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A Practical Approach for Low-Cost Hermetic Lid Sealing

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Outline

- Motivation
- Material system
- Bench top reflow equipment and lid seal process
- LCC reflow experiment
- Results
- Discussion: comparing reflow platforms
- Conclusions and future work

Motivation

- Surface mount leadless chip carrier (LCC)
- Hermetically sealed by reflow of a lead-free solder pre-form
- Large belt-style reflow furnace
  - Mass production of PCBs with surface mount devices
  - 30 to 45-minute cycle time
  - Peak input temperature above 350ºC
- An enterprise that assembles low-volume, hermetic LCCs desires:
  - Compact equipment
  - Lower acquisition cost
  - Lesser cycle time
  - Lower energy consumption

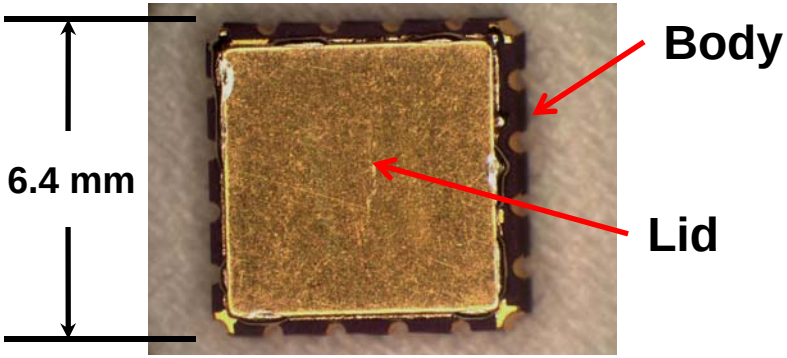


Photo: BTU International Corp.

Can a practical, low-volume lid seal process with measurable attributes be adapted to compact reflow equipment?

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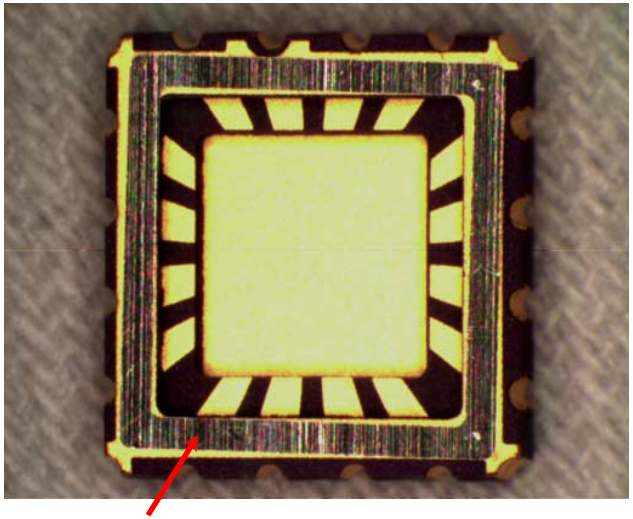
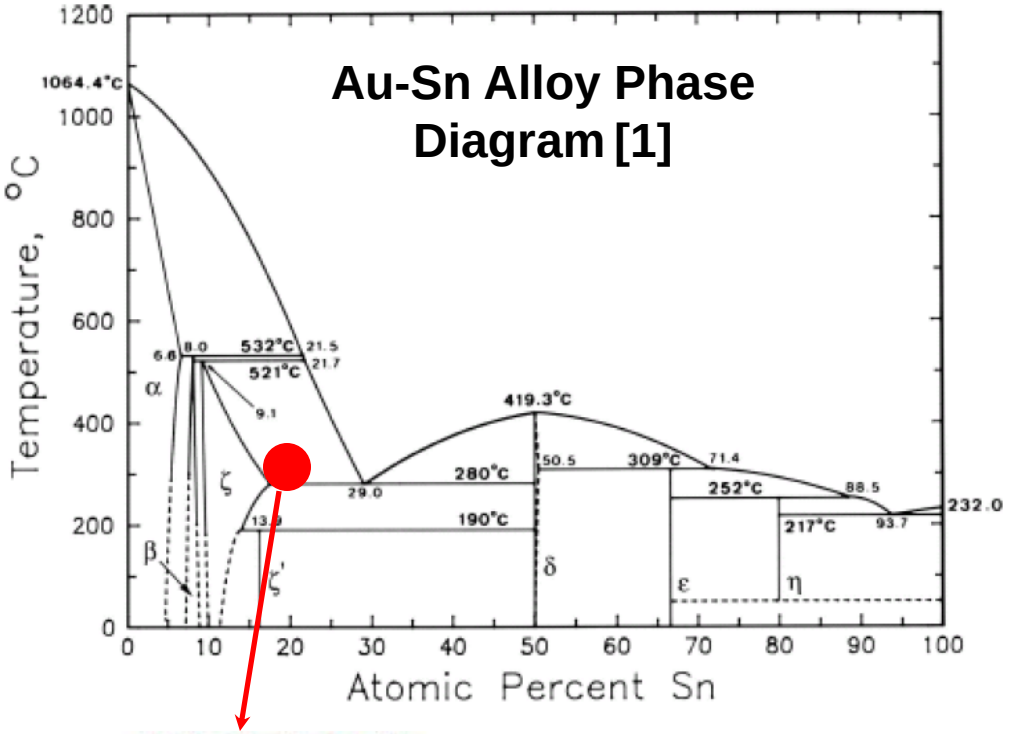
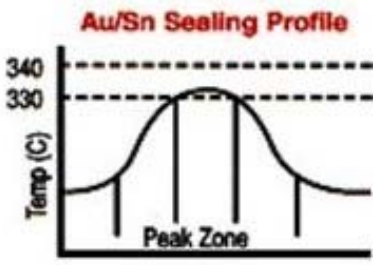
Material System



- 80Au-20Sn solder pre-form tacked to lid
- High-temperature co-fired ceramic (HTCC) body
- Seal ring plated with 60 µin Au on Ni
- Kovar lid with Ni-Au plating





2-5 minutes above 280ºC [2]

References:

[1] ***Processing and Reliability Issues for Eutectic AuSn Solder Joints*** **in Proceedings 41st International Symposium on Microelectronics (IMAPS 2008), pp. 909-916.**

[2] **Materion Corp. (www.materion.com).**

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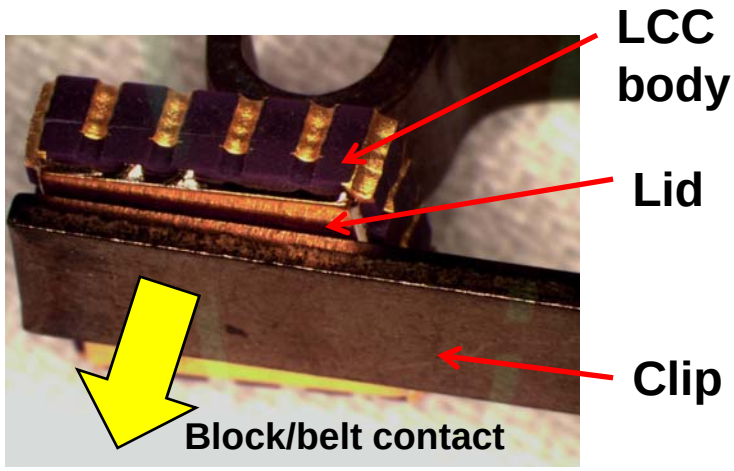
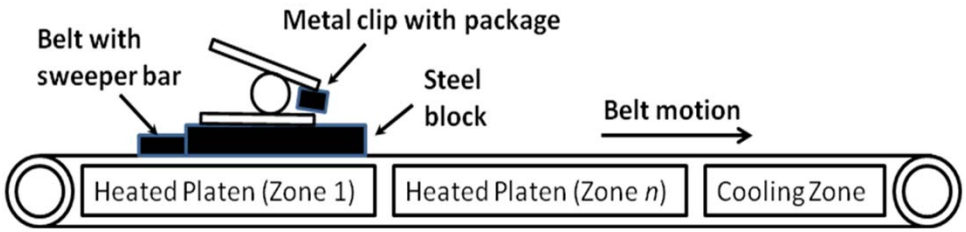
Bench Top Reflow Equipment and Lid Seal Process

- Compact dual-mode conduction/convection reflow furnace:
  - 1.2-meter long conveyor
  - Four programmable conduction heating zones
  - Four programmable convection heating zones overhead
  - Cooling stages follow conduction/convection zones.
  - Convection zones flow heated N_2 at 40 sccf/h.
  - Variable gap between opposing zones
- Traditionally for for ball attach and surface mount operations.
- Multiple LCCs oriented horizontally and arranged in parallel on metal block.
- Metal clips hold an Au-plated A42 lid with solder pre-form against package frame.
- Configured with lid facing downward for greater conduction to pre-form.





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LCC Reflow Experiment

- **Desired profile: greater than 280ºC for five minutes max., peak temperature 320ºC.**
- **Seven process trials (three parallel LCC samples per trial)**
- **Compiled a temperature history for each run.**
- **Sealed packages underwent visual and x-ray inspection of the seal area**
- **Fine and gross leak tests per MIL-STD-883G, Method 1014.2**

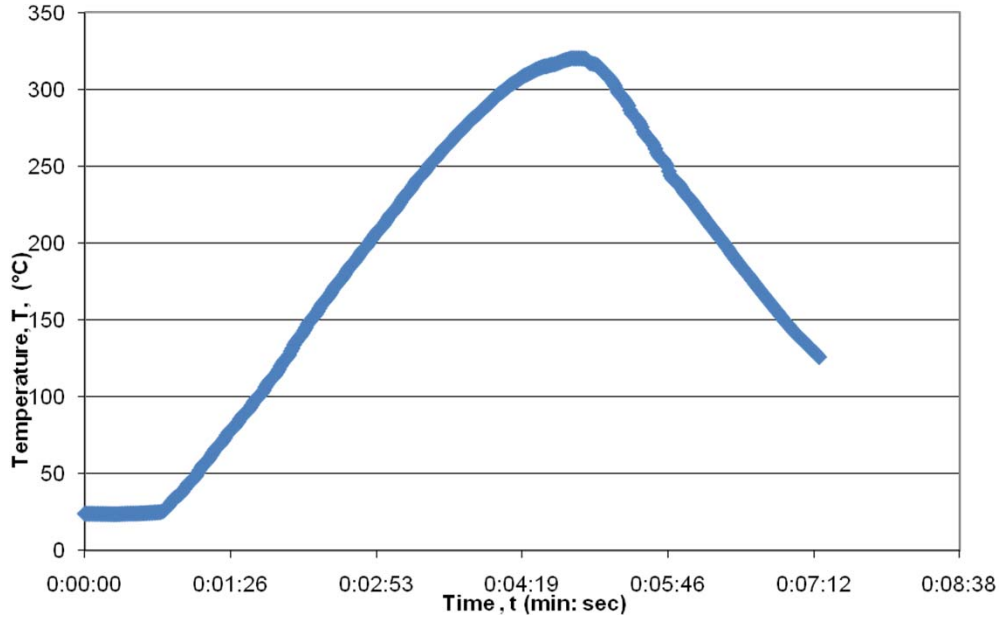
Trial	Conduction Zone Temps (ºC)	Convection Zone Temps (ºC)	Conveyor Velocity (mm/s)
1	200-280-375-375	175-245-320-332	2.96
2	200-280-375-375	175-245-320-332	2.54
3	200-280-360-360	175-245-320-332	2.54
4	200-280-350-350	175-245-320-332	2.54
5	200-280-340-340	175-245-300-315	2.12
6	200-280-340-340	175-245-300-315	2.54
7	200-280-340-340	200-230-340-340	2.12

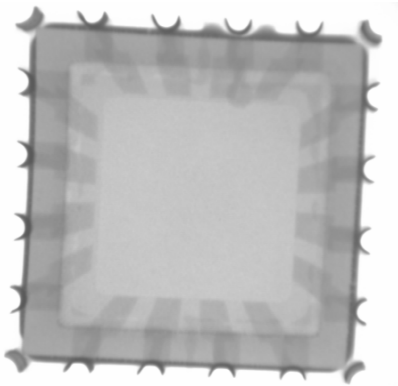
Trials were run with the compact furnace to identify the reflow recipe that yields the prescribed peak temperature profile, a structurally-sound hermetic lid seal, and the lowest cycle time.

Results

- **84% reduction in cycle time**
- **Peak temperature: 320ºC.**
- **Void-free fillet**
- **Greatest leak rate observed was 1.3 x 10^{-9} atm-cm^3/s.**
- **Standard: 9 x 10^{-8} atm-cm^3/s after 60 seconds.**

Trial	Cycle Time (min: sec)	Peak Temp at LCC Lid (ºC)
1	6:08	298
2	6:53	335
3	6:59	325
4	**7:15**	**320**
5	8:39	320
6	6:59	315
7	8:45	330





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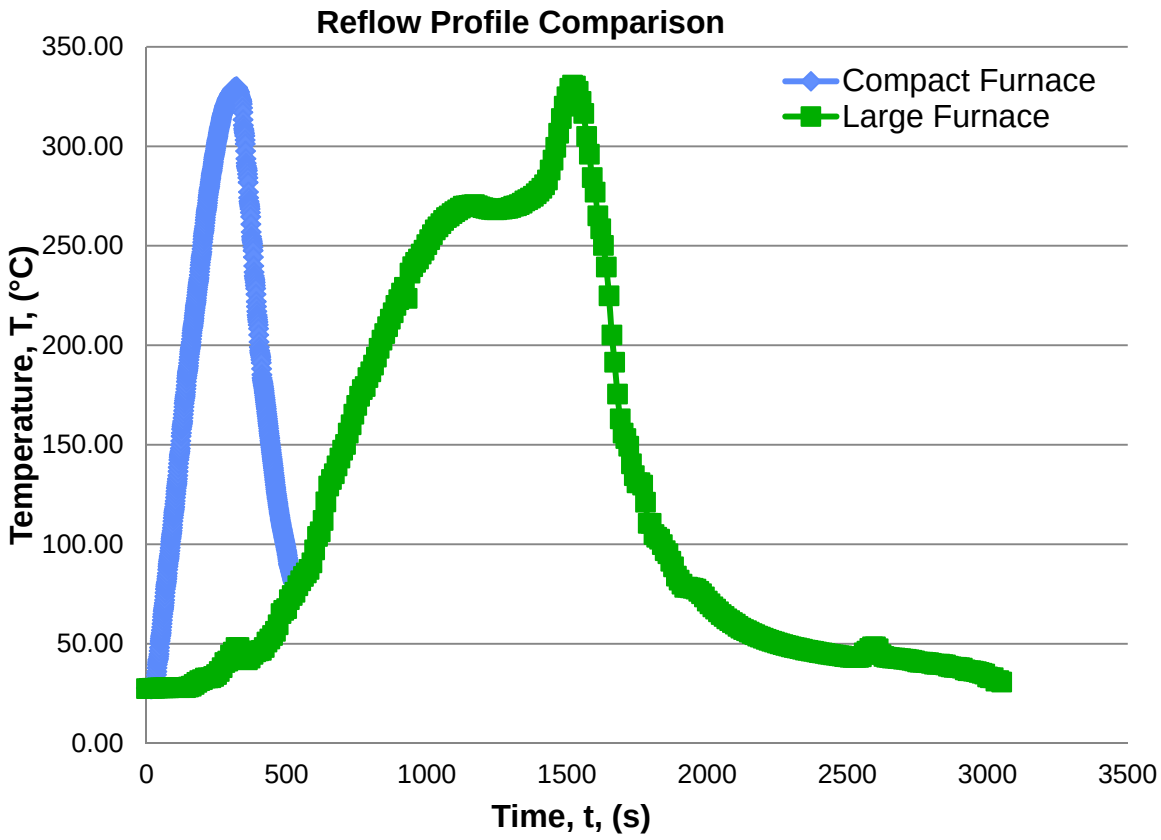
Comparing Reflow Platforms

- **Large belt-style reflow furnace:**
  - **High throughput**
  - **Stable, repeatable**
- **Compact bench top system:**
  - **Lesser cycle time, greater productivity, lower labor cost**
  - **Lower capital investment (approximately $25k US)**
  - **Lower peak input temperatures**
  - **More zones, higher rate of heat transfer**



Trade throughput for lesser cycle time.

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Conclusions and Future Work

- **Hermetic lid sealing in this example is possible with the compact, dual-mode conduction/convection reflow furnace in a fraction of the cycle time relative to the larger apparatus.**
- **Actual peak temperature closer to control input**
- **Future work:**
  - **Impact of peak reflow temperature on device functionality, e.g. GaAs thermally-activated "sinking gates"[1]**
  - **Measure true temperature at the lid seal.**
  - **Investigate repeatability.**
  - **Measure energy consumption.**

Reference:
[1]Canali, C., et al., "Gate metallization "Sinking" into the active channel in Ti/W/Au metallized power MESFET's," Electron Device Letters, 7 (3), 1986, pp. 185-187.