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TEST REPORT

Reliability Test Results for THERMFLOW® T725 Material

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CHOMERICS

Parker Seals

SUMMARY OF PHYSICAL PROPERTIES

Property	T725	Test Method
Carrier	none	
Color	Pink	Visual
Thickness, in (mm)	0.005 (0.13)	ASTM D374
Tested at 50 PSI, 70ºC		
Thermal Impedance, °C-in²/W	0.03	ASTM D5470
Thermal Conductivity, W/m-K	0.7	ASTM D5470
Phase Change Temperature, °C	58	ASTM D3418
Specific Gravity	1.11	ASTM D792
Hardness, Shore A	20	ASTM D2240
Volume Resistivity, Ohm-cm	$>10^{14}$	ASTM D257

Summary: Random production samples of THERMFLOW T725 thermal interface pads were subjected to various environmental conditions and tested for thermal performance. No change in thermal performance was found under any test condition. No evidence of delamination or drying of the joint was seen in any case. A slight darkening in color of the exposed T725 material was seen in fixtures that had been exposed to temperatures of 125ºC.
These tests include visual inspection and thermal resistance across the interface ($\theta_{junction-sink}$ and $\Delta T_{plate-sink}$)

Equipment:

1. AnalysisTech Phase VI Thermal Analyzer (ATA). The ATA was used to measure $\theta_{junction-sink}$ and $\theta_{junction-ambient}$ before and after conditioning as well as to measure the temperature of the Vbe of the heat source transistor used in the test.
2. Heat Source. A GE 9915 MKJW 16010A TO247 transistor was used as the heat source.
3. Heat Sink. Pin Fin heat sinks, 1.75 x 1.75 x 0.6 inch, attached with four-prong clips. (Newark Electronics, Type 669052AB)
4. THERMFLOW T725. Random samples of 1.00 x 1.00 inch cut parts of T725 material was taken from inventory.

Procedure:

A) Fixture assembly: A T725 pad was applied to an “as received” heat sink by removing the T725 pad from the clear liner and applying the pad to the heat sink at room temperature with finger pressure. The blue liner was then removed from the pad and the heat sink was clipped to an 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 5 watts. Temperatures of the junction, the aluminum plate, the heat sink, and the ambient 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 re-tested for thermal performance.

C) Visual: Each test fixture was inspected for joint separation, for material loss, and for any sign of joint deterioration.

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 25 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 isopropanol 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%.

Procedure: Fixtures were placed in a chamber and fully exposed with no attempt made to protect metal surfaces or leads. 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 exposed interface material did not exhibit any apparent change after exposure to this environmental test condition.

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 1000hours storage at ambient conditions. This change in $\Delta T_{plate\text{-}sink}$ is not statistically significant. There is no change in the θj-s, which is a less sensitive parameter than the $\Delta T_{plate\text{-}sink}$. The $\Delta T_{plate\text{-}sink}$ decease is consistent with a gradual cold-flow of the material at room temperature resulting is a decrease in the bond line thickness.

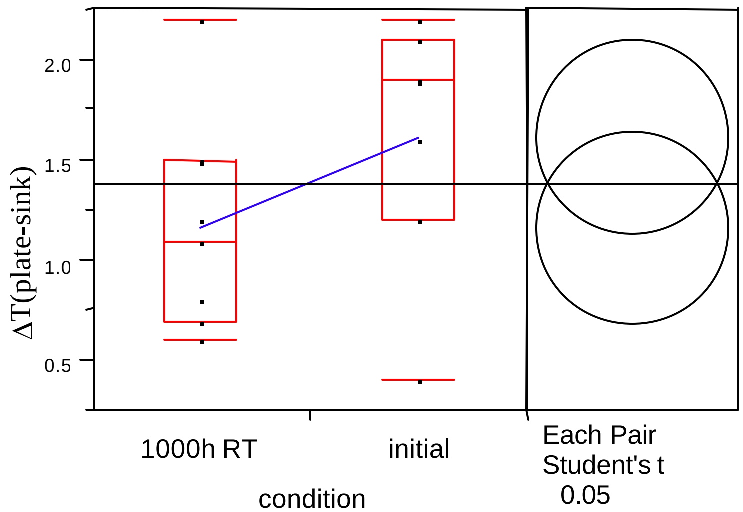
Raw Data

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

Test fixture #	Before Exposure			After Exposure		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W
22	77.0	2.1	1.94	74.4	1.2	2.05
23	75.5	0.4	2.06	74.3	0.7	2.03

24	77.4	1.9	1.84	75.8	2.2	1.91
25	76.8	1.2	2.21	74.2	0.8	2.08
26	78.3	2.2	1.91	74.4	0.6	2.16
27	78.4	1.9	1.86	74.5	1.5	1.98
28	77.9	1.6	1.93	75.1	1.1	1.96
Average		1.6	1.96		1.2	2.02

$\Delta T_{plate\text{-}sink}$,°C By condition



Oneway Anova

Means for Oneway Anova

Level	Number	Mean	Std Error
control-final	7	1.15714	0.22482
control-initial	7	1.61429	0.22482

Std Error uses a pooled estimate of error variance

Means Comparisons

Dif=Mean[i]-Mean[j]	control-initial	control-final
control-initial	0.000000	0.457143
control-final	-0.45714	0.000000

Alpha= 0.05

Comparisons for each pair using Student's t

t

2.17882

Abs(Dif)-LSD	control-initial	control-final
control-initial	-0.69274	-0.2356
control-final	-0.2356	-0.69274

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 exposed interface material darkened in color after exposure to this environmental test condition.

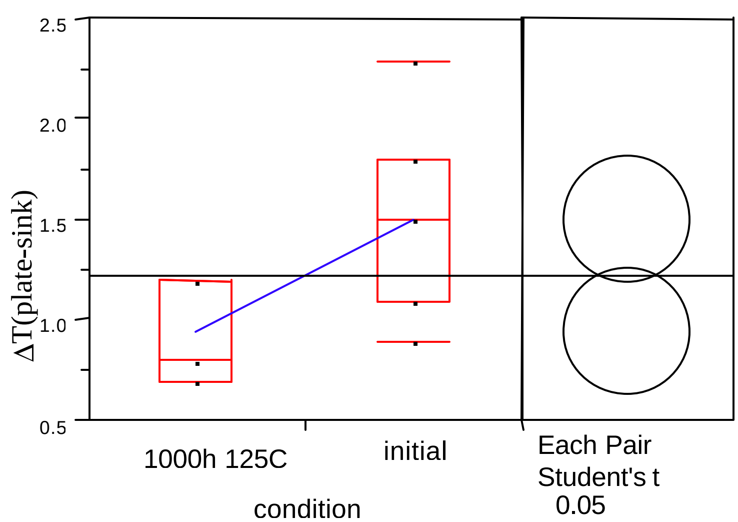
Thermal Performance: The before and after conditioning thermal resistances are given in Table 2. This data shows that there is a significant decrease in the $\Delta T_{plate\text{-}sink}$ after 1000hours storage at 125°C. There is no significant change in the θj-s, which is a less sensitive parameter than the $\Delta T_{plate\text{-}sink}$. The $\Delta T_{plate\text{-}sink}$ decease is consistent with flow of the material during conditioning resulting is a decrease in the bond line thickness.

Raw Data

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

Test fixture #	Before Exposure			After Exposure		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W
8	75.5	1.1	2.11	69.4	0.7	1.95
9	75.1	1.1	2.27	71.4	0.9	1.94
10	75.7	1.8	2.01	72.7	1.5	1.78
11	76.0	1.5	2.08	71.1	0.3	2.10
12	77.0	2.3	1.88	71.9	0.7	2.20
13	73.8	0.9	2.01	73.0	1.9	1.71
14	75.1	1.8	1.99	72.8	0.7	2.07
Average		1.5	2.05		1.0	1.96

$\Delta T_{plate\text{-}sink}$, °C By condition



Oneway Anova
Means for Oneway Anova

Level	Number	Mean	Std Error
125C-final	7	0.94286	0.14869
125C-initial	7	1.50000	0.14869

Std Error uses a pooled estimate of error variance
Means Comparisons

Dif=Mean[i]-Mean[j]	125C-initial	125C-final
125C-initial	0.000000	0.557143
125C-final	-0.55714	0.000000

Alpha= 0.05
Comparisons for each pair using Student's t
t
2.17882

Abs(Dif)-LSD	125C-initial	125C-final
125C-initial	-0.45816	0.098981
125C-final	0.098981	-0.45816

Positive values show pairs of means that are significantly different.

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

Results

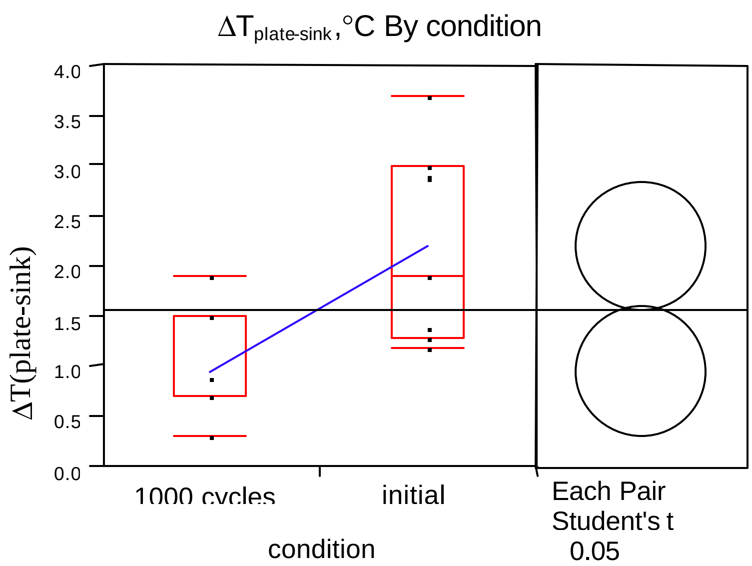
Visual: There was no evidence of delamination or drying of the joint. The exposed interface material showed a slight darkening in color after exposure to this environmental test condition.

Thermal Performance: The before and after conditioning thermal resistances are given in Table 3. This data shows that there is a significant decrease in the $\Delta T_{plate-sink}$ after 1000 cycles from 25°C to 125°C. There is no change in the θj-s, which is a less sensitive parameter than the $\Delta T_{plate-sink}$. The $\Delta T_{plate-sink}$ decease is consistent with flow of the material at during conditioning resulting is a decrease in the bond line thickness.

Raw Data

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

Test fixture #	Before Exposure			After Exposure		
	T_{plate}, °C	$\Delta T_{plate-sink}$, °C	θj-s, °C/W	T_{plate}, °C	$\Delta T_{plate-sink}$, °C	θj-s, °C/W
1	75.1	1.2	2.00	69.4	0.7	1.95
2	73.8	1.4	2.98	71.4	0.9	1.94
3	75.3	1.3	1.84	72.7	1.5	1.78
4	77.4	3.7	1.58	71.1	0.3	2.10
5	76.5	3.0	1.81	71.9	0.7	2.20
6	76.8	2.9	1.74	73.0	1.9	1.71
7	75.9	1.9	2.01	72.8	0.7	2.07
Average		2.2	1.99		1.0	1.96



Oneway Anova

Means for Oneway Anova

Level	Number	Mean	Std Error
cycle-final	7	0.95714	0.30349
cycle-initial	7	2.20000	0.30349

Std Error uses a pooled estimate of error variance

Means Comparisons

Dif=Mean[i]-Mean[j]	cycle-initial	cycle-final
cycle-initial	0.00000	1.24286
cycle-final	-1.24286	0.00000

Alpha= 0.05

Comparisons for each pair using Student's t

t

2.17882

Abs(Dif)-LSD	cycle-initial	cycle-final
cycle-initial	-0.93516	0.307696
cycle-final	0.307696	-0.93516

Positive values show pairs of means that are significantly different.

Temperature Shock, -50°C to 100°C, 25 cycles, Method 1.3.

Results

Visual: There was no evidence of delamination or drying of the joint. The exposed interface material did not exhibit any apparent change after exposure to this environmental test condition.

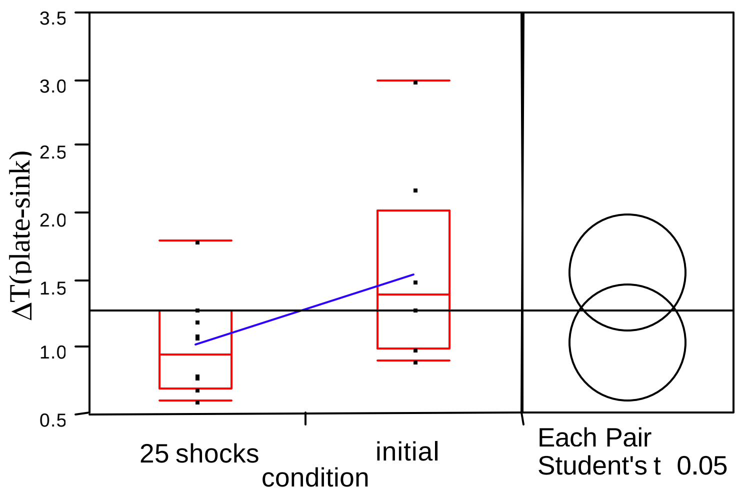
Thermal Performance: The before and after conditioning thermal resistances are given in Table 4. This data shows that there is a slight decrease in the $\Delta T_{plate-sink}$ after 25 thermal shock cycles from -50°C to 100°C. This change in $\Delta T_{plate-sink}$ is not statistically significant. There is no change in the θj-s, which is a less sensitive parameter than the $\Delta T_{plate-sink}$. The $\Delta T_{plate-sink}$ decease is consistent with flow of the material during conditioning resulting is a decrease in the bond line thickness.

Raw Data

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

Test fixture #	Before Exposure			After Exposure		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W
29	76.7	3.0	1.84	73.3	1.3	1.84
30	73.8	1.0	2.35	73.4	0.7	1.98
31	75.6	1.5	2.00	73.9	0.6	2.13
32	75.1	1.5	1.98	74.9	1.2	1.90
33	76.1	2.2	2.26	74.2	1.8	1.91
34	76.4	1.0	2.07	74.0	1.1	2.04
35	73.4	1.3	1.95	74.9	0.7	1.96
36	73.2	0.9	2.27	74.7	0.8	2.08
Average		1.6	2.09		1.0	1.98

$\Delta T_{plate\text{-}sink}$, °C By condition



Oneway Anova
Means for Oneway Anova

Level	Number	Mean	Std Error
shock-final	8	1.02500	0.20648
shock-initial	8	1.55000	0.20648

Std Error uses a pooled estimate of error variance

Means Comparisons

Dif=Mean[i]-Mean[j]	shock-initial	shock-final
shock-initial	0.000000	0.525000
shock-final	-0.525	0.000000

Alpha= 0.05

Comparisons for each pair using Student's t

t
2.14478

Abs(Dif)-LSD	shock-initial	shock-final
shock-initial	-0.62629	-0.10129
shock-final	-0.10129	-0.62629

Positive values show pairs of means that are significantly different.

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

Results

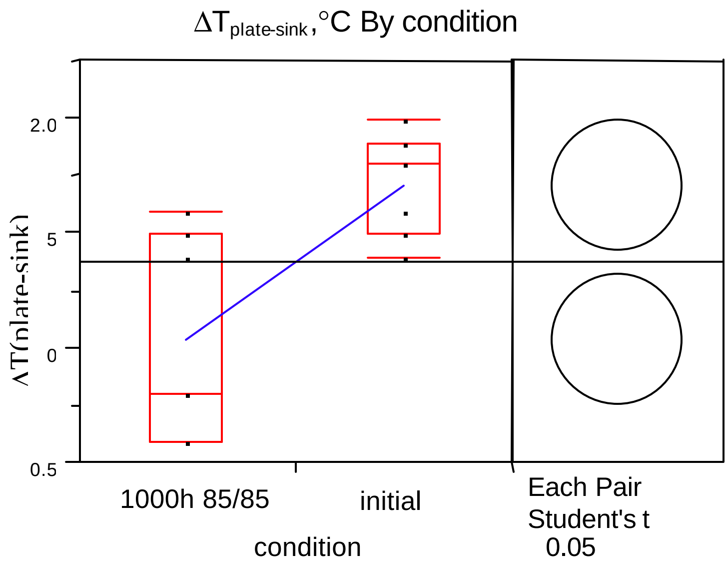
Visual: There was no evidence of delamination or drying of the joint. The exposed interface material did not exhibit any apparent change after exposure to this environmental test condition.

Thermal Performance: The before and after conditioning thermal resistances are given in Table 5. This data shows that there is a significant decrease in the $\Delta T_{plate\text{-}sink}$ after 1000hours storage at 85°C and 85% RH. There is no change in the θj-s, which is a less sensitive parameter than the $\Delta T_{plate\text{-}sink}$. The $\Delta T_{plate\text{-}sink}$ decease is consistent with flow of the material during conditioning resulting is a decrease in the bond line thickness.

Raw Data

Table 5 Thermal Performance. Samples stored in accordance with 1.4 method.

Test fixture #	Before Exposure			After Exposure		
	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$,°C	θj-s, °C/W	T_{plate}, °C	$\Delta T_{plate\text{-}sink}$, °C	θj-s, °C/W
15	75.0	1.8	2.00	70.3	1.5	1.92
16	75.8	1.8	1.83	70.9	0.8	1.95
17	75.9	2.0	1.78	70.1	0.6	1.96
18	75.8	1.5	2.14	70.9	0.8	2.01
19	75.8	1.9	1.82	70.5	0.6	1.84
20	75.8	1.4	1.89	71.3	1.4	2.04
21	75.9	1.6	2.03	71.7	1.6	2.04
Average		1.7	1.93		1.0	1.97



Oneway Anova

Means for Oneway Anova

Level	Number	Mean	Std Error
RH-final	7	1.04286	0.13119
RH-initial	7	1.71429	0.13119

Std Error uses a pooled estimate of error variance

Means Comparisons

Dif=Mean[i]-Mean[j]	RH-initial	RH-final
RH-initial	0.000000	0.671429
RH-final	-0.67143	0.000000

Alpha= 0.05

Comparisons for each pair using Student's t

t

2.17882

Abs(Dif)-LSD	RH-initial	RH-final
RH-initial	-0.40424	0.267191
RH-final	0.267191	-0.40424

Positive values show pairs of means that are significantly different.

THERMFLOW T725 in a Vertical Orientation

A brief test was conducted to determine the appropriateness of using the THERMFLOW T725 phase change material in a vertical orientation. A SECC Pentium® II heat spreader plate was used, along with a FOXCONN fan heat sink and the associated spring clips. See Figure 1. A pad of T725 was placed over the center of the fan heat sink, and the sink was clipped to the heat spreader plate. The entire assembly was placed into the oven for 20 minutes at 70°C. This exposed the T725 pad to temperature and pressure. The assembly was placed in a vertical orientation, so gravity was acting on the T725 pad parallel to the two metal surfaces.

After 20 minutes, the assembly was removed from the oven. A visual inspection of the assembly showed no signs of the THERMFLOW T725 material dripping out of the seam. A slight beading of the material, less than one inch in width, was noticed on the bottom edge of the heat spreader plate. See Figure 2.

The assembly was placed into the freezer to cool down to a comfortable temperature. This served two purposes. First, it allowed handling of the assembly so the fan heat sink could be separated from the heat spreader plate. Secondly, the T725 material is less tacky at lower temperatures, and cooling made separating the fan heat sink from the heat spreader plate easier. A screwdriver was used between the fan heat sink and the heat spreader to break the vacuum seal.

A visual inspection of the outline of the T725 material showed that the pad expanded outward from its original format in all directions equally. There was no indication of any gravity effects on the post flow pattern. See Figures 3 and 4.

Figure 1

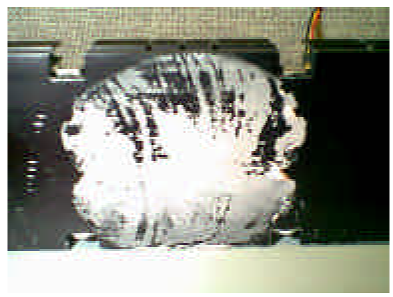


Figure 2

Figure 3

Figure 4