“Connectivity Rocks”

# Attachment of an Air Cavity Device Using Tin Bismuth Solder


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## Abstract

*The most common solders to attach components are either Sn63Pb37 or a lead free solder such as Sn96Ag3Cu5. There are some cases that come up where a lower temp solder is needed whether it is due to the order of assembly process steps or temperature sensitivity to components inside a device. This particular application which will be shown involved the attachment of a laminate air cavity device that required the use of a solder that had a max temp of 180°C due to the construction of a piece part inside the device and overall temperature sensitivity and reduction of movement due to CTE differences causing electrical performance issues. For this development two devices were selected, one with an embedded heat sink and one without a heat sink. In this particular case, tin bismuth solder was selected for its low melting temperature. Tin Bismuth solder has some known mechanical issues that include a low drop shock resistance, solder tends to be brittle, the solder tends to expand as it cools which can cause component lifting and a lower surface tension compared to standard solders which can affect the registration of the device. It will be shown how careful selection of the land pads utilized in the final design, stencil modifications due to flatness issues, dye penetrant testing to validate X-ray images, EDX analysis to confirm proper intermetallic can lead to a robust connection that allowed for the devices to pass qualification.*


## Background

- Active alignment of devices internally where movement of devices over temp is a concern
- Challenges with what type of solder to use that is low temp due to the piece part construction (max 180°C)

## Device Package Construction

- Laminate air cavity
- Metal lid
- Lid is epoxy attached
- Package A has an embedded heat sink

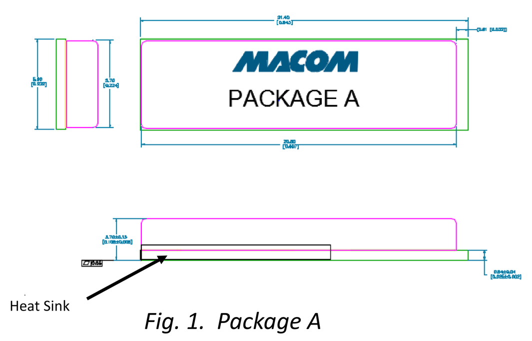




*Fig. 1. Package A*

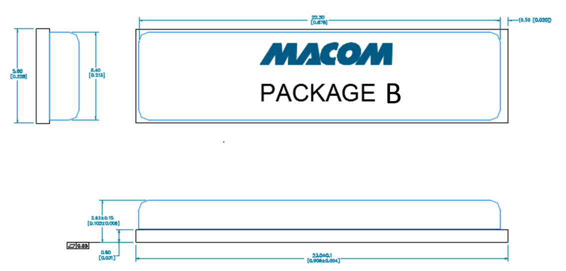




*Fig. 2. Package B*

## Tin Bismuth Solder Properties

- Alloy: Sn42Bi58
- Melt Temp: 138°C
- Low Drop Shock Resistance
- Tends to be brittle
- Tends to expand as it cools which can cause component lifting
- Lower surface tension compared to standard solders which can affect the registration of a device

## Solder Attach Evaluation Board

- .062” THK FR4
- Ground paddle solder mask grid vs no grid
- ENIG plating
- Initial evals used bare boards for the components
- Solder mask grid openings: 28 mil, 50 mil, 60 mil

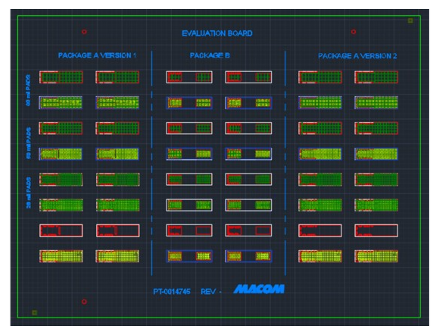


*Fig. 3. Solder Attach Evaluation Board Layout*

## Solder Attach X-ray Results

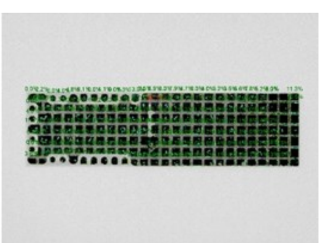


*Fig. 4. Package A X-ray*

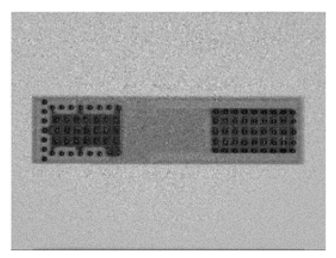
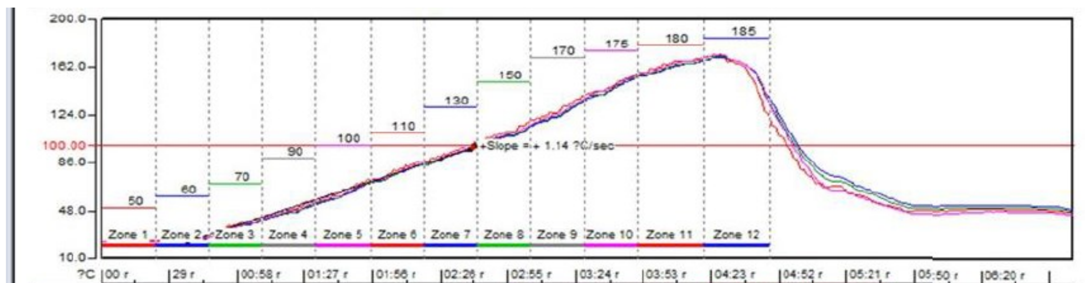


*Fig. 5. Package B X-ray*

## Reflow Profile





| | | Time Between Temperature | Maximum Temperature | Time Above Temperature: Total (+/-) |
|---|---|---|---|---|
| | | 100-140?C | \| | \|138?C |
| | | sec | ?C | sec |
| 1 | TC1 | 49 | 172.4 | 80 |
| 2 | TC2 | 52 | 170.0 | 78 |
| 3 | TC3 | 50 | 170.6 | 79 |
| 4 | TC4 | 49 | 172.0 | 79 |
| | Range | 3 | 2.4 | 2 |
| | Average | 50.0 | 171.25 | 79.0 |
| | Std Deviation | 1.41 | 1.136 | 0.82 |

*Fig. 6 Tin Bismuth Reflow Profile*

## Land Pad Selection

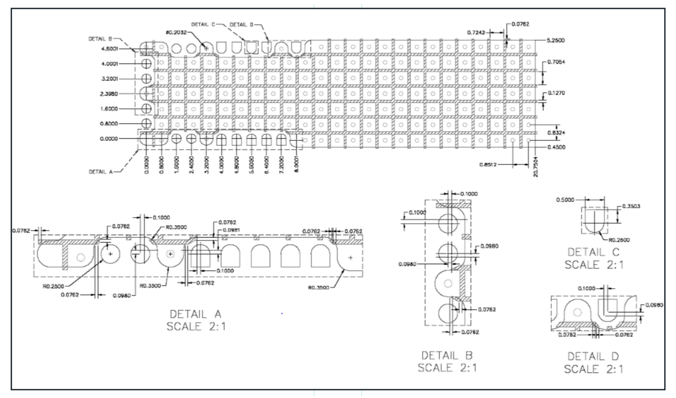


*Fig. 7 Package Device A*

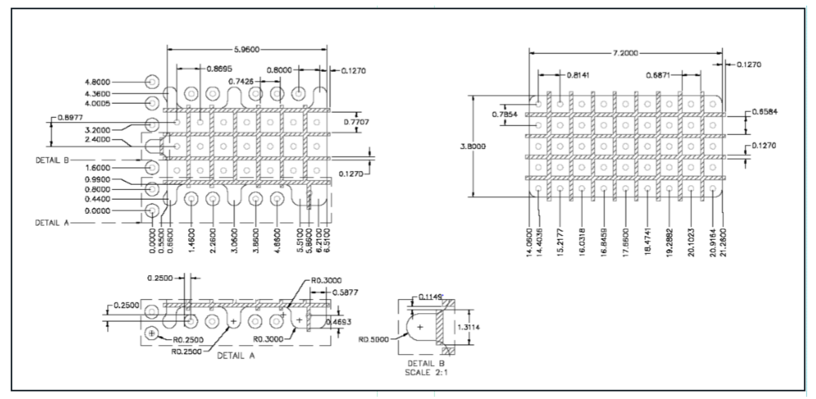


*Fig. 8 Package Device B*

## Shadow Moiré Flatness Measurements Over Temperature (Fully Assembled Devices)

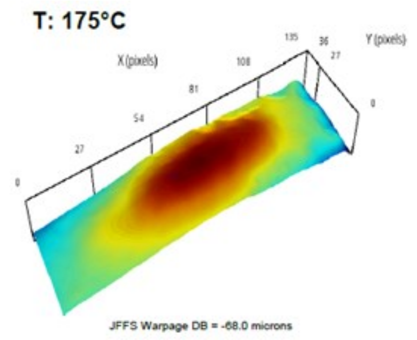




*Fig. 9 Package Device A*

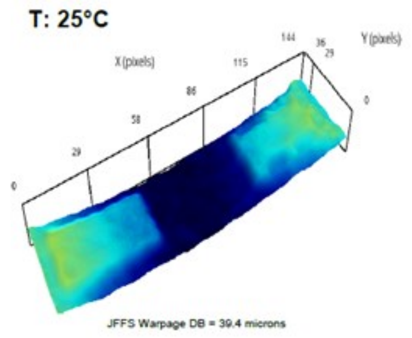
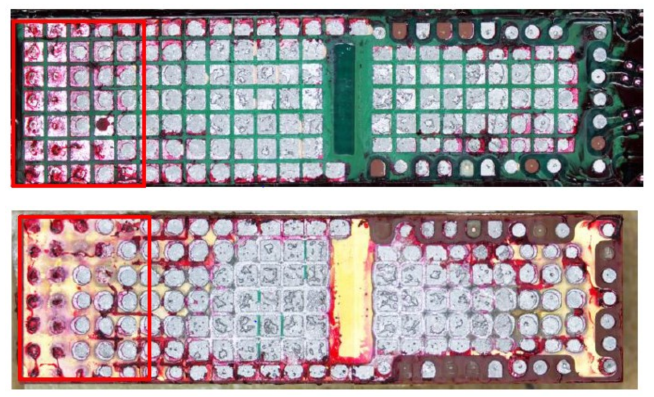




*Fig. 10 Package Device B*

## Dye Penetrant Test Results



Land Pad

Backside of Device

*Fig. 11 Package A Dye and Pry Results*

Land Pad

Backside of Device

*Fig. 12 Package B Dye and Pry Results*

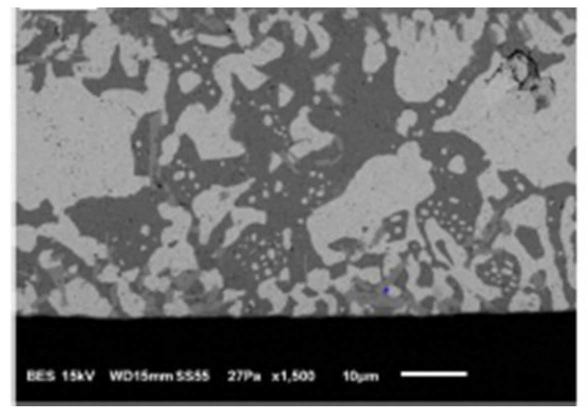
## Qualification Testing

*Table I*

*Qualification Conditions*

| No | Test | Conditions |
|---|---|---|
| | **Mechanical Tests** | |
| 1 | Mechanical Shock 1 (Not Powered) | 500g, 1ms, 5 times per direction, MIL-STD-883K Method 2002.5 Condition A |
| 2 | Vibration (Not Powered) | 20g, 20Hz to 2000Hz to 20Hz, 4min/cy, 4cy/axis, non-powered |
| | **Environmental Tests** | |
| 3 | Thermal Shock | MIL-STD-883, Method 1011.9, Condition A, 0 and 100°C |
| 4 | Temperature Cycling (Not Powered) | MIL-STD-883K Method 1010.9 Condition A (-40°C and 85°C), 100 cycles |
| 5 | Shear Test | TBD |
| | | |
| 6 | Cross Section | Line detail in X-Section sheet |
| 7 | SEM-EDX | Line detail in X-Section sheet |
| 7 | EDX | Point Analysis |

## SEM Image



No concentration of material at the interface locations

*Fig. 13 SEM Image of Solder Joint*

## EDX Analysis

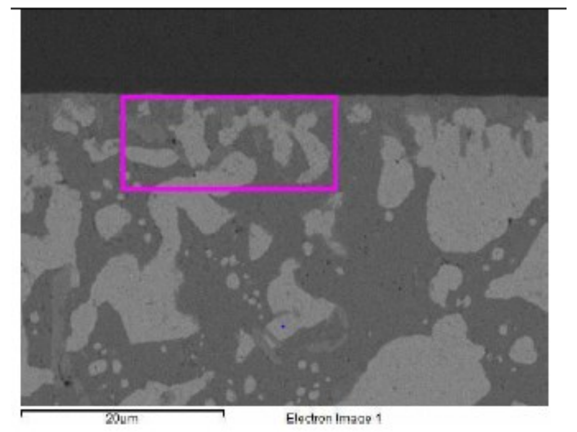


*Fig. 14 SEM Area*

| Element | Weight% | Atomic% |
|---|---|---|
| C | 8.89 | 38.00 |
| O | 7.69 | 24.68 |
| Al | 0.30 | 0.56 |
| Si | 2.20 | 4.02 |
| Ni | 1.09 | 0.95 |
| Cu | 9.46 | 7.64 |
| Sn | 36.47 | 15.78 |
| Au | 1.83 | 0.48 |
| Bi | 32.08 | 7.88 |
| Totals | 100.00 | |

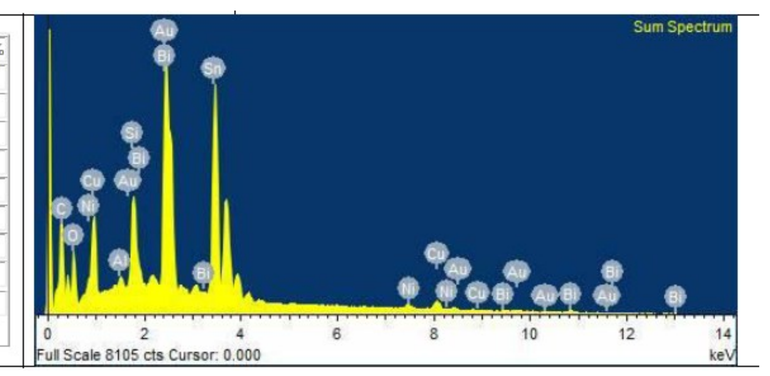
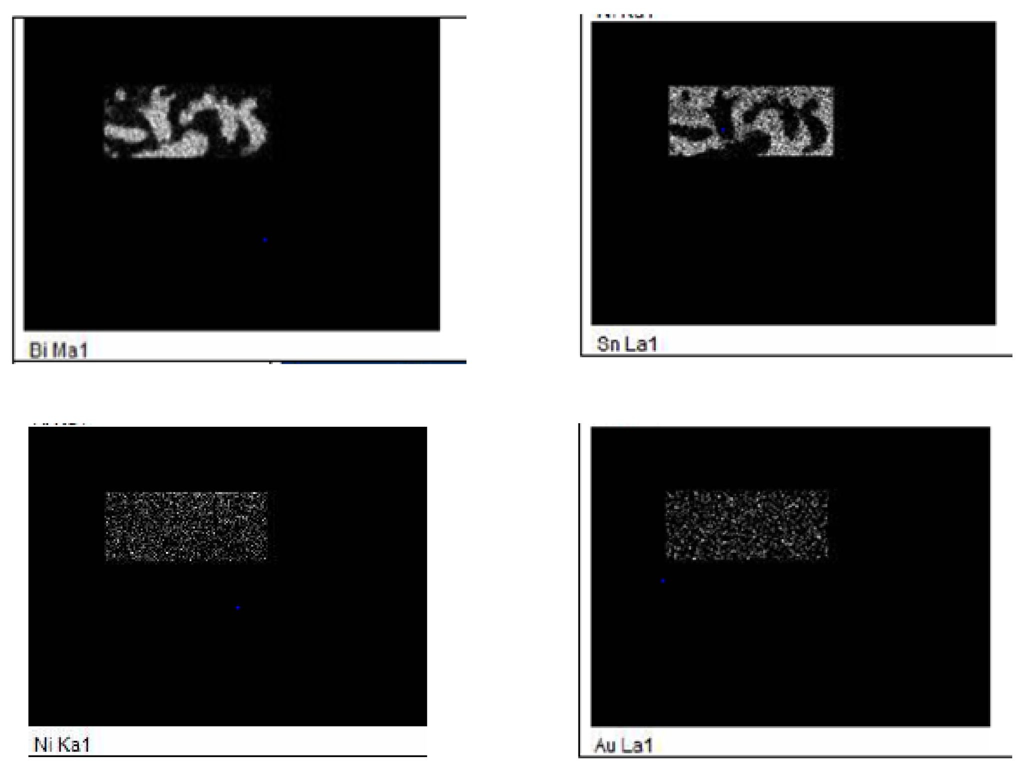




*Fig. 15 EDX Analysis*





Even dispersion of elements throughout the solder joint

*Fig. 16 EDX Plots*

## Conclusion

- Sn42Bi58 solder paste was selected due to the low temp requirements of an internal component
- No Clean Type 3 solder was selected
- Qualification testing showed that the tin bismuth solder attach could hold up to the customer environmental requirements
- A lower temp solder such as tin bismuth might be desirable if CTE issues are a concern and if active components are used in a device