THERMFLOWÔ T766

Reliability Test Report

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SUMMARY OF PHYSICAL PROPERTIES

Property	T766	Test Method
Carrier	metal foil	
Color (phase change material / foil)	light gray / silver	Visual
Phase Change Material Thickness, in (mm)	0.0025 (0.064)	ASTM D374
Metal Foil Carrier Thickness, in (mm)	0.0010 (0.025)	ASTM D374
Total Thickness, in (mm)	0.0035 (0.089)	ASTM D374
Tested at 50psi, 70ºC		
Thermal Impedance, °C-in²/W	0.04	ASTM D5470
Phase Change Temperature Range, °C	51-58	ASTM D3418

Summary: Random production samples of Thermflow™ T766 thermal interface pads were subjected to various environmental conditions and tested for thermal performance. No degradation in thermal performance was found under any test condition. No evidence of delamination or drying of the joint was seen in any case.

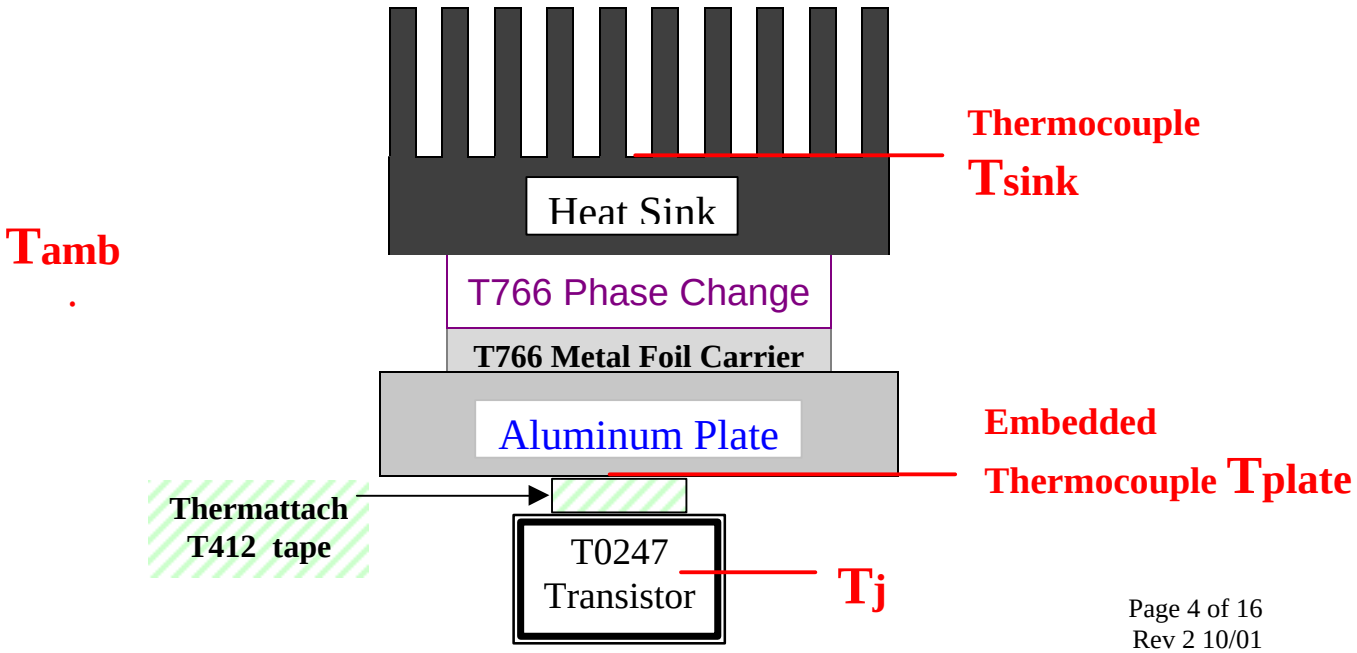
These tests include visual inspection and thermal resistance across the interface ($\theta_{plate\text{-}sink}$ and $\Delta T_{plate\text{-}sink}$)

Equipment:

1. AnalysisTech Phase VI Thermal Analyzer (ATA). The ATA was used to measure $\theta_{plate\text{-}sink}$ (the difference between $\theta_{junction\text{-}sink}$ and $\theta_{junction\text{-}plate}$) before and after conditioning as well as to measure the actual temperatures of the plate and sink.
2. Analysis Tech Wind Tunnel. The wind tunnel was used to provide constant airflow around the fixture assembly during testing.
3. Heat Source. A GE 9915 MKJW 16010A TO247 transistor was used as the heat source.
4. Heat Sink. Pin Fin heat sinks, 1.75 x 1.75 x 0.6 inch, attached with four-prong clips. (Newark Electronics, Type 669052AB)
5. Thermflow T766. Random samples of 1.00 x 1.00 inch cut parts of T766 were taken from inventory.

Procedure:

A) Fixture assembly: A T766 pad was applied to an "as received" heat sink by removing the T766 pad from the blue liner and applying the pad, phase change side to the heat sink, at room temperature with finger pressure. The heat sink was then clipped to a 6061 T6, 1.8 x 1.8 x 0.8 inch, aluminum plate. A type T thermocouple was installed in a groove in the opposite side of the aluminum plates and the heat source transistor was attached to the center of this face of the aluminum plate with Thermattach T412 tape such that the thermocouple was located under the center of the transistor. A second type T thermocouple was attached to the center of the heat sink with Thermattach T412 tape. Each test fixture was numbered.



B) Thermal Testing: The test fixture was connected to the ATA and powered to 19 watts. The air speed in the wind tunnel was set to 500 linear feet per minute. Temperatures of the junction (T_j), the aluminum plate (T_{plate}), the heat sink (T_{sink}), and the ambient (T_{amb}) were recorded at equilibrium. The heat generated during the test was used to complete the formation of the thermal joint between the aluminum plate and the heat sink. The fixture was cooled, the thermocouples removed, and the fixture was subjected to the appropriate environmental stress. After stress conditioning, the test fixture was visually inspected and retested for thermal performance.

C) Visual: Each test fixture was inspected for joint separation, for material loss, and for any sign of joint deterioration. After final data collection, the heat sink-plate assemblies were separated and the interface further visually examined.

Exposure Methods

(1.0) Control Study of performance after 1000 hours storage at room temperature environment (25°C).

(1.1) Heat Aging exposure of 1,000 hours at 125°C (250°F).

Apparatus: A forced convection Blue M oven was set at 125°C. Temperature uniformity was +/- 5°C within oven.

Procedure: Fixtures were placed in a forced convection hot air oven maintained at 125 C +/- 5°C for 1000 hours. Fixtures were then removed from oven and allowed to cool to room temperature (acclimate) for two hours minimum before evaluation.

(1.2) Temperature cycling of 1,000 cycles from 25°C to 125°C. A cycle consists of a 20 minute dwell at 25°C, heating to 125°C at 10°C/minute, a 20 minute dwell at 125°C and cooling to 25°C temperature at 10°C/minute.

Apparatus: Tenney environmental chamber Model 942 set to cycle from 25°C to 125°C. Temperature uniformity was ± 2°C of set point.

Procedure: Fixtures were placed in Tenney environmental chamber for a period of 1000 cycles. Fixtures were then removed from environmental chamber and allowed to acclimate to room temperature for two hours minimum before testing.

(1.3) Thermal shock exposure of 15 cycles from –50°C to 100°C.

Apparatus: Low temperature bath: The low temperature bath consisted of a one gallon capacity insulated glass container. Excess dry ice was added to 0.75 gallon of n-propanol to cool bath to -50°C +0/-5°C. Temperature was measured with a Type K thermocouple located approximately one inch below the liquid surface. The bath was stirred before a temperature measurement was taken. Temperature was consistently maintained by the addition of dry ice.
High temperature bath: The high temperature bath consisted of a one gallon capacity Pyrex beaker filled with water. The temperature was measured with a type K thermocouple located

approximately one inch below the liquid surface. Filled beaker was placed on electrical hot plate and maintained at a constant boil. Temperature was measured at 100°C (+0/-2°C).

Procedure: A cycle consists of placing a specimen into a 100°C boiling water bath for 5 minutes and after removal, rapidly plunging specimen into the low temperature bath of dry ice/isopropanol for 5 minutes. The specimen was then removed from the cold bath, and the next cycle started immediately.

Sample fixtures: Sample specimens were placed in a solvent resistant plastic bag, the excess air removed from the bag, and the bag hermetically sealed to ensure exposure of samples to only temperature extremes and not liquid medium.

(1.4) High temperature/Humidity Resistance 1000 hours, 85° C 85% RH.

Apparatus: A Tenney Versa Tenn II humidity cabinet chamber maintained at 85°C (+/-2°C) at a relative humidity of 85% (+/- 5%)

Procedure: Fixtures were placed in a chamber and fully exposed with no attempt made to protect metal surfaces. After constant exposure for 1000 hours samples were removed and allowed to acclimate to room temperature for two hours minimum before testing.

Room Temperature Storage, Method 1.0

Results

Visual: There was no evidence of delamination or drying of the joint. The interface material did not exhibit any apparent changes after exposure to this environmental test condition. The metal foil appeared unchanged as well.

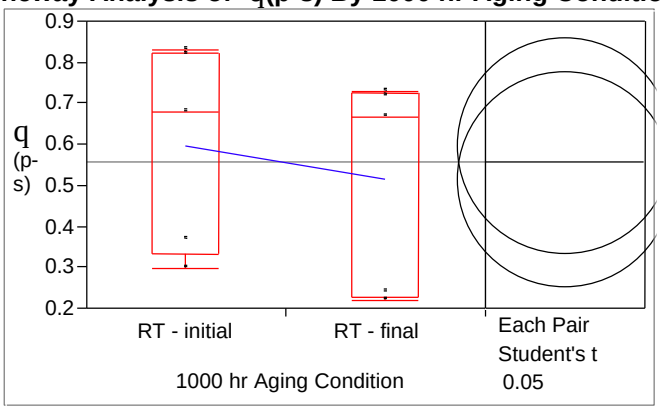
Thermal Performance: The before and after conditioning thermal resistances are given in Table 1. This data shows that there is a slight decrease in the $\Delta T_{plate\text{-}sink}$ after 1000 hours storage at ambient conditions. This change in $\Delta T_{plate\text{-}sink}$ is consistent with a gradual cold flow of the material at room temperature resulting in decreased bond line thickness. This thermal performance change is not statistically significant.

Raw Data

Table 1. Thermal Performance. Control samples in accordance with Method 1.0

Test Fixture #	**Before Exposure**			**After Exposure**		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W
76	75.4	15.8	0.83	78.6	8.1	0.73
77	72.5	7.0	0.37	71.6	8.4	0.22
78	77.3	12.9	0.68	79.4	8.7	0.67
79	71.2	5.7	0.30	73.8	5.5	0.24
80	77.0	15.6	0.82	81.2	5.3	0.72
Average	74.7	**11.4**	0.60	76.9	**9.1**	0.52

Oneway Analysis of q(p-s) By 1000 hr Aging Condition



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
RT - initial	0.3	0.3	0.335	0.68	0.825	0.83	0.83
RT - final	0.22	0.22	0.23	0.67	0.725	0.73	0.73

Means Comparisons

Dif=Mean[i]-Mean[j]	RT - initial	RT - final
RT - initial	0.000000	0.084000
RT - final	-0.084	0.000000

Alpha=0.05

Comparisons for each pair using Student's t
t=2.30600

Abs(Dif)-LSD	RT - initial	RT - final
RT - initial	-0.3738	-0.2898
RT - final	-0.2898	-0.3738

Positive values show pairs of means that are significantly different.

Heat Aging @ 125°C, 1000 hours, Method 1.1

Results

Visual: There was no evidence of delamination or drying of the joint. The interface material turned a yellow-brown color after exposure to this environmental test condition. The metal foil did not exhibit any apparent changes.

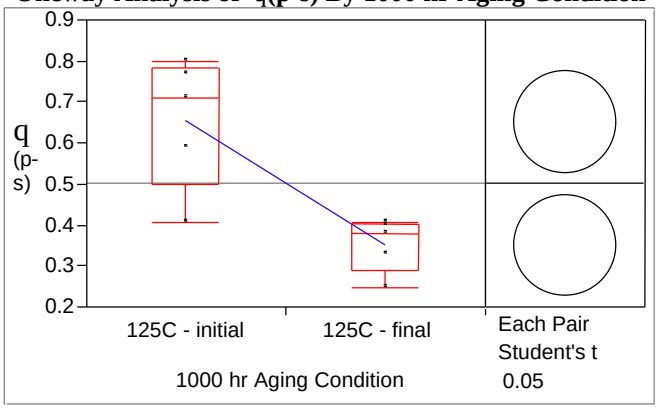
Thermal Performance: The before and after conditioning thermal resistances are given in Table 2. This data shows that there is a significant decrease in the $\Delta T_{plate\text{-}sink}$ after 1000 hours storage at 125°C. This change in $\Delta T_{plate\text{-}sink}$ is consistent with the flow of the material during conditioning resulting in decreased bond line thickness.

Raw Data

Table 2. Thermal Performance. Samples in accordance with Method 1.1

Test Fixture #	**Before Exposure**			**After Exposure**		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W
96	86.6	14.6	0.77	73.5	7.2	0.38
97	87.6	15.2	0.80	71.1	4.8	0.25
98	86.4	13.5	0.71	77.3	7.6	0.40
99	74.3	7.8	0.41	73.3	6.3	0.33
100	82.3	11.2	0.59	76.3	7.8	0.41
Average	83.4	**12.5**	0.66	74.3	**6.7**	0.35

Oneway Analysis of q(p-s) By 1000 hr Aging Condition



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
125C - initial	0.41	0.41	0.5	0.71	0.785	0.8	0.8
125C - final	0.25	0.25	0.29	0.38	0.405	0.41	0.41

Means Comparisons

Dif=Mean[i]-Mean[j]	125C - initial	125C - final
125C - initial	0.000000	0.302000
125C - final	-0.302	0.000000

Alpha=0.05

Comparisons for each pair using Student's t
t=2.30600

Abs(Dif)-LSD	125C - initial	125C - final
125C - initial	-0.17776	0.124243
125C - final	0.124243	-0.17776

Positive values show pairs of means that are significantly different.

Temperature Cycling from 25°C to 125°C, 1000 cycles, Method 1.2

Results

Visual: There was no evidence of delamination or drying of the joint. The interface material did not exhibit any visual changes after exposure to this environmental test condition. The metal foil appeared to have a slight bronze color towards the edges of the pad on the aluminum plate side consistent with slight oxidation of the metal alloy.

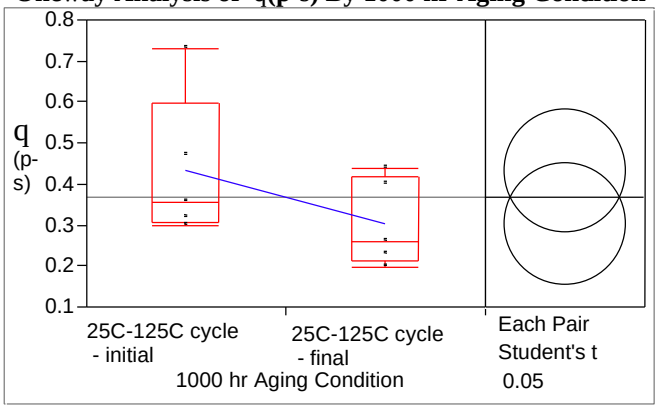
Thermal Performance: The before and after conditioning thermal resistances are given in Table 3. This data shows that there is a slight decrease in the $\Delta T_{plate\text{-}sink}$ after 1000 cycles from 25°C to 125°C. This change in $\Delta T_{plate\text{-}sink}$ is consistent with the flow of the material during conditioning resulting in decreased bond line thickness. This thermal performance change is not statistically significant.

Raw Data

Table 3. Thermal Performance. Samples in accordance with Method 1.2

Test Fixture #	**Before Exposure**			**After Exposure**		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W
81	69.8	8.9	0.47	72.9	4.4	0.23
82	73.4	6.8	0.36	75.1	4.9	0.26
83	75.7	13.9	0.73	75.1	7.6	0.40
84	71.4	6.1	0.32	73.7	3.8	0.20
85	68.7	5.7	0.30	76.6	8.4	0.44
Average	71.8	**8.3**	0.44	74.7	**5.8**	0.31

Oneway Analysis of q(p-s) By 1000 hr Aging Condition



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
25C-125C cycle - initial	0.3	0.3	0.31	0.36	0.6	0.73	0.73
25C-125C cycle - final	0.2	0.2	0.215	0.26	0.42	0.44	0.44

Means Comparisons

Dif=Mean[i]-Mean[j]	25C-125C cycle - initial	25C-125C cycle - final
25C-125C cycle - initial	0.000000	0.130000
25C-125C cycle - final	-0.13	0.000000

Alpha=0.05

Comparisons for each pair using Student's t
t=2.30600

Abs(Dif)-LSD	25C-125C cycle - initial	25C-125C cycle - final
25C-125C cycle - initial	-0.21338	-0.08338
25C-125C cycle - final	-0.08338	-0.21338

Positive values show pairs of means that are significantly different.

Temperature Shock from -50°C to 100°C, 15 cycles, Method 1.3

Results

Visual: There was no evidence of delamination or drying of the joint. The interface material did not exhibit any apparent changes after exposure to this environmental test condition. The metal foil remained unchanged as well.

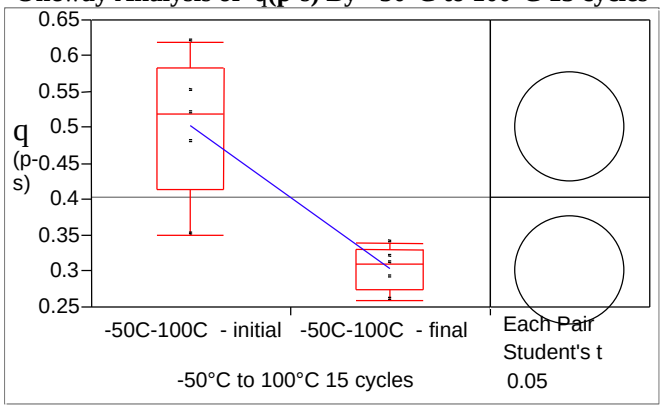
Thermal Performance: The before and after conditioning thermal resistances are given in Table 4. This data shows that there is a significant decrease in the $\Delta T_{plate\text{-}sink}$ after 15 thermal shock cycles from -50°C to 100°C. This change in $\Delta T_{plate\text{-}sink}$ is consistent with the flow of the material during conditioning resulting in decreased bond line thickness.

Raw Data

Table 4. Thermal Performance. Samples in accordance with Method 1.3

Test Fixture #	**Before Exposure**			**After Exposure**		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θp-s, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θp-s, °C/W
91	73.7	6.7	0.35	70.7	5.9	0.31
92	74.5	10.5	0.55	62.7	5.5	0.29
93	77.3	9.9	0.52	74.1	6.1	0.32
94	76.4	9.1	0.48	69.7	4.9	0.26
95	79.2	11.8	0.62	70.7	6.5	0.34
Average	76.2	**9.6**	0.50	69.6	**5.8**	0.30

Oneway Analysis of q(p-s) By -50°C to 100°C 15 cycles



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
-50C-100C - initial	0.35	0.35	0.415	0.52	0.585	0.62	0.62
-50C-100C - final	0.26	0.26	0.275	0.31	0.33	0.34	0.34

Means Comparisons

Dif=Mean[i]-Mean[j]	-50C-100C - initial	-50C-100C - final
-50C-100C - initial	0.000000	0.200000
-50C-100C - final	-0.2	0.000000

Alpha=0.05

Comparisons for each pair using Student's t
t=2.30600

Abs(Dif)-LSD	-50C-100C - initial	-50C-100C - final
-50C-100C - initial	-0.10796	0.092036
-50C-100C - final	0.092036	-0.10796

Positive values show pairs of means that are significantly different.

High Humidity Aging @ 85°C / 85% RH, 1000 hours, Method 1.4

Results

Visual: There was no evidence of delamination or drying of the joint. The exposed interface material did not exhibit any apparent changes after exposure to this environmental test condition. The metal foil turned a slightly yellow-gold color apparently due to oxidation from the moisture.

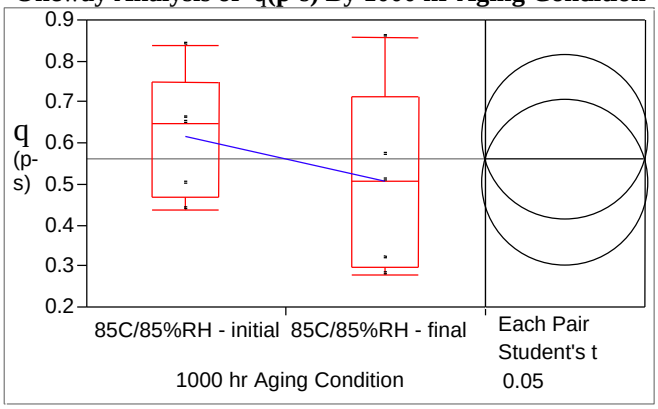
Thermal Performance: The before and after conditioning thermal resistances are given in Table 5. This data shows that there is a slight decrease in the $\Delta T_{plate\text{-}sink}$ after 100 hours storage at 85°C and 85% RH. This change in $\Delta T_{plate\text{-}sink}$ is consistent with the flow of the material during conditioning resulting in decreased bond line thickness and is not statistically significant.

Raw Data

Table 5. Thermal Performance. Samples in accordance with Method 1.4

Test Fixture #	**Before Exposure**			**After Exposure**		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	$\theta_{p\text{-}s}$, °C/W
86	76.8	12.4	0.65	74.0	10.8	0.57
87	77.0	8.4	0.44	72.6	5.3	0.28
88	78.0	12.5	0.66	71.7	6.1	0.32
89	79.3	16.0	0.84	75.8	16.3	0.86
90	73.9	9.5	0.50	71.6	9.7	0.51
Average	77.0	**11.7**	0.62	73.1	**9.7**	0.51

Oneway Analysis of q(p-s) By 1000 hr Aging Condition



Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
85C/85%RH - initial	0.44	0.44	0.47	0.65	0.75	0.84	0.84
85C/85%RH - final	0.28	0.28	0.3	0.51	0.715	0.86	0.86

Means Comparisons

Dif=Mean[i]-Mean[j]	85C/85%RH - initial	85C/85%RH - final
85C/85%RH - initial	0.000000	0.110000
85C/85%RH - final	-0.11	0.000000

Alpha=0.05

Comparisons for each pair using Student's t
t=2.30600

Abs(Dif)-LSD	85C/85%RH - initial	85C/85%RH - final
85C/85%RH - initial	-0.28837	-0.17837
85C/85%RH - final	-0.17837	-0.28837

Positive values show pairs of means that are significantly different.