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Pittsburgh, PA., 15208, USA
+1 (412) 409 - 9019 • partner@arieca.com

TIM - ALT Series
High Reliability TIM
Preliminary Reliability Study

Overview:

Arieca's has partnered with Enerdyne Solutions (https://www.enerdynesolutions.com/) and NanoTest (https://nanotest.eu/) to evaluate the thermal performance and reliability of the ALT series of Liquid Metal Encapsulated Elastomer (LMEE). ALT is a Thermal Interface Material (TIM) specifically designed to combine the thermal benefits of liquid metal with the manufacturing ease of polymer and Gel TIM (PTIM). The ALT family can establish a low thermal resistance connection between an integrated circuit die and package lid or integrated heatsink without the need of sophisticated manufacturing processes required to contain liquid metal migration.

The scope of the evaluations is limited to the availability of commercially available TTV (Thermal Test Vehicles). This has limited thermal characterization to a 10mm x 10mm TTV, and reliability to a 11mm x 13mm PGA (Pin Grid Array) package. Arieca has performed more extensive evaluations with larger, BGA die. However, these results were obtained with proprietary designs, and the owners of those designs do not allow publication of performance results

Thermal Performance:

The benefits of LMEE technology are best demonstrated when the emulsion is compressed into a thin bond line. This maximizes the connection of liquid metal particles so that thermal conductivity is maximized. Such a situation is similar to the application of a TIM in a semiconductor package.

The first level of thermal characterization is performed on a D5470 compliant test setup based on the NanoTest TIMA system. As shown in Figure 1, the TIMA uses a silicon-based TTV that uses 5 Tantalum-based resistors biased with a precision current as temperature sensors. This TTV is brought into contact with a nickel-platted copper lid. The advantage of the TIMA setup is that is allows the bondline thickness (BLT) to be a variable.

Figure 2 shows how thermal resistance varies with BLT. At BLT < 35µm, the thermal resistance can be seen to converge to ~ 6-7 C*mm^2/W.

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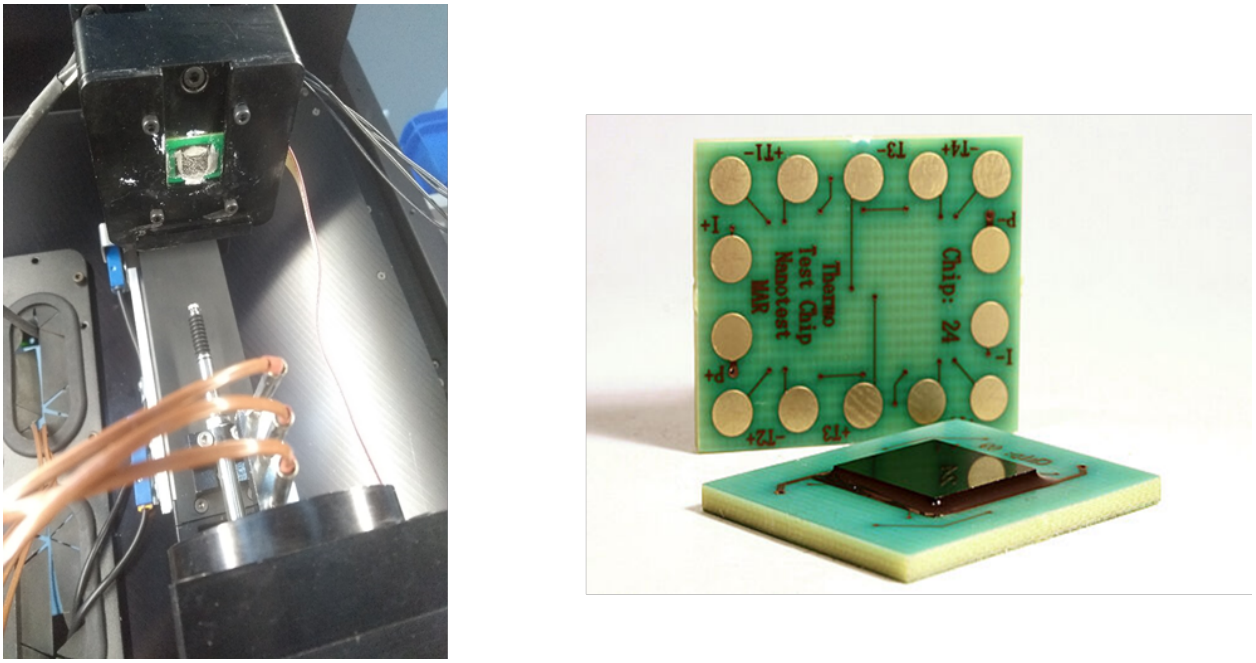

Figure 1: TIMA Test Set-up

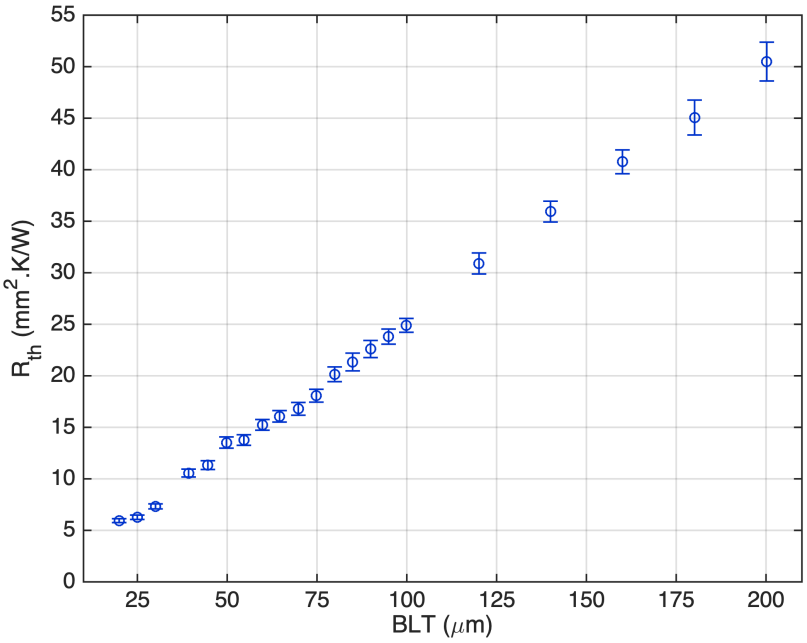

Figure 2: Thermal Resistance as a Function of BLT

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Reliability:

A key application concern is the reliability of TIM performance at low BLT. To demonstrate the robust reliability of ALT, Enerdyne Solutions performed a suite of reliability tests on the material in a 11mm x 13mm PGA package.

The application of the ALT on the silicon surface is shown below for an application pressure of 10psi.

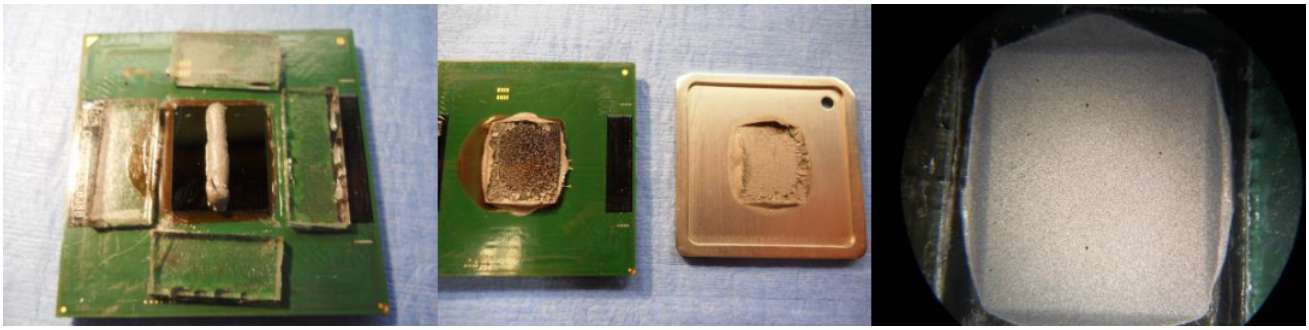

Figure 3: Deposition, and post-test de-lid, and microscope of die coverage for reliability package

T0 Thermal Performance

The initial, or T0 thermal performance for this TIM was characterized on the TTV shown above. The profile of the TTV and the resulting thermal performance are shown below.

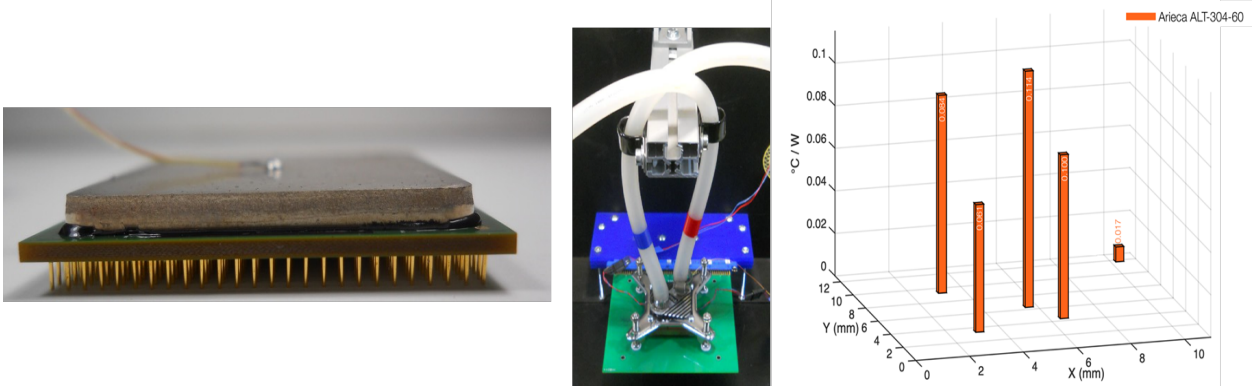

Figure 4 : Thermal Test Vehicle and Time Zero (T_0) Measured Results.

The thermal performance of the TTV shows an in-package thermal resistance of 6.8 C*mm^2/W, which agrees well with TIMA TTV test results.
This performance level is then used as a baseline for the reliability tests.

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High Temperature Bake – 125°C

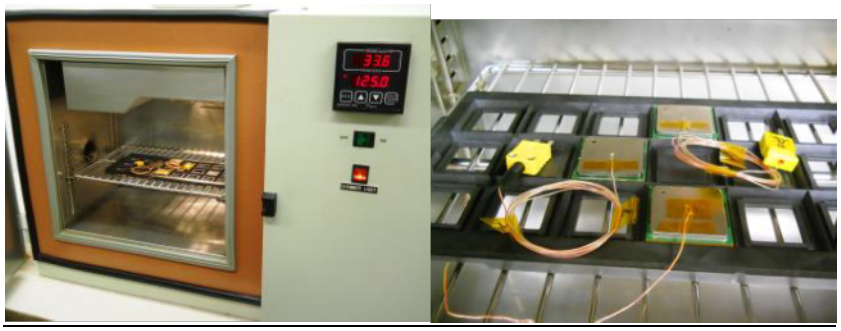

Figure 5: Thermal Bake (125C) Set-up

Baseline (100%) = 6.8 mm^2°C/W

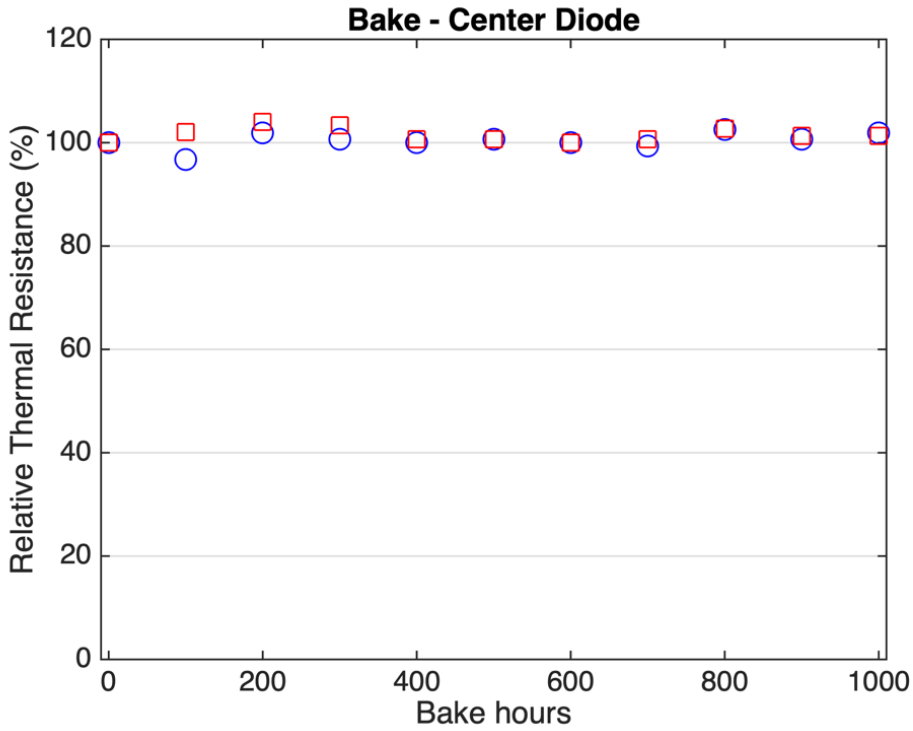

Figure 6: High Temperature Bake Performance over Time (measured every 100 hours)

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Highly Accelerated Stress Test (HAST) – 85C/85% RH

Figure 7: HAST Test Set-up

Baseline (100%) = 6.8 mm^2*K/W

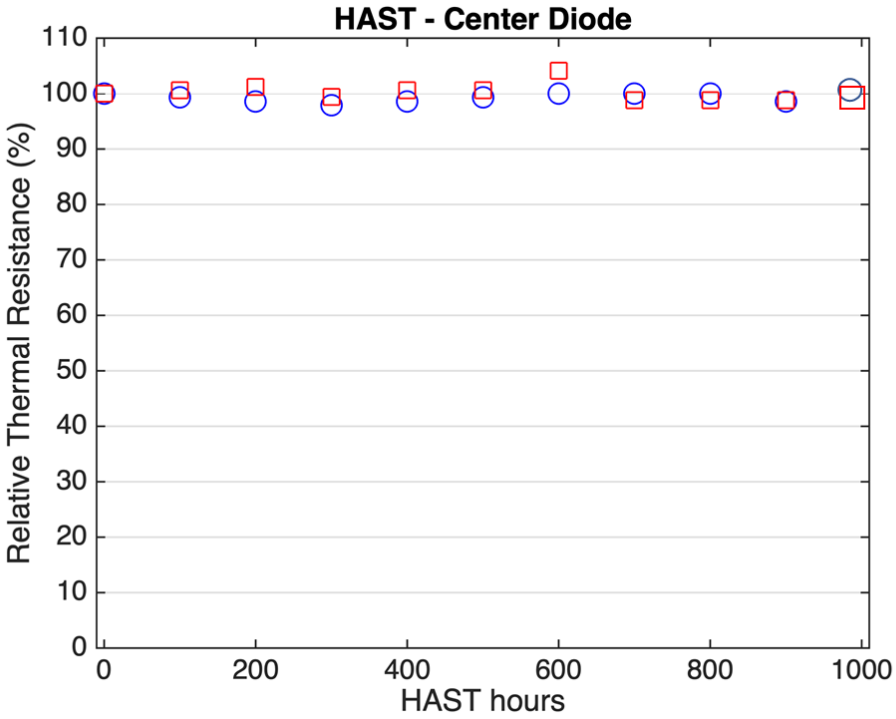

Figure 8 HAST Performance over Time (Measured every 100 hours)

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Thermal Cycling (-55C ⇔ 125C)

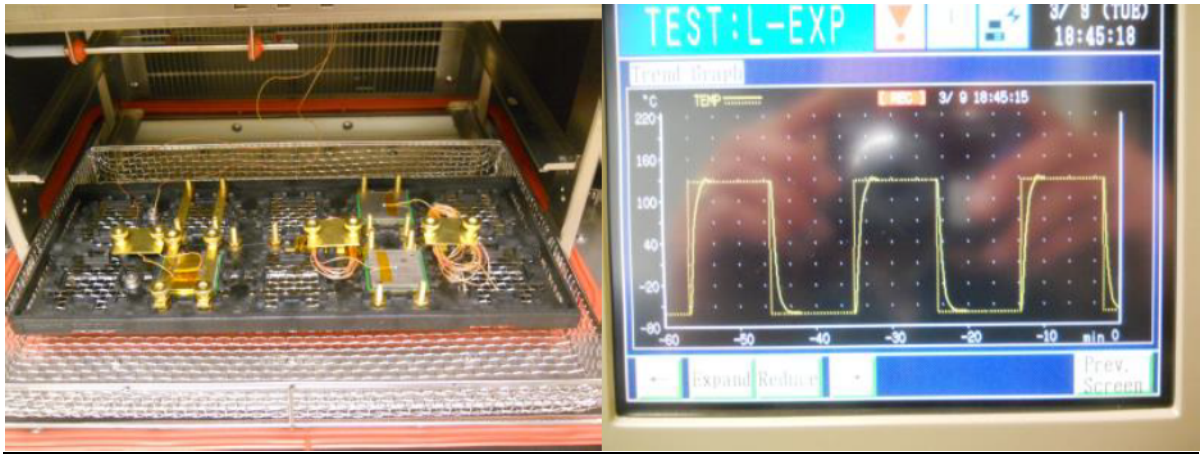

Figure 9: Thermal Shock Test Vehicle and Temperature Profile of 22minute Cycle

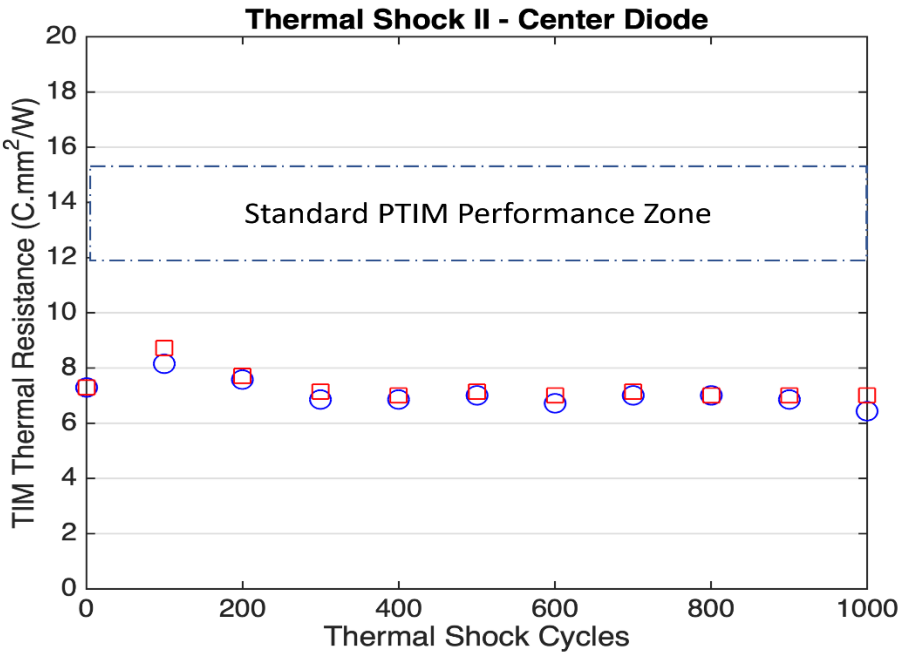

Figure 10: Temperature Cycling Performance (Measured every 100 cycles)

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MSL3:

We subject a fully packaged thermal test vehicle (comprised of AT TIMbber TIM1) to environmental conditions per JEDEC STD 22-A113D, an industry standard preconditioning flow, and exposed the devices to 5 cycles of the solder reflow temperature profile.

Preconditioning:

Preconditioning Flow		
Process	**Conditions**	**Equipment**
Bake	125°C, 24hrs; temp/humidity within 30min.	Tenney Jr.
Temp/humidity	60°C/60%RH, 40hrs; reflow within 2hrs	Tenney BTRC
Reflow	245°C peak, ~80sec above liquidus (217°C), 5X reflow cycles, 5min. cool down between reflows	Vitronics Soltec 8-zone convection

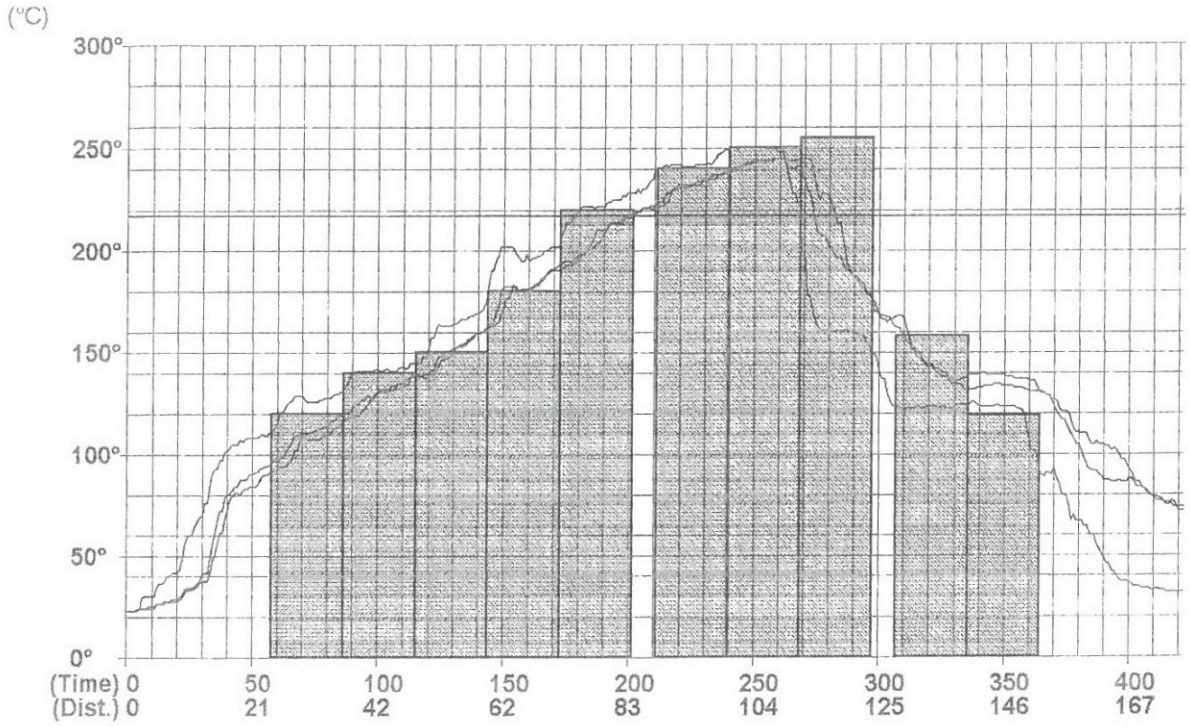

Figure 11: Solder Reflow Temperature Profile

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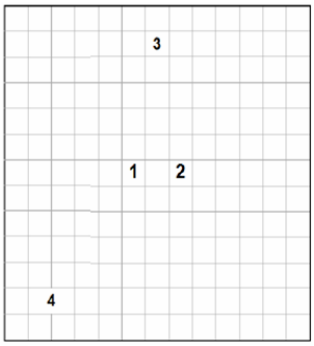
Results:

Preconditioning Θjc Results		
Channel #	**TimeØ**	**Post-Precon**
1	0.096	0.087
2	0.093	0.084
3	0.069	0.060
4	0.047	0.038
5	N/A	N/A
Ave. Θjc	**0.076**	**0.067**



TTV Channel Map

Conclusion:

Arieca has performed a preliminary in-situ evaluation of ALT's thermal and reliability characteristics. Though limited to commercially available TTV, the evaluation demonstrates that ALT offers improved thermal resistance compared to alternative PTIMs, and is able to maintain this performance after environmental stress.

Further evaluation needs to be performed on customer specific TTV, but these preliminary results demonstrate that TIMbber has the capability of being a viable TIM alternative.