TEST REPORT

THERMATTACH® T412 *Thermal Tapes*

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Table of Contents

Section I Physical Properties

Summary of Physical Properties

Section II Strength and Thermal Properties vs Storage Conditions

1000 Hours
25°C/95% Relative Humidity
85°C/85% Relative Humidity
85°C Continuous
150°C Continuous

1000 Cycles

-40° to 150°C at 10 degrees per minute

100 Cycles

-50° to 150°C Air to Air
-50° to 150° Liquid to Liquid

Summary of Physical Properties

Property		Units	Test Method
Thickness, inches		0.009	
Tensile Strength, psi		900	ASTM D-412
Tear Strength, lb/in		80	ASTM D-624
Elongation, %		7	ASTM D-412
Specific Gravity		2.5	ASTM D-792
Shore Hardness		81 "A"	ASTM D-2240
Compressive Modulus, psi		2400	MIL-G-83528
Tensile Modulus, psi		17	ASTM D-412
Lap Shear Adhesion		70.0 psi	ASTM D-1002
Peel Adhesion		2.4 lb/in	ASTM D-1000
Die Shear Adhesion			
Aluminum	@25°C	135. psi	Chomerics QC #54
	@50°C	65 psi	
	@75°C	45 psi	Ref Mil-Std 883
	@100°C	30 psi	Method 5011
	@125°C	25 psi	
	@150°C	25 psi	
Copper	@25°C	115 psi	
	@150°C	35 psi	
Alumina	@25°C	125 psi	
	@150°C	40 psi	
Creep Adhesion	@25°C 12 psi >50 days		P.S.T.C. #7
	@150°C 12 psi >50 days		P.S.T.C. #7
Thermal Impedance		0.35 °C-in ^{2}/watt	ASTM D-5470-93
Thermal Conductivity		1.4 watt/m-°K	ASTM D-5470-93
Heat Capacity at 25°C		0.97 cal/g-°C	proposed ASTM test method TM-01-06A in comm E-37
Glass Transition Temperature		-35°C	ASTM D-3386
Adhesive C.T.E.		alpha 1 50 ppm/°C alpha 2 147 ppm/°C	ASTM D-3386
Volume Resistivity		1.27 x 10^{-2} ohm/cm	ASTM D-991

Chomerics Thermattach T-412

25°C/95% RH Storage for 1000 Hours

Test Report on Strength and Thermal Properties

Summary: Random production samples of Thermattach T-412 were taken and prepared into test specimens that were subjected to 1000 hours of continuous exposure to 25°C/95% relative humidity conditions. These test specimens were then tested for strength and thermal properties versus a control group of test specimens. T-412 passed this test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Terra Universal Inc. Glove Box Model #1689-00
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.005" x 0.500" x 0.020" die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
5. Transistors - GE 3055P, Motorola TIP 33A
6. Ametek/Hunter Spring Model #RM
7. Instron Model 1125
8. Die Shear Testers Models 1750 with heated stage 1770 and Model 1760
9. Anatek Thermal Analyzer (ATA)

Procedure:

Die shear test specimen preparation is as follows. T-412 samples were cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side near each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA.

All of the above test specimens were sealed into the humidity chamber for 1000 hours of conditoning. The temperature and humidity were monitored for the duration of the 1000 hour conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimen were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die shear strength before and after 1000 hours of conditioning at 25°C/95% relative humidity.

25°C Testing		150°C Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	220.5	22.0	28.0
2) 123.5	220.5	26.0	30.0
3) 185.2	194.0	24.0	28.0
4) 123.5	194.0	26.0	30.0
5) 123.5	194.0	22.0	32.0
6) 123.5	211.7	22.0	30.0
Avg. 135.2	205.8	23.7	29.7

The conditioned samples show a 52.2% increase in shear strength at Room Temperature.
The conditioned samples show a 25.3% increase in shear strength at 150°C.

Table 2: Lap shear strength before and after 1000 hours of conditioning at 25°C/95% relative humidity.

Control Samples	Conditioned Samples
1) 71.0	111.0
2) 72.0	121.0
3) 68.0	112.0
4) 72.0	100.0
5) 73.0	112.0
Avg. 71.0	111.0

The conditioned samples show a 56.3% increase in shear strength.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 1000 hours of conditioning at 25°C/95% relative humidity.

		BEFORE		AFTER	
Material	Transitor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	2.8	5.2	3.0	5.4
	Motorola TIP33	3.1	5.5	3.4	5.8
T-412	GE 3055P	2.2	4.6	2.3	4.7
	Motorola TIP33	2.9	5.3	3.0	5.4

Chomerics Thermattach T-412

85°C/85% RH Storage for 1000 Hours

Test Report on Strength and Thermal Properties vs Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and prepared into test specimens that were subjected to 1000 hours of continuous exposure to 85°C/85% relative humidity conditions. Those test specimens were then tested for strength and thermal properties versus a control group of test specimens. T-412 passed this test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Blue M Humidity Chamber Model FR-386-PC-1
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020" die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
5. Transistors - GE 3055P, Motorola Tip 33A
6. Ametek/Hunter Spring force gauge and mechanical press Model# RM
7. Instron Model 1125
8. Die Shear Testers Models 1750 with heated stage 1770 and Model 1760
9. Anatek Thermal Analyzer (ATA)

Procedure:

Die Shear test specimen preparation is as follows. T-412 samples were cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side near each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA.

All of the above test specimens were sealed into the humidity chamber for 1000 hours of conditioning. The temperature and humidity were monitored for the duration of the 1000 hour conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimen were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyze. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die shear strength before and after 1000 hours of conditioning at 85°C/85% relative humidity.

25°C Testing		150°C Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	396.9	22.0	56.0
2) 123.5	529.2	26.0	46.0
3) 185.2	423.4	24.0	56.0
4) 123.5	423.4	26.0	66.0
5) 123.5	529.2	22.0	72.0
6) 123.5	335.2	22.0	46.0
Avg. 135.2	439.5	23.7	50.0

The 25°C test results show a 275.1% increase in shear strength over the control.
The 150°C test results show a 110.9% increase in shear strength over the control.

Table 2: Lap shear strength before and after 1000 hours of conditioning at 85°C/85% relative humidity.

	Control Samples	Conditioned Samples
1	71.0	250.0
2	72.0	255.0
3	68.0	260.0
4	72.0	263.0
5	73.0	265.0
Avg	71.0	258.0

The conditioned samples show a 263.4% increase over the control.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 1000 hours of conditioning at 85°C/85% relative humidity.

		BEFORE		AFTER	
Material	Transistor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	3.0	5.5	2.9	5.3
	TIP 33	3.2	5.6	3.1	5.5
T-412	GE 3055P	2.2	4.7	2.2	4.6
	TIP 33	2.8	5.2	2.6	5.0

Chomerics Thermattach T-412

85°C Continuous Storage for 1000 Hours

Test Report on Strength and Thermal Properties versus Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and preparedinto test specimens that were subjected to 1000 hours of continuous exposure to85°C forced correction conditions. These test specimens were then tested for strength and thermal properties versus a control group of test specimens. T-412 passed this test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Blue M forced convection oven Model# OV490A-3
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020"die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type Kthermocouples
5. Transistors - GE 3055P, Motorola TIP 33A
6. Ametek/Hunter Spring force gauge and mechanical press Model #RM
7. Instron Model 1125
8. Die Shear Testers Models 1750 with heated stage 1770 and Model1760
9. Anatek Thermal Analyzer (ATA)

Procedure:

Die Shear test specimen preparation is as follows. T-412 samples were cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side near each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA.

All of the above test specimens were sealed into the forced convection oven at 85°C for 1000 hours of conditioning. The temperature was monitored for the duration of the 1000 hour conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimens were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die Shear strength before and after 1000 hours of conditioning at 85°C continuous forced convection.

25°C Testing		150° Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	229.3	22.0	38.0
2) 123.5	238.1	26.0	42.0
3) 185.2	264.6	24.0	44.0
4) 123.5	185.2	26.0	40.0
5) 123.5	246.9	26.0	46.0
6) 123.5	220.5	22.0	40.0
Avg. 135.2	230.8	23.7	41.7

The 25°C test results show a 159.3% increase in shear strength over the control.
The 150°C test results show a 75.9% increase in shear strength over the control.

Table 2: Lap shear strength before and after 1000 hours of conditioning at 85°Ccontinuous forced convection.

	Control Samples	Conditioned Samples
1	71.0	124.0
2	72.0	126.0
3	68.0	130.0
4	72.0	130.0
5	73.0	120.0
Avg	71.0	126.0

The conditioned samples show a 77.5% increase in shear strength over the control.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 1000 hours of conditioning at 85°C continuous forced convection.

		BEFORE		AFTER	
Material	Transistor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	2.9	5.3	Transistor	Failure
	TIP 33	3.2	5.6	- 11-	
T-412	GE 3055P	2.1	4.5	2.7	4.6
	TIP 33	2.9	5.3	3.0	5.4

Chomerics Thermattach T-412

150°C Continuous Storage for 1000 Hours

Test Report on Strength and Thermal Properties versus Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and preparedinto test specimens that were subjected to 1000 hours of continuous exposure to85°C forced correction conditions. These test specimens were then tested for strength and thermal properties versus a control group of test specimens. T-412 passed this test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Blue M forced convection oven Model# OV490A-3
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020" die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
5. Transistors GE 3055P, Motorola TIP 33A
6. Ametek/Hunter Spring force gauge and mechanical press Model #RM
7. Instron Model 1125
8. Die Shear Testers Models 1750 with heated stage 1770 and Model 1760
9. Anatek Thermal Analyzer (ATA)

Procedure:

Die Shear test specimen preparation is as follows. T-412 samples cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side new each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA

All of the above test specimens were sealed into the forced convection oven at 150°C for 1000 hours of conditioning. The temperature was monitored for the duration of the 1000 hour conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimens were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die Shear strength before and after 1000 hours of conditioning at 150°C continuous forced convection.

25°C Testing		150° Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	352.8	22.0	60.0
2) 123.5	370.4	26.0	68.0
3) 185.2	335.2	24.0	72.0
4) 123.5	352.8	26.0	70.0
5) 123.5	388.1	22.0	60.0
6) 123.5	370.4	22.0	62.0
Avg. 135.2	361.7	23.7	65.3

The 25°C test results show a 167.4% increase in shear strength over the control.
The 150°C test results show a 175.5% increase in shear strength over the control.

Table 2: Lap shear strength before and after 1000 hours of conditioning at 150°Ccontinuous forced convection.

	Control Samples	Conditioned Samples
1	71.0	507.0
2	72.0	587.0
3	68.0	507.0
4	72.0	685.0
5	73.0	460.0
Avg	71.0	487.0

The conditioned samples show a 585.9% increase in shear strength over the control.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 1000 hours of conditioning at 150°C continuous forced convection.

		BEFORE		AFTER	
Material	Transistor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	2.9	5.3	2.9	5.3
	TIP 33	2.8	5.2	2.7	5.1
T-412	GE 3055P	2.9	5.3	3.5	5.9
	TIP 33	3.3	5.7	3.6	6.0

Chomerics Thermattach T-412

1000 Thermal Cycles from -40° to 150°C at 10°C/Min

Test Report on Strength and Thermal Properties versus Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and prepared into test specimens that were subjected to 1000 Thermal cycles from -40° to 150°C at 10°C per minute. These test specimens were then tested for strength and thermal properties versus a control group of test specimens. T-412 passed this test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Tenny Jr. Model T shock Jr. Ser# 12222-14
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020" die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
5. Transistors GE 3055P, Motorola TIP 33A
6. Ametek/Hunter Spring force gauge and mechanical press Model #RM
7. Instron Model 1125
8. Die Shear Testers Models 1750 with heated stage 1770 and Model 1760
9. Anatek Thermal Analyzer (ATA)

Procedure:

Die Shear test specimen preparation is as follows. T-412 samples cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side new each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA.

All of the above test specimens were sealed into the Thermal Cycle chamber for 1000 cycles of conditioning. The temperature was monitored for the duration of the 1000 cycle conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimens were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die Shear strength before and after 1000 Thermal cycles from -40° to 150°C at 10°/min..

25°C Testing		150° Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	238.2	24.0	57.0
2) 123.5	220.5	26.0	62.0
3) 185.2	194.0	26.0	57.0
4) 123.5	238.2	24.0	57.0
5) 123.5	202.9	26.0	59.0
6) 123.5	238.2	26.0	52.0
Avg. 135.2	222.0	25.3	57.3

The 25°C test results show a 60.6% increase in shear strength over the control.
The 150°C test results show a 126.5% increase in shear strength over the control.

Table 2: Lap shear strength before and after 1000 Thermal cycles from -40° to 150°C at 10°/min.

	Control Samples	Conditioned Samples
1	72.0	107.0
2	77.0	120.0
3	85.0	103.0
4	89.0	101.0
5	82.0	80.0
Avg	81.0	102.2

The conditioned samples show a 26.2% increase in shear strength over the control.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 1000 Thermal cycles from -40° to 150°C at 10°/min.

		BEFORE		AFTER	
Material	Transistor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	3.2	5.6	4.2	6.5
	TIP 33	3.3	5.7	3.7	6.1
T-412	GE 3055P	2.2	4.7	2.2	4.7
	TIP 33	2.7	5.2	2.6	5.1

Chomerics Thermattach T-412

100 Thermal Shocks -50° to 150°C Liquid to Liquid

Test Report on Strength and Thermal Properties versus Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and preparedinto test specimens that were subjected to 100 Thermal shocks from -50° to 150°C , liquid to liquid. These test specimens were then tested for strength thermal properties versus a control group of test specimens. T-412 passed is test based on visual, die shear, hot die shear, lap shear, and thermal performance criteria.

Apparatus:

1. Corning Stirring hot plate, Model PC-320
2. Insulated vessel filled with an alcohol dry ice slurry
3. Insulated vessel filled with silcone oil
4. Omega digital thermometer Model HH80
5. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
6. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020" die
7. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
8. Transistors - GE 3036P, Motorola TIP 33A
9. Ametek/Hunter Spring force gauge and mechanical press Model #RM
10. Instron tensile tester Model 1125
11. Die Shear Testers Models 1750 with heated stage 1770 and Model 1760
12. Anatek Thermal Analyzer (ATA)

Procedure:

Die Shear test specimen preparation is as follows. T-412 samples cut to 0.600" x 0.600". The clear release film is removed and the T-412 is applied to a clean aluminum substrate. Six pieces of T-412 are used per each of two aluminum substrates. The air pockets are squeezed out from the bond interface using the back edge of a razor blade. The blue release film is then removed and a silicon die placed in the center of each tape pad. Each silicon die is then subjected to 25 pounds of force for 10 seconds in a Ametek/Hunter Spring mechanical press.

Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

Thermal test specimens are prepared as follows. The clear release film is removed from a piece of T-412 that is over sized for the transitor. The T-412 is then applied to the clean transistor covering all of its contact area. Air is squeezed out of the bond interface using the back edge of a razor blade. Excess T-412 is trimmed off the edges of the transistor. The blue release film is then removed. The transistor is then applied to the heat sink over the sites that have been prefitted with type K thermocouples. Four transistors are mounted, two per side new each outside edge and centered between the fins. And application force of 100 psi for a duration of 10 seconds is applied to each transitor. After one hour dwell, the Rj-s and Rj-a of each transitor was determined using the ATA.

All of the above test specimens were ssubjected to 100 thermal shocks from -50°C to 150°C by liquid to liquid immersion. The cold bath consisted of an insulated vessel containing 1.5 gallons of an alcohol dry ice slurry. The hot bath conbsisted of an insulated vessel on a stirring hot plate containing 1.5 gallons of silicon oil. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimens were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

Results:

Table 1: Die Shear strength before and after thermal shocks from -50°C to 150°C liquid to liquid.

25°C Testing		150° Testing	
Control Samples	Conditioned Samples	Control Samples	Conditioned Samples
1) 132.3	141.2	22.0	36.0
2) 123.5	132.2	26.0	32.0
3) 185.2	132.2	24.0	32.0
4) 123.5	132.2	26.0	32.0
5) 123.5	123.5	22.0	32.0
6) 123.5	123.5	22.0	30.0
Avg. 135.2	130.9	23.7	32.3

The 25°C test results show a 3.3% decrease in shear strength over the control.
The 150°C test results show a 36.3% increase in shear strength over the control.

Table 2: Lap shear strength before and after 100 thermal shocks from -50° to 150°C liquid to liquid.

	Control Samples	Conditioned Samples
1	71.0	76.0
2	72.0	79.0
3	68.0	76.0
4	72.0	80.0
5	73.0	84.0
Avg	71.0	79.0

The conditioned samples show a 11.3% increase in shear strength over the control.

Table 3: Rj-s, Rj-a for T-405 control and T-412 before and after 100 thermal shocks from -50° to 150°C liquid to liquid.

		BEFORE		AFTER	
Material	Transistor	Rj-s	Rj-a	Rj-s	Rj-a
T-405	GE 3055P	3.3	5.6	3.5	5.9
	TIP 33	3.9	6.3	3.7	6.0
T-412	GE 3055P	2.1	4.5	2.2	4.6
	TIP 33	2.5	4.9	3.0	5.1

Chomerics Thermattach T-412

100 Thermal Shocks -50° to 150°C Air to Air

Test Report on Strength versus Storage Condition

Summary: Random production samples of Thermattach T-412 were taken and prepared into test specimens that were subjected to 100 Thermal shocks from -50° to 150°C , air to air. These test specimens were then tested for strength versus a control group of test specimens. T-412 passed is test based on visual, die shear, hot die shear, lap shear, criteria.

Apparatus:

1. Tenny Jr. Model T shock Jr Ser# 12370-22
2. Aluminum substrates 1"x4" x 0.063" 2024 T3 Bare
3. Bare Silicon wafer cut to 0.500" x 0.500" x 0.020" die
4. Heat Sinks EG&G Wakefield (403K) fitted with Type K thermocouples
5. Transistors - GE 3055P, Motorola TIP 33A
6. Ametek/Hunter Spring force gauge and mechanical press Model #RM
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Procedure:

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Lap shear test specimen preparation is as follows. Samples that are preslit to 1" width are cut to 1.25" lengths. The clear release film is removed and the T-412 applied to one end of a clean aluminum substrates so that the 1" width is perpendicular to the 4" length of the aluminum substrate. Air is squeezed out of the bond interface using the back edge of a razor blade. The excess T-412 is then trimmed off the edges. The blue release film is then removed. The second clean aluminum substrate is applied so that it is parallel to the first aluminum substrate, but with only a 1" overlap. Five test specimens are prepared and placed individually into the Ametek/Hunter Spring press at 100 pounds for 10 seconds.

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All of the above test specimens were sealed into the thermal shock chamber for 100 thermal shocks from -50°C to 150°C air to air. The temperature was monitored for the duration of the 100 cycle conditioning period. After conditioning six of the die shear specimens were sheared on the model 1760 die shear tester at room temperature. The other six die shear specimens were sheared at 150°C on the model 1750 tester equipped with a model 1770 heated stage. The five lap shear specimens were sheared on a model 1125 Instron at a rate of 0.1" per minute at room temperature. The thermal test specimen was retested after conditioning on the ATA Analyzer. The Rj-s and Rj-a was determined for each of the transitors for comparison to the initial values.

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	TIP 33	2.5	4.9	3.0	5.1