Abstract

While lid sealing has been around for many years and is considered a legacy technology, it is helpful to revisit the topic and consider how lid sealing compares to seam sealing. By understanding the technology and its typical uses and within the context of individual package designs, the ability to determine which method to select improves the likelihood of success. The key factors to consider when choosing either technology are the thermal impact on the components that are being sealed inside the package, the hermeticity level (Hermetic – Non-Hermetic), and the production volume.
Seam sealing (welding process)

A seam-welding machine can perform seam welding. The resistance welding process is performed along one axis, sealing two parallel sides of the package and then rotating the package 90° to seal other sides of the package. Seam sealing is typically used for the assembly of commercial-grade products (usually with Kovar lids). Low-cost lids are used, and the size of the lids and packages do not change very frequently. Because the package is moving along the 2-axis, fixturing is critical to ensure the parts do not shift in the process. Specific considerations that add to the cost/complexity of the process need to be taken into account, such as tacking the lid to avoid the movement during the sealing, wear and tear of the electrodes and fixture tolerances. Because of these steps and fixturing requirements, the productivity/UPH is not as good when compared to lid sealing (soldering process).

Another item to consider is if a specific gas environment is required for the sealed package. If so, then the seam-welding machine will need to be placed inside the glove box to limit the exposure of the sealed device with open air. This will add to the overall cost of the assembly. Since this is a welding process, only electrically conductive materials, metalized packages, and metal lids can be used. Therefore, if the lid is ceramic or glass (Si or Ge), the seam sealing process cannot be used.

In summary, a seam sealing process is ideal for commercial grade products that do not have high hermeticity requirements. In other words, typical defense applications and high-reliability applications generally don’t consider seam sealing an option.

Lid Sealing (soldering process)

Lid sealing is performed through a vacuum reflow process. Using a vacuum reflow oven, like an SST 5100 Vacuum Reflow Furnace, the entire process is completed inside the chamber in a single step in a nearly, oxygen-free environment. While inside the vacuum chamber, impurities are removed using a combination of vacuum purges and pre-bake process with inert gas (Formic Acid fumes or Forming Gas can also be used before reflow to remove surface oxides “if needed”). Then a precisely controlled temperature profile is applied to achieve the hermetic seal. Since this is a soldering process, the broader range of lid materials can be soldered, unlike in seam sealing, where only metal lids can be used.

Set up: “Dead bug”, Non-Hermetic and Hermetic Sealing

To set up this process, the lid can be placed upside down (“dead bug”) or right side up. (At SST Vacuum Reflow Systems, our experience has been that the lid-down dead bug method is the most robust). Note that the vacuum reflow oven is capable of lid sealing for both epoxy seals and solder seals.
The number of devices per tooling (Figure 3) will depend on the size of the package and the use of the loose preforms or “combo-lid” (Preform attached to the lid).

Figure 3. Lid Sealing Tooling using a Graphite Boat (source: SST Vacuum Reflow Systems)

Figure 4 shows the typical appearance of the hermetically sealed device. (Note, it is a photo of similar devices)

Figure 4. Lid Sealing with Soldering Process (source: SST Vacuum Reflow Systems)

For non-hermetic lid sealing, epoxy is used. Epoxy lid sealing, by default, is considered a non-hermetic, because epoxy is a porous material. Even if the vacuum reflow oven could remove the voids from the sealed area, the epoxy will not support a high-reliability hermetic seal due to the inherent limitations of the material itself.

Hermetic lid sealing is achieved with the soldering process to make the seal. The thickness of the solder has a significant effect on the outcome of the process; too little will result in a non-hermetic seal, and too much will cause the solder to spill out. One of the critical visual indicators to look for is a uniform fillet. This visual inspection plus an X-ray inspection will show initially if the desired result has been achieved. The next step is to perform a fine leak, and gross leak test as a quality assurance check on the hermetic seal.

AuSn is most often used for the lid sealing. The preform is designed for the specific size of the lid and the package. The preform can be either loose or tacked to the lid (“combo lid”). The AuSn alloy melting temperature is 280°C, but the actual temperature the parts will experience will be between 305°C - 310°C. The key question needs to be asked when considering the lid sealing process, if the components/die survive the thermal impact during the soldering process, i.e., the melting temperature of the solder alloy.
Hermetic sealing process

Figure 5. Hermetic Sealing Process using AuSn, note the Visual Inspection Criteria (source: SST Vacuum Reflow Systems)

Observe the appearance of the AuSn solder after the reflow process. It needs to be shiny and free of any pinholes or discoloration.

Fixturing and Tooling:

Maintaining the position of the die in the package and applying uniform heat has a significant effect on the quality of the lid sealing process. SST uses its proprietary graphite machining technology to create custom fixtures that hold and align the packages and lids and provide uniform heating. Graphite is used because it has a CTE that is close to ceramic and Kovar. It has exceptional heat conductivity, which provides uniform heating of the packages inside the chamber, graphite edge heaters and heating elements at the base of the chamber enable +/- 1% temperature uniformity. During process development, up to six (6) thermocouples measure the temperature of the graphite tooling or specific devices in the tooling.

Figure 6: Lid Sealing fixtures inside SST 5100 vacuum reflow furnace.
Conclusions:

Summing up, there are several main points that companies should consider when deciding between lid sealing and seam sealing. First, they should determine if their package was designed for seam sealing or lid sealing by reviewing what the thermal impact is on the components being sealed inside the package. If the components inside the package can withstand the melting temperature of the solder alloy, then it can be a candidate for the lid sealing process. If not, the seam welding process most likely will need to be used or alternative material, such as epoxy, for sealing the package. Next, determine the hermeticity level (Hermetic – Non-Hermetic). If high-reliability sealing is required for the package, lid sealing is required. If the package is non-hermetic, then a decision will need to be made on the type of epoxy used to seal the lid. If there is a need for a specific vacuum or pressure level or a specific gas to be sealed inside the package, then the choice for the process must be lid sealing. And lastly, defining the UPH requirement will determine which sealing method is best used for the package design.

SST Vacuum Reflow Systems, a Palomar Solution designs and manufactures automated and manual vacuum reflow systems and furnaces. The company’s solutions differ from current systems on the market by utilizing SST’s unique method of applying both vacuum and gas pressure for the soldering interface of critical components within a package. For the full line of SST Vacuum Reflow Systems, visit: www.palomartech.com

**SST 5100 VACUUM PRESSURE FURNACE**

The SST 5100 is a programmable vacuum/pressure furnace that creates void-free solder joints without the use of flux, resulting in high reliability electronic components.

- **Programmable Vacuum Furnace**
  Precise control of soldering process profile

- **Creates void-free, flux-free joints**
  Consistent, highly reliable solder interface

- **Temperature up to 500°C**
  Wide range of solder alloys & other interconnect materials

- **Vacuum Level**
  <50 mTorr or .067 mBar

- **Edge heat systems**
  Optimizes temperature uniformity across the entire thermal work area

- **Single chamber process**
  Minimizes maintenance and lowers cost of ownership

- **Pressure to 40 psig**
  Collapses solder voids across larger surface areas

**SELECTED 5100 OPTIONS**

- QuikCool™ system
- Formic Acid
- Oil-Sealed or Dry Vacuum Pump*
- Multiple Temperature Zone Measurement
- Mid-Vacuum (<10⁻⁵ Torr) system
- Barcode reader
- Water chiller/Recirculator
- Custom Component Fixtures/Tooling
- Status Light
- 3rd Process Gas Input
- Moisture and Oxygen Analyzers
- Alternative Heated Target Plate Materials
- Illuminated Chamber Viewport
- Casters

**TYPICAL APPLICATIONS**

- Flux-less Soldering
- MMIC Die Attach
- Power Module Assembly
- Lead-Free Soldering
- Hermetic Package Sealing
- Fiber Optic Packaging
- Hybrid Assembly
- High Intensity LED Attach
- Eutectic Die Attach
- PV Solar Cell Assembly
- Flip Chip Assembly
- Automotive Device Assembly
Making the connected world possible™

Making the connected world possible by delivering a Total Process Solution™ for advanced photonic and microelectronic device assembly processes utilized in today's smart, connected devices. With a focus on flexibility, speed, and accuracy, Palomar’s Total Process Solution includes die bonders, wire and wedge bonders, vacuum reflow systems, along with Innovation Centers for outsourced manufacturing and assembly, and Customer Support services, that together deliver improved production quality and yield, reduced assembly times, and rapid ROI.

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