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TEST REPORT

THERMATTACH® T424/T427 BGA Assembly Tapes

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CHOMERICS
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FOREWORD

THERMATTACH T424 and T427 thermal tapes are variations of existing THERMATTACH tape products.

To meet the requirements of the semiconductor packaging industry, the THERMATTACH T424 and T427 raw materials have been reviewed and sources of ionic contaminants have been eliminated.

The adhesive performance of THERMATTACH T424 and T427 tapes are considered equivalent to THERMATTACH T404 and T405. Portions of this test report reflects performance data generated with THERMATTACH T404 and T405 samples. In the opinion of Chomerics' Technical staff, the data presented in this test report accurately predicts the expected performance of THERMATTACH T424 and T427 tapes.

SUMMARY OF TYPICAL PHYSICAL PROPERTIES

Property	T424	T427	Test Method
Carrier	Fiberglass	MT Kapton	
Thickness, in (mm)	0.007 (.178)	0.007 (.178)	
Tack Adhesion, gm	700	500	Polyken PSTC
Dielectric Strength, KVAC/mm	22.5	39.4	ASTM D149
Breakdown Voltage, VAC	4000	6000	ASTM D149
Volume Resistivity, ohm-cm	1.0x10'5	1.0x10'5	ASTM D257
Thermal Impedance, °C-in z/watt	0.65	0.60	ASTM D5470
Thermal Conductivity,			
W/m-K	0.40	0.43	ASTM D5470
Specific Gravity	1.5	1.75	ASTM D2240
Die Shear Adhesion, psi (MPa)	180 (1.24)	150 (1.04)	Chomerics Test #54
Peel Adhesion, Ib/in (kN/m)	3.4 (.6)	2.75 (.5)	ASTM D1000
Creep Adhesion, days			
25°C, 12 psi (.083 MPa)	>50	>50	P.S.T.C. #7
150°C, 12 psi (.083 MPa)	> 10	> 10	P.S.T.C. #7
Dielectric Constant			
@1 KHz	4.7	4.0	ASTM D150-93
@1 MHz	3.9	3.4	
Dissipation Factor			
@1 KHz	0.015	0.008	ASTM D150-93
@1 MHz	0.063	0.056	

APPLICATION PERFORMANCE - SUMMARY

Test	**Results**	Comments
High Humidity @ Ambient		
1000 Hours, 25°C, 95% RH	Pass	No negative effects
High Temperature/Humidity Resistance		
1000 Hours, 66°C, 85% RH	Pass	No negative effects Die shear improved
Heat Aging		
1000 Hours, 150°C	Pass	No negative effects Die shear improved
100 Cycles	Pass	No negative effects
Heat Aged Samples	Pass	No negative effects
Vibration	Pass	No negative effects
Vibration @ 150°C	Pass	No negative effects
Mechanical Shock	Pass	No negative effects
Solvent Exposure	Pass	10-20% decrease in performance
Conformal Coat Compatibility	Pass	Silicone cure retarded
Potting Compound Compatibility	Pass	
Temperature Cycling, -40 to +150°C 1000 Cycles	Pass	

THERMATTACH RESEARCH REPORT
IONIC CONTENT

Ionic Extraction Analysis

Summary: Oneida Research, an independent test laboratory, was contracted to conduct ionic extraction analysis of THERMATTACH T424 tape in accordance with MIL-STD-883. Summarized below are the findings of that analysis. This data indicates that THERMATTACH T424 tape meets the requirements of MIL-STD-883.

Chomerics conducts ionic extraction analysis on all T424 tape production runs to confirm conformance to MIL-STD-883.

IONIC IMPURITIES

	Results	Requirements
Total Ionic Content	0.8	<4.50 millisiemens/meter
Hydrogen (pH)	5.7	4.0 < pH < 9.0
Chloride	19.7	< 50 ppm
Potassium	ND	< 50 ppm
Fluoride	19.0	< 50 ppm
Other (>5 ppm) Sulfate	22.2	

ND = None detected

THERMATTACH Research Report
Dielectric Constant

Summary: Delsen Testing Laboratories, an independent test laboratory, was contracted to conduct dielectric constant and dissipation factor analysis of THERMATTACH T424 tape. Below is a summary of the findings of that analysis.

DIELECTRIC CONSTANT AND DISSIPATION FACTOR
Tested "as received" at room temperature

Test Method:	ASTM D150-93
Electrode Type:	Unequal size inconel

Test Frequency Hz	Top Electrode Diameter inches	Specimen Thickness inches	Dissipation Factor	Dielectric Constant
Specimen I.D.: THERMATTACH T424 Tape				
1 K	1 .251	0.0065	0.015	4.7
1 K	1 .251	0.0065	0.063	3.9

Application Study/Corrosion Effects

Summary. In order to determine the effects of ionic impurities in thermal attachment tapes used for circuit attachment, experiments were conducted in conjunction with a major semi-conductor manufacturer. Those results are summarized on the following pages. The results indicate that Chomerics' THERMATTACH T424 and T427 tapes consistently showed reduced signs of corrosion when compared to other tapes.

Application Study/Corrosion Effects

1. Summary

Samples of thermal tapes including the THERMATTACH T424 and T427 adhesive formula were attached to nickel and gold plated copper heat spreaders and exposed to 192 hours of steam at 235°F (113°C).

On the nickel plated heat spreaders, the T424 and T427 tapes caused less corrosion than the other tape samples. All tapes tested showed some discoloration. This discoloration was found to be nickel corrosion products that had migrated from the nickel-plated heat spreader.

No significant corrosion of gold plated heat spreaders was observed and minimal discoloration on the tape samples was observed.

2. Introduction

Thermal tapes can be used to fasten plated metal heat spreaders to IC circuits (in this case a polyimide flex circuit with gold circuit traces). These packages are typically tested under severe environmental conditions to ensure the integrity of the package. A typical environmental test includes a pressure cooker test (high humidity/high temperature/high pressure test), where corrosion of plated heat spreaders can occur. Chomerics tested customer supplied heat spreaders and package circuits to determine if various attachment tape adhesives can cause such corrosion.

3. Experimental Design

Table I shows the samples tested. All samples were tested in an aluminum pressure cooker at an average temperature of 235°F. Test duration was 192 hours. Two specimens of each type were tested. For the tape samples, one specimen was tested with the release liner removed and one specimen was tested with the release liner in place.

After the test, the thermal tape was removed from each metal heat spreader. The metal heat spreaders were examined visually. The metal heat spreaders were also examined using optical microscopy and by SEM/EDAX. Some of the tapes were also examined by SEM/EDAX.

4. Observations

The following observations were made:

Sample*	**Thermal Tape**	**Plating on** Heat Spreader	Observations **Heat Spreader**	**Observations** Tape
1	T424 Adhesive	Nickel	Minimal Pitting	Minimal Discoloration
2	Sample #2	Nickel	Increased Pitting	Minimal Discoloration
3	Sample #3	Nickel	Increased Pitting & Increased Discoloration	Increased Discoloration
4	T424 Adhesive	Gold	No Pitting	Min. Discoloration
5	Sample #5	Gold	No Pitting	Min. Discoloration
6	Sample #6	Gold	No Pitting	Min. Discoloration
7	None	Gold	No Pitting	Min. Discoloration
8	None	Nickel	No Pitting	Min. Discoloration

*Two of each type

5. Results and Discussion

The observed results show that the corrosion on nickel plated heat spreaders caused by T424 was significantly less than other tape samples. These results were observed as significantly less pits per area on the nickel plated heat spreaders in contact with T424 adhesive. Tape sample #3 also caused more discoloration of the nickel surface than the T424 adhesive.

All tape samples attached to the nickel plated heat spreaders discolored after exposure.
This discoloration of the tape was due to migration of nickel corrosion products from the nickel plated heat spreader.

No significant corrosion of any gold plated heat spreaders was observed.

No corrosion was observed on either nickel plated or gold plated heat spreaders which had no thermal tape attached.

6. Conclusions

Tape systems with ionic contaminants (chloride, bromide, etc.) can lead to an increased possibility of corrosion of metal parts under severe environmental conditions.

A more noble plating such as gold can reduce or eliminate potential corrosion problems.

Alpha Emissions

1. Williams Advanced Materials conducted alpha particle emissions testing on THERMATTACH T424 tape. The results are reported in the table below:

Alpha Count Calculations: #1

Total Counts Observed (Counts)	58
Total Time Counted (Hours)	18.04
Gross a (Counts/Hour)	2,22
Background a (Counts/Hour)	2.45
Net a (Counts/Hour)	0,77
Sample Size (Cm^2)	77.42
Final a Count Results (Counts/ cm^2/Hour)	0.0100

High Humidity at Ambient Temperature

Summary: Random production samples of THERMATTACH thermal were subjected to high humidity at ambient laboratory temperature for 1000 hours. These products have passed this test as shown by no decrease in adhesion or thermal performance.

Apparatus:

A) Humidity Chamber. 95 +5/-0 % relative humidity was achieved by sealing the test specimens into a plastic container with sufficient water and insulating the container to minimize temperature fluctuations.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Test Conditions. All test specimens were sealed into the humidity chamber for 1000 hours. The chamber was located so that temperature variations were minimized.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. There was no evidence of delamination, tape lifting or any other sign of adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1 . The data shows improved thermal performance after 1000 hours at high humidity.

C) Die Shear Strength. The data given in Table 2 shows no loss of adhesion after exposure to high humidity.

Table 1. Rj-s, Rj-a before and after 1000 hours at 25°C, 95-100 % RH

	BEFORE	AFTER	
Group TI	Rj-s, °C/W	4.84	4.88
1	Rj-a, °C/w	7.82	7.47
Motorola	Rj-s, °C/W	5.93	5.28
Rj-a, °C/W	8.50	7.94	
Group TI	Rj-s, °C/W	4.24	4.25
2	Rj-a, °C/w	7.20	6.94
Motorola	Rj-s, °C/W	5.43	4.96
Rj-a, °C/W	7.79	7.75	

Table 2. Die shear strength before and after 1000 hours at 25°C 95-100% RH

Test			CONTROL	AFTER
Material		Temp.	P Group 1 250C 1	126.5
306.1				
	2	171.4	324.2	
	3	90.0	270.1	
			270.1	
			288.1	
			306.1	
	Avg.	132.0	294.1	
Group 2	250C	1	114.3	306.1
	2	110.2	288.1	
	3	151.0	396.2	
			324.2	
			306.1	
			306.1	
	Avg.		125.2	321.1

High Temperature / Humidity Resistance
1000 Hours, 66°C @ 85% RH

Summary: Random production samples of THERMATTACH thermal tapes have been subjected to 1000 hours of 66°C at 85% Relative Humidity. These products have passed this test based on visual, die shear strength and thermal performance criteria.

Apparatus:
A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after shock testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.
B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.
C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.
D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:
A) Humidity. Fixtures were placed in the humidity cabinet in a vertical position. Temperature was raised to 66°C and the humidity was set at 85%. No attempt was made to protect exposed metal surfaces or leads.
B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.
C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The test fixture was subjected to 1000 hours at 66°C / 85% RH. The individual Rj-s and Rj-a were again measured and recorded.
D) Die Shear strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to 1000 hours of 66°C / 85% RH. and tested for die shear strength at room temperature.

Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after high humidity exposure. All exposed metal parts were corroded.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the high humidity at elevated temperature has no effect on thermal performance.

C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that the adhesive strength is significantly improved by high humidity at elevated temperature. This is most like due to increase in the modulus of the adhesive under these conditions.

Table 1 . Rj-s, Rj-a before and after high temperature and humidity

		BEFORE	AFTER
Group TI	Rj-s, °CIW	5.54	5.56
1	Rj-a, °C/w	8.31	8.12
Motorola	Rj-s, °C/W	5.92	5.42
Rj-a, °C/W	8.53	8.09	
Group TI	Rj-s, °C/W	3.82	3.75
2	Rj-a, °C/W	6.67	6.43
Motorola	Rj-s, °C/W	4.60	4.49
Rj-a, °C/W	7.27	7.16	

Table 2. Die shear strength before and after high temperature and humidity.

Test Material		CONTROL Temp.	AFTER psi	psi
Group 1	250C	1	126.5	540.2
	2	171 .4	504.2	
	3	90.0	576.3	
	Avg.	132.0	540.2	
Group 2	250C	1	114.3	540.2
	2	110.2	540.2	
	3	151.0	603.3	
	Avg.	125.2	561.2	

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Heat Aging
1000 Hours at 1500C

Summary: Random production samples of THERMATTACH thermal tapes were subjected to 1000 hour heat aging at 150°C. These products passed this test based on visual, die shear strength and thermal performance criteria.

Apparatus:

A) Oven. A forced convection Blue M oven was set at 150°C. Temperature uniformity within the oven was +/- 5°C.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after heat aging as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure: A) Heat Aging. Fixtures were placed in an forced convection hot air oven maintained at 150 +/- 2°C for 1000 hours. Fixtures were then removed and evaluated.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The test fixture was subjected 1000 hours at 150°C. The individual Rj-s and Rj-a were again measured and recorded.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06 x 1 x 4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to 1000 hours at 150°C and tested for die shear strength at room temperature.

Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after aging. The exposed adhesive showed moderate discoloration and had lost surface tack.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that the thermal resistances after aging are lower than before testing. This change is due to several factors, including improved thermal contact, elimination of entrapped air, variability of the ATA method and stress in the transistors and thermocouples.

C) Die Shear Strength. The results of the die shear strength tests are given in Table 2. The data shows that the adhesive strength is significantly improved by heat aging. This is probably due to increase in the modulus of the adhesive with long term exposure to high temperatures.

Table 1. Rj-s, Rj-a before and after 1000 hours at 150°C

	BEFORE	AFTER	
Group 1 TI	Rj-s, °C/W	5.04	4.60
Rj-a, °C/w	7.63	7.18	
Motorola	Rj-s, °C/W	6.16	5.35
Rj-a, °C/W	8.79	7.99	
Group 2 TI	Rj-s, °C/W	5.14	4.16
Rj-a, °C/W	7.74	6.79	
Motorola	Rj-s, °C/W	5.56	4.22
Rj-a, °C/W	7.96	6.86	

(Table 2. Die shear strength before and after 1000 hours at 150°C.

Test Material		CONTROL Temp.	AFTER psi	psi
Group 1	250C	1	126.5	450.2
	2	171.4	396.2	
	3	90.0	387.2	
	4		396.2	
	5		378.2	
	6		414.0	
	Avg.	132.0	403.7	
Group 2	250C	1	114.3	504.2
	2	110.2	450.2	
	3	151.0	468.2	
	4		450.2	
	5		459.2	
	6		486.0	
	Avg.	125.2	469.7	

THERMATTACH Research Report

Thermal Shock Resistance 100 Cycles -60 to + 1500C

Summary: Random production samples of THERMATTACH thermal tapes were subjected to ten thermal shock cycles following ASTM D-1674 guidelines. These products passed this test based on visual, die shear strength and thermal performance criteria.

Apparatus:

A) Low temperature bath. The low temperature bath consisted of a one gallon capacity insulated plastic container. 0.75 gallon of isopropanol was added to this container and sufficient finely crushed dry ice was added to cool the bath to -65 +0/-5°C. Temperature was measured with a Type K thermocouple located one inch below the liquid surface. The bath was stirred before a temperature measurement was taken. Temperature was maintained by addition of dry ice.

B) Oven. A forced convection Blue M oven was set at 1 50°C. Temperature uniformity was +/2°C. Recovery time after opening the door and test specimen placement was 5-6 minutes.

F) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Shock Cycle. A cycle consisted of placing a specimen into the oven at 150°C for 30 minutes and after removal from the oven, rapidly plunging the specimen into the -65°C bath for 5 minutes. The specimen was removed from the cold bath, excess isopropanol was wiped off with a towel, rapidly visually examined and the next cycle started.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

D) Die Shear strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon dies were applied to the tape with light pressure. Six dies were applied per aluminum panel. The fixtures were subjected to 100 shock cycles, inspected visually between cycles and tested for die shear strength at room temperature after 100 cycles.

Results.

A) Visual. There was no visual evidence of adhesion failure, lifting or flagging after cycling.

B) Die Shear Strength. The results of the die shear strength tests are given in Table 1. The data shows that the adhesive strength is not altered by thermal shock.

Table t. Die shear strength before and after thermal shock.

Test Material	Temp.		CONTROL psi	AFTER psi
Group 1	25°C	1	126.5	122.4
	2	171.4	106.1	
	3	90.0	106.1	
	Avg.	132.0	115.6	
150°C		1	40.8	44.9
	2	49.0	57.1	
	3	65.3	57.1	
	Avg.	51.7	53.1	
Group 2	25°C	1	114.3	146.9
	2	110.2	142.9	
	3	151.0	163.3	
	Avg.	125.2	151.0	
150°C		1	49.0	81.6
	2	55.1	85.7	
	3	61.3	81.6	
	Avg.	55.1	83.0	

Vibration Resistance

Summary: Random production samples of THERMATTACH thermal tapes were subjected to vibration by Associated Testing Laboratories of Burlington MA. These products passed the test with no loss of adhesion or thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Vibration. Specimens were subjected to sine-wave vibration as specified in GM 9110P test procedure. Specimens were vibrated for four hours per axis in all three axes with a sweep rate of 1 octave /minute from a frequency of 10 to 1000 Hz. This method is considered more severe that the random vibration called out by GM 9103P procedure.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. There was no apparent adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is not affected by vibration.

C) Die Shear Strength. There was no loss of shear strength after exposure to vibration.

Table 1. Rj-s, Rj-a before and after vibration.

			BEFORE	AFTER
Group 1	TO-220	Rj-s, °C/W	5.93	5.89
		Rj-a, °C/w	8.53	8.65
	TO-218	Rj-s, °C/W	3.82	3.79
		Rj-a, °C/W	6.38	6.46
Group 2	TO-220	Rj-s, °C/W	4.66	4.68
		Rj-a, °C/W	7.32	7.41
	TO-218	Rj-s, °C/W	3.06	3.27
		Rj-a, °C/W	6.00	5.95

Table 2. Die shear strength before and vibration.

Material	Test Temp.		CONTROL p-ssi	AFTER PSI'
Group 1	25°C	1	126.5	159.2
		2	171 .4	244.9
		3	90.0	193.9
				244.0
				208.2
				212.2
		Avg.	132.0	210.5
	150°C	1	40.8	61.2
		2	49.0	57.0
		3	65.3	61 .2
				55.1
				63.3
				63.3
		Avg.	51.7	60.2
Group 2	25°C	1	114.3	171.4
		2	110.2	195.9
		3	151.0	218.4
				179.6
				236.7
				175.5
		Avg.	125.2	196.2
	150°C	1	49.0	57.1
		2	55.1	61.2
		3	61.3	73.5
				59.2
				73.5
				77.6
		Avg.	55.1	67.0

Vibration Resistance at Elevated Temperature

Summary: Random production samples of THERMATTACH thermal tapes were subjected to vibration at elevated temperature by Associated Testing Labs of Burlington MA. The results show that these products are not affected by vibration at elevated temperature.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Vibration. Specimens heated to 125°C and subjected to sine-wave vibration as specified in GM 91 10P test procedure. Specimens were vibrated for four hours per axis in all three axes with a sweep rate of 1 octave /minute from a frequency of 10 to 1000 Hz. This method is considered more severe that the random vibration called out by GM 9103P procedure.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. Thermal performance was again determined after high temperature vibration testing.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. Die shear strength was determined after high temperature vibration testing.

Results.

A) Visual. There no signs of delamination or other signs of adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is unaffected by vibration at elevated temperature.

C) Die Shear Strength. The data listed in Table 2 shows that vibration at elevated **temperature** does not have a negative affect on the shear strength of the adhesive. The room temperature strength increases and the high temperature strength remains unchanged.

Table 1 Rj-s, Rj-a before and after vibration at 125°C

		BEFORE	AFTER	
Group 1 TO-220		Rj-s, °C/W	5.85	5.77
	Rj-a, °C/w	8.60	8.64	
TO-218		Rj-s, °C/W	3.41	3.58
	Rj-a, °C/W	6.09	6.21	
Group 2 TO-220		Rj-s, °C/W	5.12	5.10
	Rj-a, °C/W	7.86	7.84	
TO-218		Rj-s, °C/W	3.29	3.25
	Rj-a, °C/W	5.99	5.98	

Table 2. Die shear strength before and after vibration at 125°C.

Test Material	Temp.		CONTROL psi	AFTER P-si
Group 1	250C	1	126.5	228.6
	2	171.4	226.5	
	3	90.0	224.5	
			151.0	
			214.3	
			220.4	
	Avg.	132.0	210.9	
1500C		1	40.8	63.3
	2	49.0	57.1	
	3	65.3	44.9	
			46.9	
			53.1	
			44.9	
	Avg.	51.7	51.7	

TABLE 2 Cont.

Material	Test Temp.		CONTROL PSI	AFTER psi
Group 2	250C	1	114.3	253.1
		2	110.2	216.3
		3	151.0	269.4
				224.5
				220.4
				224.5
		Avg.	125.2	234.7
	1500C	1	49.0	38.8
		2	55.1	65.3
		3	61.3	51.0
				56.1
				57.1
				55.1
		Avg.	55.1	53.7

Mechanical Shock

Summary: Random production samples of THERMATTACH thermal tapes tested for mechanical shock resistance by Associated Testing Laboratories of Burlington MA. These products passed the test as evidenced by no loss of adhesion or deterioration of thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were mounted to the heat sink without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Shock. Test specimens were subjected to a half sine shock pulse of 20g amplitude and 11 millisecond duration in each axis and in both directions.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. Examination of the transistors and the dies showed no sign of delamination or other adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The results show that mechanical shock has had no effect on the thermal performance.

C) Die Shear Strength. The results given in Table 2 show that mechanical shock had no negative effect on the die shear adhesion. The room temperature shear strength of the adhesive has increased.

(Table 1. Rj-s, Rj-a before and after mechanical shock.

		BEFORE	AFTER	
Group 1 TO-220	Rj-s, °C/W	5.12	5.16	
	Rj-a, °C/w	7.77	7.82	
TO-218		Rj-s, °C/W	3.16	3.33
	Rj-a, °C/W	5.77	5.95	
Group 2 TO-220	Rj-s, 'CM	4.94	4.92	
	Rj-a, °C/W	7.63	7.67	
TO-218		Rj-s, °C/W	2.92	2.89
	Rj-a, °C/W	5.67	5.63	

Table 2. Die shear strength before and after mechanical shock.

Test Material	Temp.		CONTROL psi	AFTER
Group 1	25°C	1	126.5	228.6
	2	171.4	253.1	
	3	90.0	240.8	
			249.0	
			220.4	
			242.9	
	Avg.	132.0	239.1	
150°C		1	40.8	46.8
	2	49.0	57.1	
	3	65.3	40.8	
			40.8	
			61 .2	
			49.0	
	Avg.	51.7	48.3	
Group 2	25°C	1	114.3	195.9
	2	110.2	200.0	
	3	1 51 .0	244.9	
			208.2	
			220.4	
			261.2	
	Avg.	125.2	221.8	
150°C		1	49.0	53.1
	2	55.1	53.1	
	3	61 .3	69.4	
			44.9	
			44.9	
			49.0	
	Avg.	55.1	52.4	

THERMATTACH Research Report
Solvent Exposure

Summary: Random production samples of THERMATTACH thermal tapes were sequentially subjected to hot isopropanol, MEK, toluene and 1,1,1 trichloroethane vapors to simulate a degreasing process. This test is considered extremely severe since the thermal tape is exposed to four different solvents for a total of 24 minutes with very little time allowed for drying between exposures. These products resisted these solvents as judged by the die shear strength and also the thermal performance of TO-220 and TO-218 transistors.

Apparatus:

A) Reflux. A two liter beaker containing the test solvent was heated to reflux and stirred by a magnetic hot plate.

B) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

C) Transistors. Motorola TIP29C TO-220 and TIP33 TO-218 transistors were used. The transistors were used as received without additional cleaning.

D) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

E) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

Procedure:

A) Solvent Exposure. 100 cc of test solvent was brought to rapid ref lux in a 2000 cc covered beaker. When the solvent vapors reached the cover, the test specimen was inserted into the vapor and the cover was replaced. After two minutes exposure, the specimen was removed into the ambient atmosphere for two minutes. This cycle was repeated two more times: total contact time with each solvent vapor was 6 minutes. The test solvent was replaced with the next solvent and the specimen was subjected to three cycles with this new solvent. This solvent change represented a 30 minute drying period. The order of solvent exposure was Toluene, MEK, isopropanol and 1,1,1 TCE.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing during and after the solvent exposures.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA. The specimens were exposed to hot solvent vapors, allowed to dry 1 hour after the last exposure and the thermal resistances were re-measured.

D) Die Shear Strength. 0.5 x 0.6 inch thermal tape was applied to 0.06x1 x4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel. The test panels were exposed to hot solvent vapors, allowed to dry 1 hour after the last exposure and the die shear tests were performed.

Results.

A) Visual. There was considerable swelling of the exposed adhesive especially after exposure to MEK and 1,1,1 TCE. Minor edge lifting was also apparent following exposure to 1,1,1 TCE.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The results show that the initial thermal resistances increase by 10% over that of the before test values. This increase is most likely due to trapped solvent beneath the transistor.

C) Die Shear Strength. The results in Table 2 show that the die shear values are 10 - 20 % lower after solvent exposure. This decrease is probably caused by factors such as trapped solvent under the dies and normal variability of the test and sample preparation.

Table 1 . Rj-s, Rj-a before and after solvent exposure.

		BEFORE	AFTER	
Group 1 TO-220	Rj-s, °C/W	5.65	6.12	
	Rj-a, °C/w	8.33	8.77	
TO-218		Rj-s, °C/W	3.46	4.04
	Rj-a, °C/W	6.04	6.63	
Group 2 TO-220	Rj-s, °C/W	5.15	5.60	
	Rj-a, °C/W	7.83	8.27	
TO-218		Rj-s, °C/W	3.28	3.56
	Rj-a, °C/W	5.99	6.19	

Table 2. Die shear strength before and after solvent vapor exposure.

Test Material	Temp.		CONTROL psi	AFTER
Group 1	25°C	1	126.5	110.2
	2	171.4	110.2	
	3	90.0	81 .6	
	Avg.	132.0	100.7	
150°C		1	40.8	40.8
	2	49.0	42.9	
	3	65.3	44.9	
	Avg.	51.7	42.9	
Group 2	25°C	1	114.3	102.0
	2	110.2	116.3	
	3	151.0	116.3	
	Avg.	125.2	111.6	
150°C		1	49.0	36.7
	2	55.1	65.3	
	3	61.3	53.1	
	Avg.	65.1	51.7	

Conformal Coating Compatibility

Summary: Random production samples of THERMATTACH thermal tapes were conformal coated with acrylic and silicone conformal coatings. THERMATTACH was not affected by the conformal coatings but some inhibition of the cure of the silicone conformal coating was observed.
Conformal Coatings. The following conformal coats were evaluated:

Emerson & Cuming Unicoat S7001-1, silicone
57002, silicone
UV79-20, acrylic

Procedure:
A) Coating. TO-220 transistors attached to a black anodized heat sink with the thermal tapes. The specimens were then subjected to a simulated vapor degreasing step and dried for 30 minutes at ambient. Conformal coatings were applied by pouring a thin layer onto the specimens and were cured following the manufacturer's recommendations.
B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing. Specimens were also examined for conformal coat dewetting and cure.

Results.

A) Visual. THERMATTACH adhesive retarded the cure of the silicone conformal coats only where the coating was in contact with the adhesive layer. The acrylic cure was unaffected. None of the conformal coats showed signs of dewetting.

THERMATTACH Research Report
Potting Compound Compatibility

Summary: Random production samples of THERMATTACH thermal tapes were encapsulated with a silicone potting compound base known to be sensitive to contamination induced loss of cure. THERMATTACH adhesive did not cause any loss of cure or show any signs of dewetting.

Procedure:

A) Potting. TI TIP29 TO-220 transistors were mounted to 1 " x 2.5" glass slides using 0.7" x 2" sample of THERMATTACH tape. G.E. RTV 615 base was prepared according to directions. A 0.25 inch dam was prepared around the test specimen, the potting mix was poured onto the transistor and cured at 150°C for 10 minutes.

B) Visual. All test specimens were examined for cure, compound wetting and any sign that the tape was interfering.

Results.

A) Visual. The compound was properly cured even when exposed to the tape surface. There were no signs of dewetting and all leads and openings were completely filled.

THERMATTACH Research Report

Temperature Cycling, -40 to + 150°C, 1000 Cycles

Summary: Random production samples of THERMATTACH thermal tapes were subjected to temperature cycling by Associated Testing Laboratories of Burlington MA. These products passed the test with no loss of adhesion or thermal performance.

Apparatus:

A) Anatek Thermal Analyzer (ATA). The ATA was used to measure Rj-s and Rj-a before and after testing as well as to measure the temperature sensitive Vbe of each transistor used in the test.

B) Transistors. TI TIP29C and Motorola TIP29C TO-220 transistors were used. The transistors were used as received without additional cleaning.

C) Heat Sink. EG&G Wakefield heat sink (403K) was fitted with Type K thermocouples at the transistor mounting sites. Four transistors were mounted (2 per side) near the edges and centered between the fins.

D) Silicon Die. 0.35 x 0.35 inch dies were sawed from a blank disk and cleaned before use.

E) Temperature Chamber. A temperature chamber with a range of -100 to + 550°F and accuracy of +/- 2°F was used.

Procedure:

A) Temperature Cycling. Specimens were subjected to 1000 cycles from -40 to + 150°C. A cycle consisted of a fifteen minute dwell at -40°C, heating to 1 50°C at 10°C / minute, a fifteen minute dwell at 150°C and cooling to -40°C at 10°C / minute.

B) Visual. All test specimens were examined for tape lifting, delamination or any other sign that the tape was failing.

C) Thermal Performance. Thermal tape (0.6 x 1 inch) was applied to a transistor first using light pressure (2-5 lb). The second layer of release liner was removed and the transistor was attached to the heat sink again using light pressure. Four transistors were applied one after the other. After a one hour dwell, the Rj-s and Rj-a of each transistor was determined using the ATA.

D) Die Shear Strength. 0.5 x 0.5 inch thermal tape was applied to 0.06 x 1 x 4 inch cleaned aluminum panels using light pressure. The silicon die was applied to the tape with light pressure. Six dies were applied per aluminum panel.

Results.

A) Visual. There was no apparent adhesive failure.

B) Thermal Performance. The before and after thermal resistances are given in Table 1. The data shows that thermal performance is not affected by temperature cycling. One of the devices failed during the cycling. The failure was a mechanical lead breakage and not related to the product being tested.

C) Die Shear Strength. There was no loss of shear strength after exposure to temperature cycling.

Table 1 Rj-s, Rj-a before and after temperature cycling

		BEFORE	AFTER	
Group 1 TO-220		Rj-s, °C/W	5.85	5.69
	Rj-a, °C/w	8.60	8.28	
TO-218		Rj-s, °C/W	3.41	Device
	Rj-a, °C/W		6.09	Failed
Group 2 TO-220		Rj-s, °C/W	5.12	5.42
	Rj-a, °C/W		7.86	8.36
TO-218		Rj-s, °C/W	3.29	3.19
	Rj-a, °C/W	5.99		5.88

Table 2 Die shear strength before and after temperature cycling

Test Material	Temp.		CONTROL psi	AFTER r. psi
Group 1	250C	1	126.5	342.0
	2	171.4	216.0	
	3	90.0	315.0	
			270.0	
			252.0	
			234.0	
	Avg.	132.0	271.5	
1500C		1	40.8	49.0
	2	49.0	44.9	
	3	65.3	49.0	
			44. 9	
			40.8	
			40.8	
	Avg.	51.7	44.9	

TABLE 2 Cont.

Test Material	Temp.		CONTROL psi	AFTER psi
Group 2	250C	1	114.3	216.0
	2	110.2	288.0	
	3	151.0	306.0	
			324.0	
			378.0	
			378.0	
	Avg.	125.2	315.0	
1500C		1	49.0	65.3
	2	55.1	61.2	
	3	61.3	57.1	
			44. 9	
			55.1	
			67.4	
	Avg.	55.1	58.5	