Solder thickness under the lead.
4. The thickness of the heat sink cavity
5. The thickness of the solder between the flange and the heat sink
6. Q: is the dimension (also known as standoff plane) between the bottom of the flange and the bottom of the leads. This is defined by the package.

However, each item of considerations has their dimensional tolerances to consider. To have a realistic or workable specification it is important that the customer derive the most accurate specification to achieve a good quality and repeatable soldering process. A more common way is to do this is calculating Square Root of Sum of the Square method (2σ or 3σ respectively 95.5 % and 99.7 % of the population).

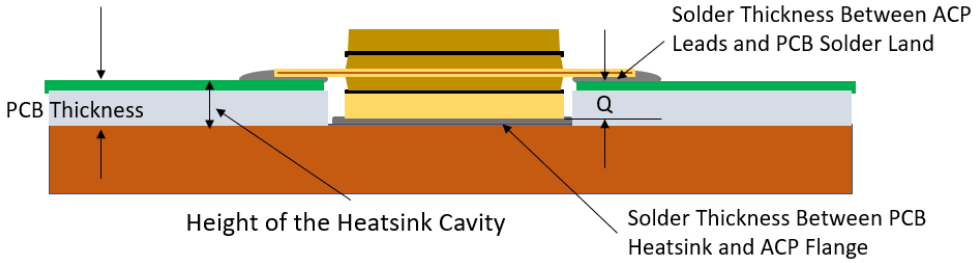

Figure 10. Consideration in Designing the PCB Cavity

Note: Too deep of a cavity will result in poor contact either on leads to PCB, and or ACP flange to PCB heatsink. If the cavity depth is too shallow, solder of leads will be inadequate and or there will solder bridging between ACP flange and ACP leads.

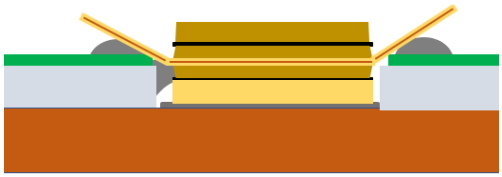

Figure 11: Flange Cavity is Too Thick

Figure 11: Flange Cavity is Too Shallow

5.1.6 PCB Aperture Opening for Soldering the ACP Package on the PCB Board:

The ACP package body is placed through an aperture in the PCB, and onto the heat sink cavity. The dimensions of the aperture in the PCB should be such that the package can be easily positioned on.

RJR Technologies, Inc. recommends that a 200um allowance on all sides ACP flange in designing the PCB aperture attain the ease in soldering process of the ACP.

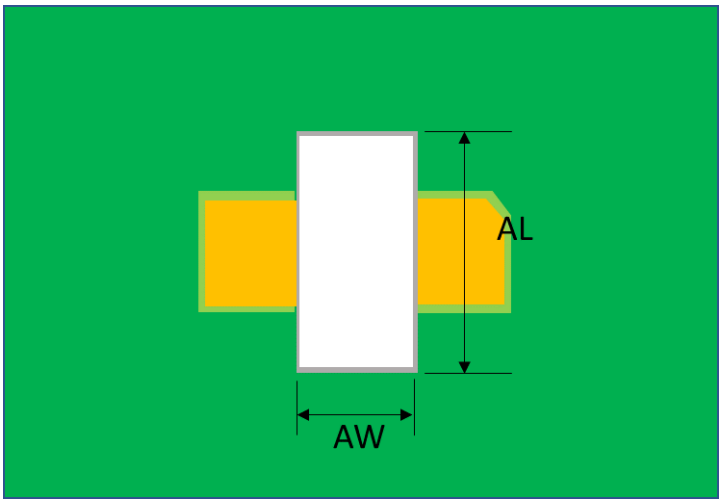

Figure 12. Recommended PCB Aperture Dimensions

In figure 12, AL is equal to Length of the ACP flange in mm + 0.200mm while AW is equal to the Width of the ACP flange in mm + 0.200mm.

The customer however will judge what level of accuracy is needed in the placement of the ACP package. You may choose to use conservative allowance but needs to consider the PCB manufacturing accuracy.

5.1.7 Distance of ACP Leads Solder Land to Aperture Opening:

The distance between the ACP leads solder land is recommended to be 350 µm per side. This is to ensure isolation of the ACP flange from solder flow or solder bridging:

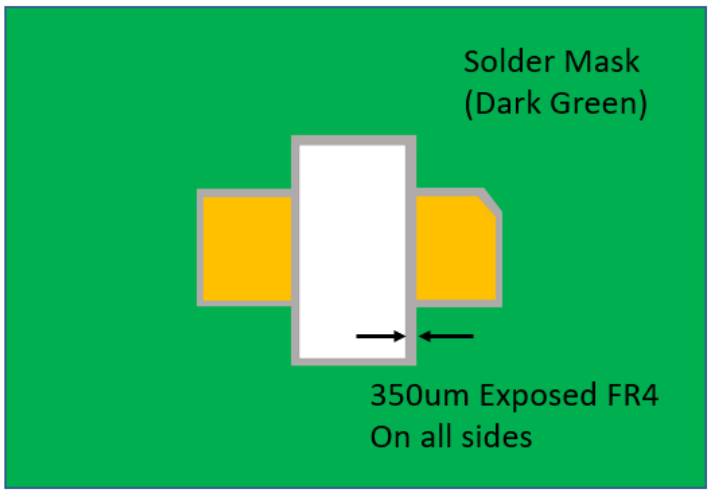

Figure 13. Distance of the Copper Solder Land to Aperture is the exposed PCB' FR4

The 350um distance can also allow a solder mask of at least 150um; in the same intention of isolating the flange from the leads soldering.

5.1.7.1 Surface Condition of the PCB Heatsink Cavity:

RJR Technologies, Inc. recommends that the heatsink will have the following:

- Flatness not greater than 0.025mm
- Surface roughness Ra not more than 0.5um, with no protruding burrs or plating nodules.

5.1.8 Soldering Paste Printing:

It is assumed that the customer is knowledgeable with stencil printing process. Primarily the stencil design should match the target solder interface between the PCB heatsink and ACP flange, and ACP leads to PCB solder land. It is important to mention however that the insufficient solder paste printing leads to open contacts or bad solder joints that will compromise the overall performance and the reliability of the device or product.

5.1.9 Solder Paste Preform:

It is recommended to use a Pb-free solder paste or preform as compliance to environmental standards. Exemptions are granted for selected applications, and RJR Technologies, Inc. assumes that the customers are fully aware of the requirements and will only mention recommendations based on information shared with vendors and some published information from customers themselves.

A wide variety of Pb-free solder pastes are available, containing combinations of Sn, Cu, Sb, Ag, Bi, In, and other elements. The different types of Pb-free solder pastes/preforms have a wide range of melting temperatures

As a substitute for SnPb solder, the most common Pb-free paste/preforms is SAC, a combination of tin (Sn), silver (Ag), and copper (Cu). SAC typically has a melting temperature of around 217 °C, and it requires a reflow temperature of more than 235 °C.

A no-clean solder paste or preform does not require cleaning after reflow soldering and is, therefore, preferred. Worth noting though that a no-clean pasted, flux residues may be visible on the board after reflow. If the peak temperature will not exceed 245°C, ACP package will pose no reliability risk.

5.1.10 Reflow Soldering Procedure:

RJR Technologies, Inc. recommends convection oven rather than a conduction or radiation oven. A convection oven provides a uniform heat and a very controlled temperature (± 5°C). Moreover, it allows soldering a wide range of products due to the temperature uniformity.

5.1.10.1 Peak Temperatures:

- Lower limit of peak temperature: The minimum peak temperature must at least be high enough for the solder to make reliable solder joints.
- Upper limit of peak temperature: The maximum peak temperature must be lower than the temperature at which the components are damaged. If the peak temperature will not exceed 245°C, ACP package will pose no reliability risk.

5.1.10.2 PCB Board Damage During Reflow: This is a board characteristic; the customer should the supplier in cases of PCB failure during process.

5.1.10.3 SAC Solder Reflow Profile:

- Calibration: it is important that the customer performs this step before soldering process. The procedure includes the use of thermocouple glued down on the cap of the ACP package to simulate the actual temperatures the device undergoes over time/speed of reflow process
- At least 6-zone reflow oven machine must be used, with inert N2 atmosphere.
- Temperature profiles based on JEDEC (JSTD020d):

Parameter	Units	Specifications
Time Above Liquidous State	seconds	60 to 150
Maximum Ramp-Up Slope	°C/sec	3
Maximum Package Temperature	°C	245

NOTE: RJR Technologies, Inc.is not recommending hot plate to solder the ACP package on the PCB heatsink. It will be the customer's responsibility to determine the soldering process if they choose to use hot plate machine.

5.1.11 Inspection:

5.1.11.1 Wetting Appearance Visual Inspection:

Pb-free solder joints are less shiny than SnPb solder joints. This is because they have different microstructure after solder curing.

5.1.11.2 X-Ray and CSAM inspection is recommended to see further the overall soldering interface of ACP and PCB. Criteria is expected to be based on product performance and reliability requirements.

5.1.12 Mounting Procedure:

5.1.12.1 ACP Package Placement:

- Handling: for a manual process, where operators will use metal or plastic tweezers the ACP package must be held on the flange. For auto pick-place, and or vacuum pen ACP package can be held on the top of the lids.

- Placement: Place the package positioned with the flange inserted in the PCB cavity and into the PCB heat sink. Package alignment is done visually, by adjusting the position so that the package leads are exactly aligned with the PCB pads.

  Due to different soldering planes, leads and PCB heatsink, it is necessary to use mounting jig to keep the placement position consistent

5.1.12.1.1 Demo Boards Jig:

- Below is a sketch of customer demo board soldering jig. The idea is to keep equally distributed load on the top of the package, not more than 800gms

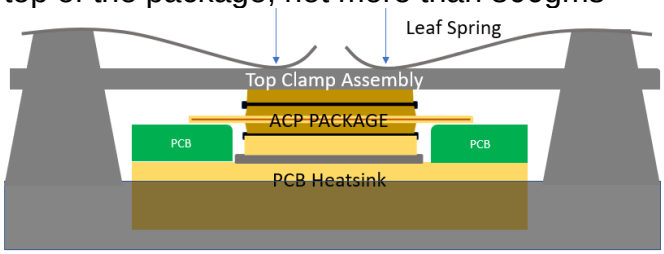

Figure 14: Demo Board Soldering Jig

- Customers are advised not to scrub nor shake the package during soldering process

- Point loading on the package during soldering process is also not recommended:

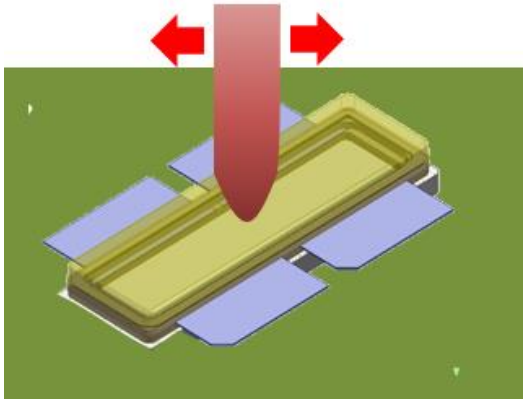

Figure 15: Point Loading Pressure Illustration

5.1.12.1.2 Application Board Jig:

As a rule, the ACP package will be held together with the PCB during reflow process. Illustrated below is an example of reflow jig used by one of the customers:

- The jig clamps together all components in one reflow pass
- The product is inserted in the PCB hole into the heatsink that is also cavitated. Cavity can be assumed to play around >100ums, almost snugged
- The top press is spring loaded, there are product types where ACP package is pressed the products with not more than >800grams
- The pusher is pressure is specified, and effectively works only when the preform is melting

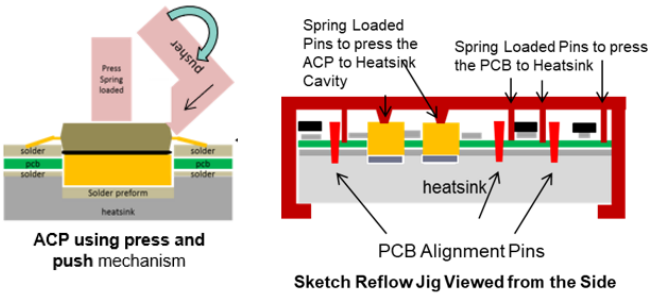

Figure 15: Application Board Jig

5.1.13 Reworking of ACP board Soldering Process:

RJR Technologies, Inc. recommends replacement of ACP package when reworking board level soldering.

6.0 REFERENCE DOCUMENTS:

6.1 ICP-075-002 - B-Stage Shipping, Handling and Storage Instructions for RJR Products at Customer Manufacturing Sites

7.0 DISCLAIMER:

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