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DIODE

STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX 1N5615

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Prepared
For

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FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transisters, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the switching diode JANTX1N5615 manufactured by SEMTECH and MICRO SEMICONDUCTOR.

1.1 Sample Distribution

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum

rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours with temperature steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the

devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Semtech. The Semtech sample lot completed 1525 hours of Group I Testing before the lot was stopped because 50% of the devices failed. The first six failures occurred 500 hours into the 100% MRP step. Serial numbers 7495, 7496, 7497, 7498, 7499, and 7501 failed the maximum I_R limit. The next failure occurred 250 hours into the 125% MRP step. Serial number 7502 failed the maximum I_R limit. The last failure occurred 25 hours into the 150% MRP step. Serial number 7500 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 3.56nA from an initial mean of 36.51nA to a final mean of 40.07nA.
2) The mean value for V_F changed 0.022V from an initial mean of 1.388V to a final mean of 1.41V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Micro Semiconductor. The Micro Semiconductor sample lot completed 1650 hours of Group I Testing before the lot was stopped because more than 50% of the devices failed. The first two failures

occurred 250 hours into the 125% MRP step. Serial number 7530 failed the maximum I_R limit. Serial number 7531 was removed from the Group I Testing as a visual catastrophic failure.* The next four failures occurred 25 hours into the 150% MRP step. Serial numbers 7526, 7528, 7535 and 7538 were removed from the Group I Testing as visual catastrophic failures.* The last three failures occurred 150 hours into the 150% MRP step. Serial numbers 7533, 7534, and 7540 were removed from the Group I Testing as visual catastrophic failures. (See Table 8 for explanation.) Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 128.48nA from an initial mean of 95.62nA to a final mean of 224.1nA.
2) The mean value for V_F changed 0.018V from an initial mean of 1.0999V to a final mean of 1.081V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for each of the electrical parameters and all measurement points for both Siemens and Micro Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Semtech. The Semtech sample lot completed 480 hours of Group II Testing before the lot was stopped because 50% of the devices failed. The first two failures occurred 160 hours into the

100°C-temperature step. Serial numbers 7505 and 7506 failed the maximum I_R limit. The last six failures occurred 160 hours into the 125°C-temperature step. Serial numbers 7503, 7504, 7508, 7509, and 7510 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 1.19mA from an initial mean of 50.91nA to a final mean of 1.19mA.
2) The mean value for V_F changed 0.013V from an initial meean of 1.374V to a final mean of 1.387V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Micro Semiconductor. The Micro Semiconductor sample lot completed a total of 640 hours of Group II Testing before the lot was stopped because 50% of the devices failed. The first two failures occurred 160 hours into the 125°C-temperature step. Serial number 7542 was removed from the Group II Testing as a visual catastrophic failure. (See Table 8 for explanation.) Serial number 7553 failed the maximum I_R limit. The last six failures occurred 160 hours into the 150°C-temperature step. Serial numbers 7547, 7548, and 7556 failed the maximum I_R limit. Serial number 7544 was removed from the Group II Testing as a visual catastrophic failure.* Serial numbers 7554 and 7555 were removed from the Group II Testing as visual catastrophic failures. (See Table 8 for explanation.) Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 964.96nA from an initial mean of 77.04nA to a final mean of 1.042μA.

2) The mean value for V_F changed 0.020V from an initial mean of 1.110V to a final mean of 1.130V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II - Temperature Stress I Testing, for each of the electrical parameters and all of the measurement points pertaining to both Semtech and Micro Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Semtech. The Semtech sample lot completed a total of 32 hours of Group III Testing before the lot was stopped because 50% of the devices failed. The first seven failures occurred 16 hours into the 150°C-temperature step. Serial numbers 7511, 7512, 7513, 7514, 7516, 7517, and 7518 failed the maximum I_R limit. The last failure occurred 16 hours into the 175°C-temperature step. Serial number 7515 failed the maximum I_R limit. Typical characteristics of this sample lot's performannce were:

1) The mean value for I_R changed 3.798mA from an initial mean of 49.14nA to a final mean of 3.798mA.

2) The mean value for V_F changed 0.005V from an initial mean of 1.339V to a final

mean of 1.344V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 112-hour Group III Testing with 11 catastrophic failures. The first failure occurred 16 hours into the 225°C-temperature step. Serial number 7561 failed the maximum I_R limit. The next four failures occurred 16 hours into the 275°C-temperature step. Serial number 7558 failed the maximum I_R limit. Serial numbers 7557, 7565, and 7569 were removed from the Group III Testing as visual catastrophic failures. (See Table 8 for explanation.) The last six failures occurred 16 hours into the 300°C-temperature step. Serial number 7572 was removed from the Group III Testing as a visual catastrophic failure.* Serial numbers 7563, 7564, 7566, 7567, and 7568 were removed from the Group III Testing as visual catastrophic failures (See Table 8 for explanation.) Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 18.21μA from an initial mean of 87.09nA to a final mean of 18.30μA.
2) The mean value for V_F changed 0.011V from an initial mean of 1.108V to a final mean of 1.119V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines

the results of Group III - Temperature Stress II Testing, for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

Each of the three stress tests proved to be detrimental to both Semtech and Micro Semiconductor. Both manufacturers exceeded the 50% failure rate in all three groups. However, the MSC lots were processed about 100 hours longer than the Semtech lots in each case. The Semtech failures

were all due to reverse leakage current. Failure Analysis of Groups I and II revealed that these failures were caused by conductive external paint. When a band of paint was removed from each diode to interrupt the electrical conductivity, the diodes reverted to within acceptable test limits.

The failure mode for the Micro Semiconductor lots was mainly visual but there were some I_R failures also. The Group I MSC diodes that were submitted to failure analysis failed due to glass and silicon breakage caused by exposure to excessive power-generated heat. The three diodes submitted to failure analysis from the Group III sample lot exhibited significant drift in breakdown voltage and leakage during the curve tracer tests. The parts seem to be effected from surface contamination. The source of the contamination is unknown, particularly since one diode had the voltage drift problem and is still hermetically sealed.

A graph showing the cumulative failure distribution for Group II was drawn for the Semtech (Figures 2 and 3) and Micro Semiconductor (Figures 4 and 5) sample lots, but because of the visual catastrophic failures the Group III distributions could not be plotted. Likewise, the activation energies for both manufacturers could not be calculated.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The regression line was calculated using the least squares method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2}\right)\right]\left[\frac{8.63 \times 10^{-5}\ eV/^{o}K}{\left(\frac{1}{T_1+273}\right) - \left(\frac{1}{T_2+273}\right)}\right] eV$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in ^{o}C of 16% failure for Group II.

T_2 = temperature in ^{o}C of 16% failure for Group III.

NOTE:

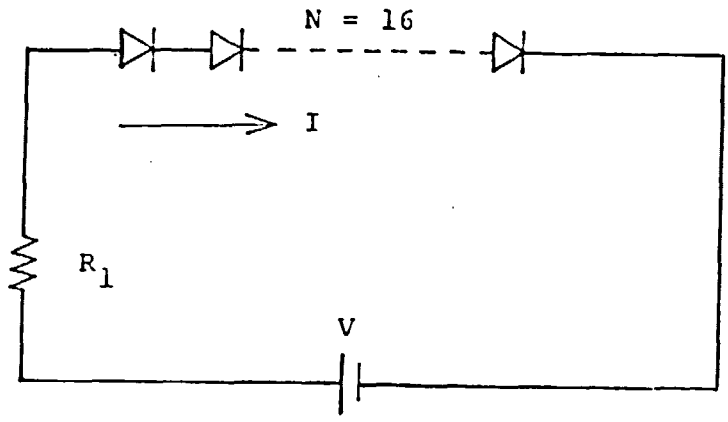
* Conditions for failure:

A) Open or short

B) Leakage exceeds the maximum limit by 100 times

C) Other parameters exceed MIL limits by 50% or more.

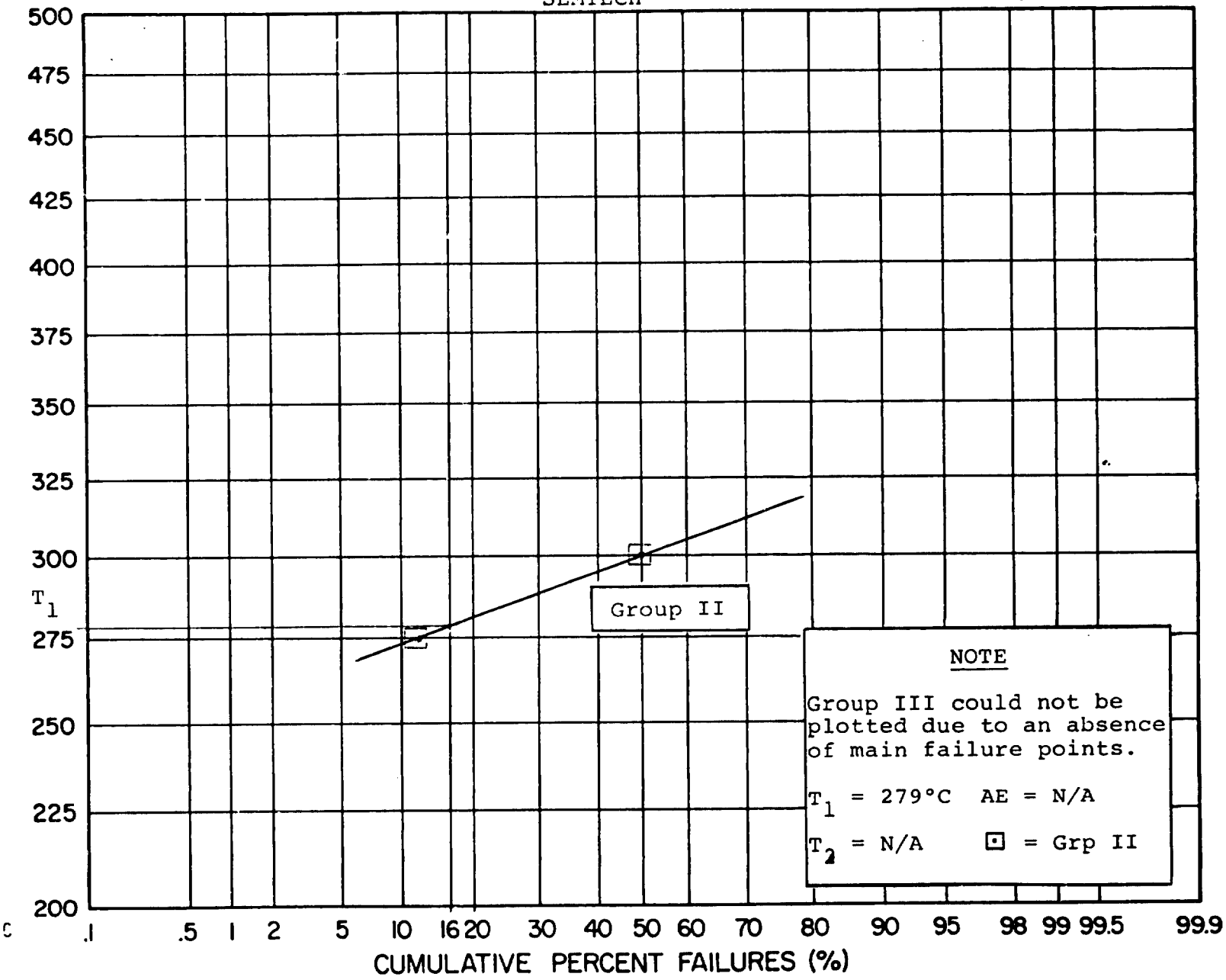
SWITCHING DIODES



$R_1 = 1V/_1 \pm 1\%$

$P_d = IE$

FIGURE 1
Power/Temperature Stress Circuit for
JANTX1N5615



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Semtech

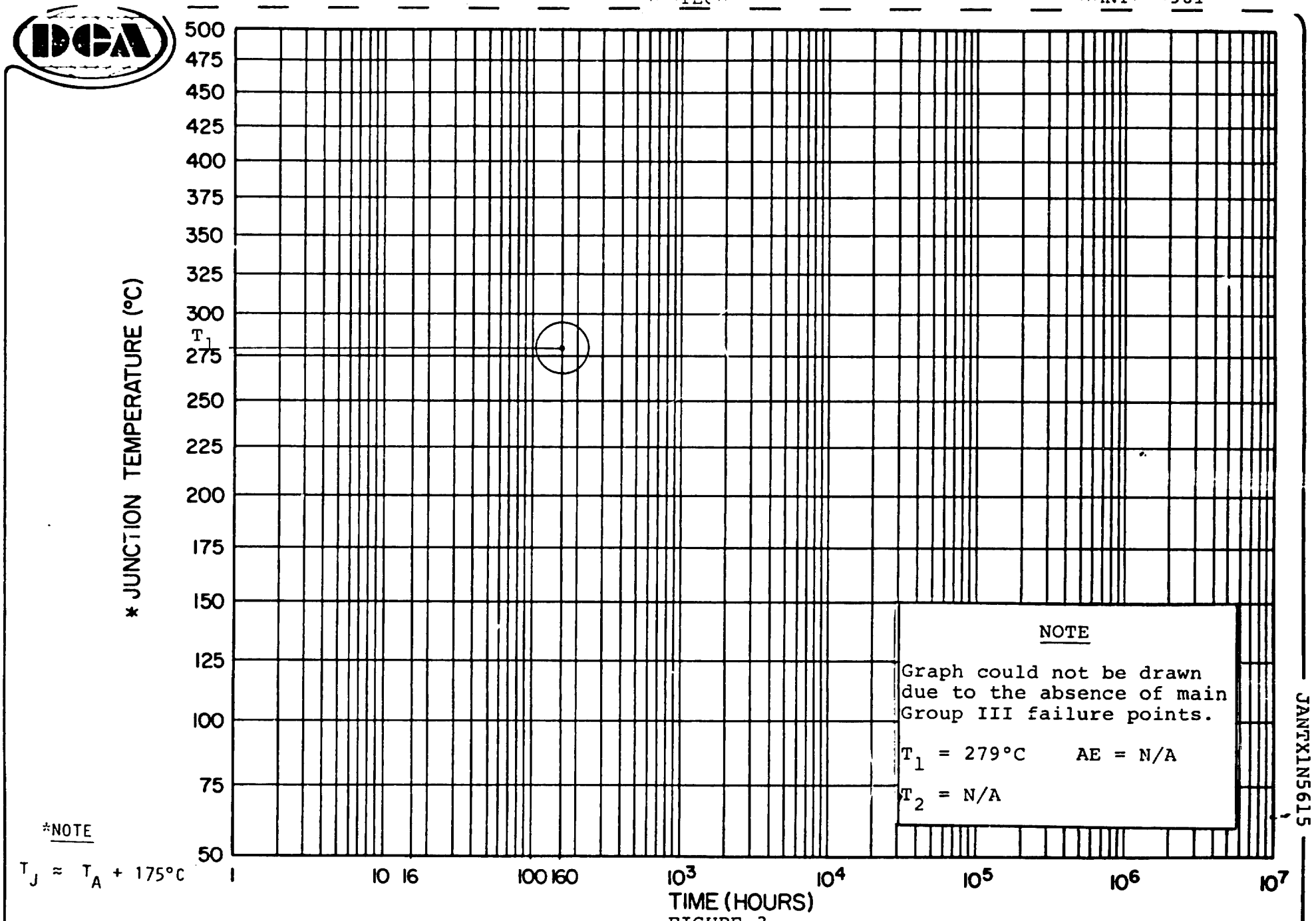
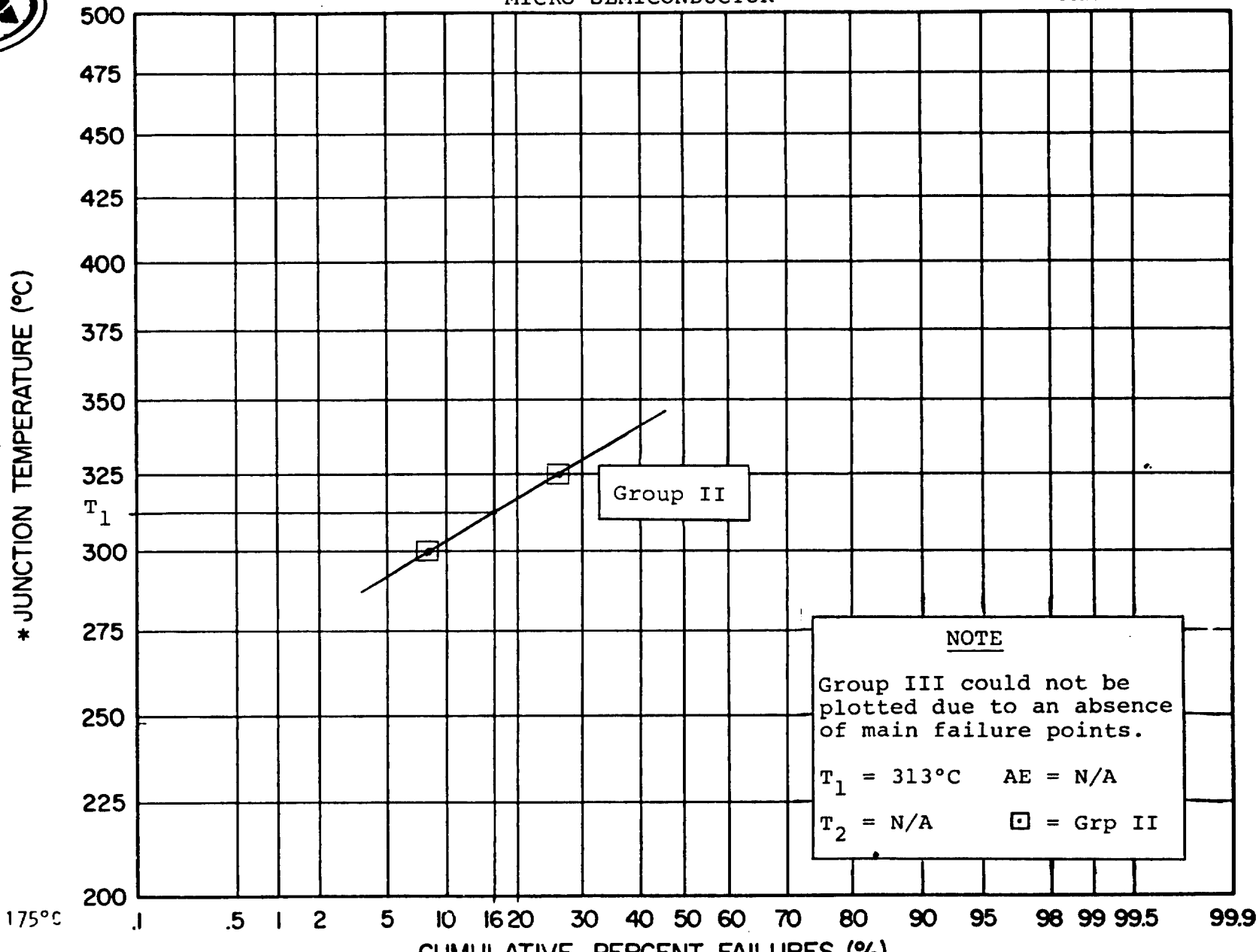


FIGURE 3
Time Steps Versus Junction Temperature, Semtech



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor

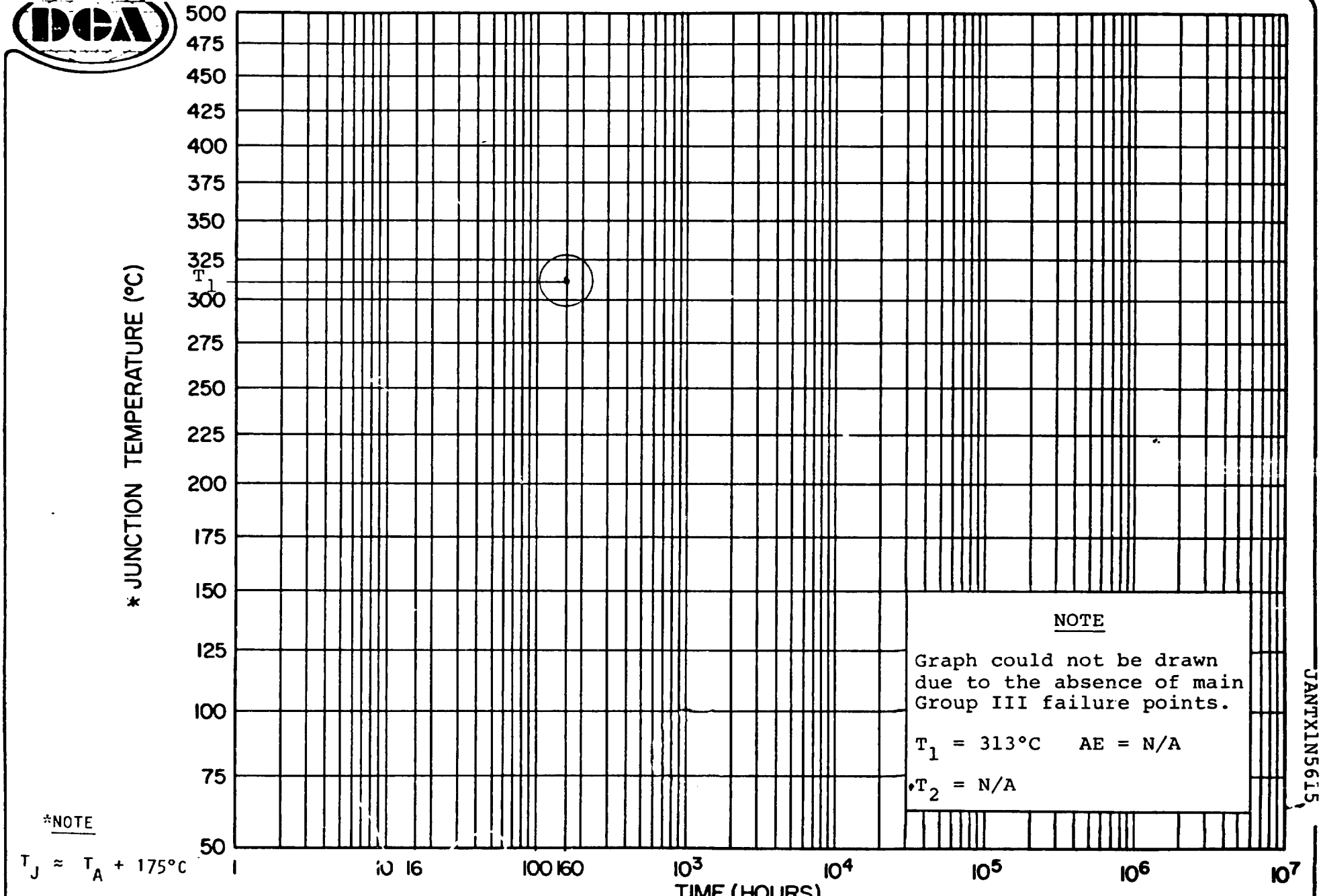
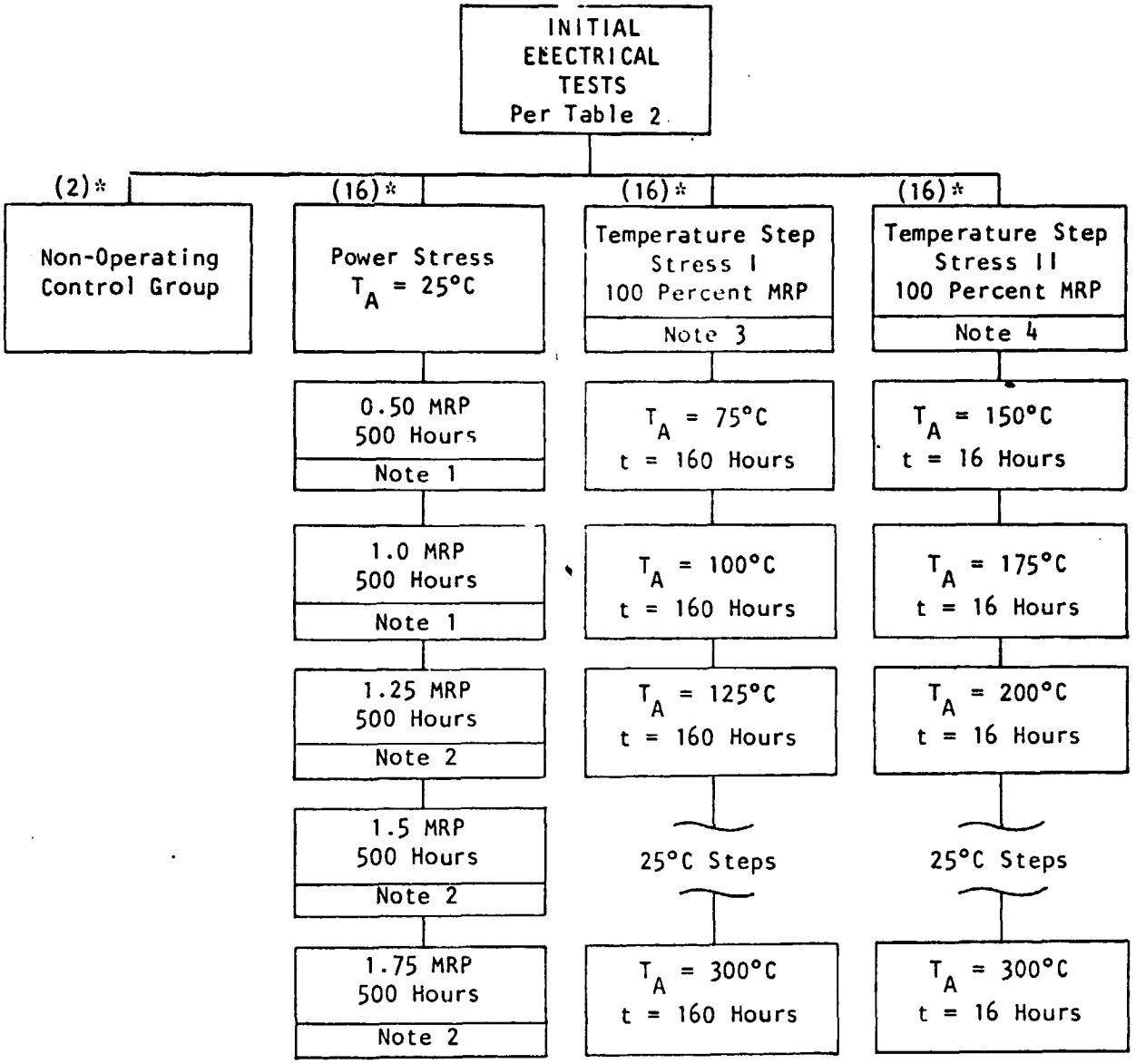


FIGURE 5
Time Steps Versus Junction Temperature, Micro Semiconductor

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Semtech and Micro Semiconductor)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were maue at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ V_R = 200V		.5		50	µA
V_F	@ I_F = 3.0A (Pulsed)	.8	1.6	.4	2.4	V

NOTES:
1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

V_F = 1.0V	
I_F =	Percent P_D
0.6A	50
1.2A	100
1.5A	125
1.8A	150
2.1A	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ±1% of the reading and ± one digit except for readings greater than 9.99mA which have an absolute accuracy of ±2% of the reading and ± one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_F = .5μA (MAX)		V_F = .8V(MIN) 1.6V(MAX)					
CONDITIONS AND LIMIT	@ V_R = 200V		@ I_F = 3.0A (Pulsed)					
IDENTIFICATION	SEM	MSC	SEM	MSC				
INITIAL DATA								
MIN VALUE	15.60nA	71.80nA	1.180V	1.070V				
MAX VALUE	75.00nA	155.00nA	1.580V	1.130V				
MEAN	36.51nA	95.62nA	1.388V	1.099V				
STD DEV	16.84nA	25.02nA	0.108V	0.015V				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	0.93nA	-2.92nA	-0.003V	-0.001V				
150 HRS	2.82nA	-4.75nA	-0.002V	0.001V				
150 HRS	3.78nA	-0.01nA	-0.001V	0.000V				
500 HRS	1.98nA	-8.71nA	0.000V	0.002V				
100% POWER								
550 HRS	-0.68nA	-21.86nA	-0.038V	-0.036V				
650 HRS	-5.87nA	-26.01nA	-0.016V	-0.003V				
750 HRS	391.09nA	-18.14nA	0.007V	0.002V				
1000 HRS	*2.17mA	-29.17nA	0.001V	0.002V				
125% POWER								
1010 HRS	1.29mA	-21.14nA	-0.017V	-0.001V				
1025 HRS	90.47μA	-31.22nA	-0.014V	-0.001V				
1050 HRS	447.49nA	-25.81nA	-0.003V	0.007V				
1150 HRS	3.76μA	-24.13nA	-0.009V	-0.003V				
1250 HRS	*34.61μA	*104.60μA	-0.019V	-0.024V				
1500 HRS	6.54μA	220.58nA	0.002V	0.005V				

(continued on second sheet)

TABLE 4 (Cont'd)
GROUP I — POWER STRESS DATA SUMMARY

(continued from first sheet)

PARAMETER	I_R = .5μA(MAX)		V_F = .8V(MIN) 1.6V(MAX)					
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 3.0A (Pulsed)					
IDENTIFICATION	SEM	MSC	SEM	MSC				
INITIAL DATA								
MIN VALUE	15.60nA	71.80nA	1.180V	1.070V				
MAX VALUE	75.00nA	155.00nA	1.580V	1.130V				
MEAN	36.51nA	95.62nA	1.388V	1.099V				
STD DEV	16.84nA	25.02nA	0.108V	0.015V				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	-3.09nA	2.91μA	0.012V	0.007V				
1525 HRS	*3.56nA	-15.84nA	0.022V	0.008V				
1550 HRS	JOB STOPPED	-12.56nA	JOB STOPPED	0.006V				
1650 HRS		128.48nA		-0.018V				
1750 HRS		JOB STOPPED		JOB STOPPED				
2000 HRS								
175% POWER								
2010 HRS	↓	↓	↓	↓				
2025 HRS	↓	↓	↓	↓				
2050 HRS	↓	↓	↓	↓				
2150 HRS	↓	↓	↓	↓				
2250 HRS	↓	↓	↓	↓				
2500 HRS	↓	↓	↓	↓				
FINAL DATA								
MIN VALUE	19.60nA	55.5nA	1.32V	1.060V				
MAX VALUE	91.80nA	739.0nA	1.51V	1.100V				
MEAN	40.07nA	224.1nA	1.41V	1.081V				
STD DEV	26.36nA	240.9nA	0.60V	0.015V				

* NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	I_R = .5μA (MAX)		V_F =.8V(MIN) 1.6V(MAX)					
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 3.0A (Pulsed)					
IDENTIFICATION	SEM	MSC	SEM	MSC				
INITIAL DATA								
MIN VALUE	15.00nA	57.60nA	1.210V	1.080V				
MAX VALUE	141.00nA	115.00nA	1.510V	1.160V				
MEAN	50.91nA	77.04nA	1.374V	1.110V				
STD DEV	41.98nA	17.05nA	0.099V	0.018V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
160 / 75°C	0.15nA	-16.40nA	0.007V	0.006V				
320 / 100°C	*36.77μA	62.86nA	0.011V	0.019V				
480 / 125°C	*1.19mA	*4.57μA	0.013V	0.031V				
640 / 150°C	JOB STOPPED	*964.96nA	JOB STOPPED	0.020V				
800 / 175°C		JOB STOPPED		JOB STOPPED				
960 / 200°C								
1120 / 225°C								
1280 / 250°C								
1440 / 275°C								
1600 / 300°C								
FINAL DATA								
FINAL TEMP (T_A)	125°C	150°C	125°C	150°C				
MIN VALUE	12.20nA	0.038μA	1.230V	1.11V				
MAX VALUE	5.02mA	7.090μA	1.530V	1.14V				
MEAN	1.19mA	1.042μA	1.387V	1.13V				
STD DEV	1.53mA	2.302μA	0.099V	0.01V				

* NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I_R = .5μA		V_F = .8V(MIN) 1.6V(MAX)					
CONDITIONS AND LIMITS	@ V_R = 200V		@ I_F = 3.0A (Pulsed)					
IDENTIFICATION	SEM	MSC	SEM	MSC				
INITIAL DATA								
MIN VALUE	16.00nA	58.20nA	1.170V	0.080V				
MAX VALUE	191.00nA	216.00nA	1.540V	1.140V				
MEAN	49.14nA	87.09nA	1.339V	1.108V				
STD DEV	50.29nA	35.61nA	0.106V	0.016V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS / TEMP (T_A)								
16 / 150°C	*1.286mA	-25.88nA	0.010V	0.008V				
32 / 175°C	*3.798mA	1.22nA	0.005V	0.002V				
48 / 200°C	JOB STOPPED	41.81nA	JOB STOPPED	0.005V				
64 / 225°C		*11.98μA		-0.016V				
80 / 250°C		9.58μA		0.003V				
96 / 275°C		*5.62μA		0.004V				
112 / 300°C		18.21μA		0.011V				
FINAL DATA								
FINAL TEMP (T_A)	175°C	300°C	175°C	300°C				
MIN VALUE	0.018μA	45.30nA	1.170V	1.100V				
MAX VALUE	9.990mA	122.00μA	1.540V	1.150V				
MEAN	3.798mA	18.30μA	1.344V	1.119V				
STD DEV	4.052mA	42.37μA	0.105V	0.015V				

*NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			SEM	MSC	SEM	MSC	SEM	MSC
I_R		.5	μA		*+224.76	*+5.9787	*+408.92	*+1.3954	*+2542.0	*+6.4882
V_F	.8	1.6	V		-.00488	-.00261	+.01033	+.0190	+.00750	+.00243

* NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N5615

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	0	–	0	–
100% 50 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	0	–	0	–
250 hr.	6	A	0	–
125% 10 hr.	0	–	0	–
15 hr.	0	–	0	–
25 hr.	0	–	0	–
100 hr.	0	–	0	–
100 hr.	1	A	1 / 1	A / B
250 hr.	0	–	0	–
150% 10 hr.	0	–	0	–
15 hr.	1	A	4	B
25 hr.	JOB STOPPED		0	–
100 hr.			3	C
100 hr.			JOB STOPPED	
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.	↓	↓	↓	↓

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	–	0	–
100°C	2	A	0	–
125°C	6	A	1 / 1	A / C
150°C	JOB STOPPED		3 / 2 / 1	A / C / B
175°C			JOB STOPPED	
200°C				
225°C				
250°C				
275°C				
300°C	↓	↓	↓	↓

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	7	A	0	–
175°C	1	A	0	–
200°C	JOB STOPPED		0	–
225°C			1	A
250°C			0	–
275°C			1 / 3	A / C
300°C	↓	↓	1 / 5	B / C

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

NOTES: A - I_R > 50μA

B - Visual (other than handling)*

C - Visual (other than handling)**

* 1) Visual due to the device cracking in half from the stress.

** 2) Visual due to an external lead detaching from the stress.

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N5615

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	1	A	0	-
250 hr.	1	A	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	0	-	0	-
250 hr.	0	-	1	A
150% 10 hr.	0	-	1	A
15 hr.	0	-	0	-
25 hr.	JOB STOPPED		0	-
100 hr.			JOB STOPPED	
100 hr.				
250 hr.				
175% 10 hr.				
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.	↓	↓	↓	↓

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	3	A	1	A
125 °C	0	-	3	A
150 °C	JOB STOPPED		2	A
175 °C			JOB STOPPED	
200 °C				
225 °C				
250 °C				
275 °C				
300 °C	↓	↓	↓	↓

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T_A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150 °C	0	-	0	-
175 °C	0	-	0	-
200 °C	JOB STOPPED		1	A
225 °C			3	A
250 °C			0	-
275 °C			1 \ 2	A \ B
300 °C	↓	↓	3	B

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

NOTES: A - I_R maximum limit failure

B - Visual failure due to handling

APPENDIX A

FAILURE ANALYSIS

POWER STRESS

FAILURE ANALYSIS

Date 3 January 1979

J/N 2CN242-17A **P/N** 1N5615 **MFR** SEMTECH

FAILURE VERIFICATION:

S/N	PIV -volts-	I_R @ 200 V.dc End Point: 50μA Max.	V_F @ 3.0A dc End Point: 0.4-2.4 V	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
7495 Paint removed	R = $4.8 \times 10^5 \Omega$ 430	>50μA <100nA		21 (125% MRP 1025 Hrs.)	I_R
7500 Paint removed	R = $3 \times 10^6 \Omega$ 480	>50μA 0.1μA		31 (150% MRP 1510 Hrs.)	I_R
7501 Paint removed	R = $4.5 \times 10^5 \Omega$ 410	>50μA 0.1μA		19 (100% MRP 1000 Hrs.)	I_R

VISUAL INSPECTION:

There were no significant visual defects on these diodes (see Figure A-1).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

Date 3 January 1979

J/N 2CN242-17A **P/N** 1N5615 **MFR** MICRO SEMICONDUCTOR

FAILURE VERIFICATION:

End Point: 50μA Max. End Point: 0.4-2.4 V

S/N	PIV -volts-	I_R @ 200 V. dc	V_F @ 3.0A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
7531	Cannot test	Cannot test	Cannot test	27 (125% MRP 1250 Hrs.)	Visual
7534	Cannot test	Cannot test	Cannot test	37 (150% MRP 1650 Hrs.)	Visual
7538	Cannot test	Cannot test	Cannot test	33 (150% MPR 1525 Hrs.)	Visual

VISUAL INSPECTION:

All three samples exhibit broken glass and siiicon die (see Figure A-2).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSIONS:

The Semtech samples failed because of conductive external paint. When a band of paint was removed from each diode to interrupt its electrical continuity, the diodes past within acceptable test limits. (See Failure Verification data above.)

All Micro Semiconductor samples failed due to glass and silicon breakage which was caused by exposing the diode components to excessive power-generated heat.

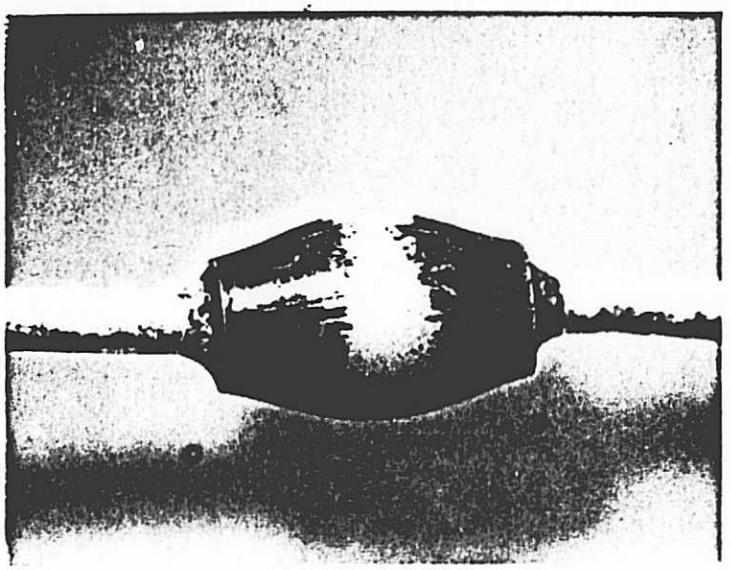


FIGURE A-1.
S/N 7495, Semtech, 10X.
Typical Semtech diode after removing a band
of paint to interrupt its electrical continuity.

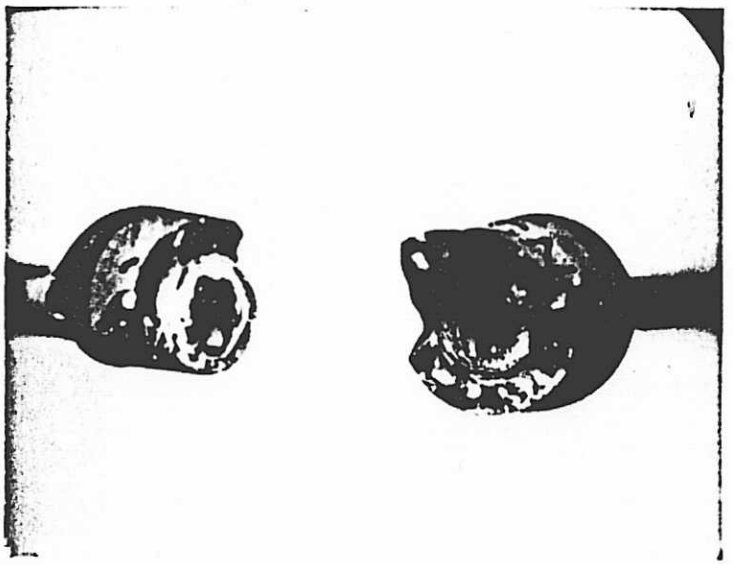


FIGURE A-2
S/N 7531, Micro Semiconductor, 12X.
Typical Micro Semiconductor diode
showing broken glass and silicon.

APPENDIX B

FAILURE ANALYSIS

TEMPERATURE STRESS

FAILURE ANALYSIS

Date 7 April 1978

J/N 2CN242-17C **P/N** 1N5615 **MFR** SEMTECH

FAILURE VERIFICATION:

S/N	PIV -volts-	I_R @ 200 V.dc	V_F @ 3 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
03	460	3.2mA(R)	1.45 volts	05	I_R
04	380	5 mA (R)	1.20 volts	05	I_R
05	480	9 mA (R)	1.20 volts	05	I_R
After 03	stripping paint:	40 nA			
04		64 nA			
05		160 nA			

INTERNAL VISUAL INSPECTION

No internal visual inspection performed.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

FAILURE ANALYSIS

Date 7 April 1978

J/N 2CN242-17C **P/N** 1N5615 **MFR** MICRO SEMICONDUCTOR

FAILURE VERIFICATION:

S/N	PIV -volts-	I_R @ 200 V.dc	V_F @ 3 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
7558	300	350μA	1.12 volts	13 (275°C)	I_R
7561	420	100μA	1.12 volts	09 (225°C)	I_R
7568	360	350μA	1.12 volts	15 (300°C)	Lead detached

VISUAL INSPECTION

The external wire leads have blackened from the oven heat. The tarnished leads are still conductive but their solderability has dropped to zero. S/N 7558 and 7561 have cracked glass (see Figure B-1). S/N 7568 has a missing anode lead which came loose and detached during burn-in (see Figure B-2).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

CONCLUSIONS:

Semtech. The paint on the Semtech devices was probed for conductivity at 200 volts. Several diodes had conductive paint averaging about 600 K-ohms. S/N 03, S/N 04 and 05 had conductive paint, with leakages in the milliamp range (see Failure Verification data above). After chemically stripping the paint and retesting, S/N 03, 04, and 05 came well within the acceptable range.

Micro Semiconductor. All three samples exhibited significant drift in breakdown voltage and/or leakage during the curve tracer tests (see Failure Verification data above). The parts seem to be affected from surface contamination. The source of the contamination is unknown, particularly since S/N 7568 had the voltage drift problem and is still hermetically sealed.

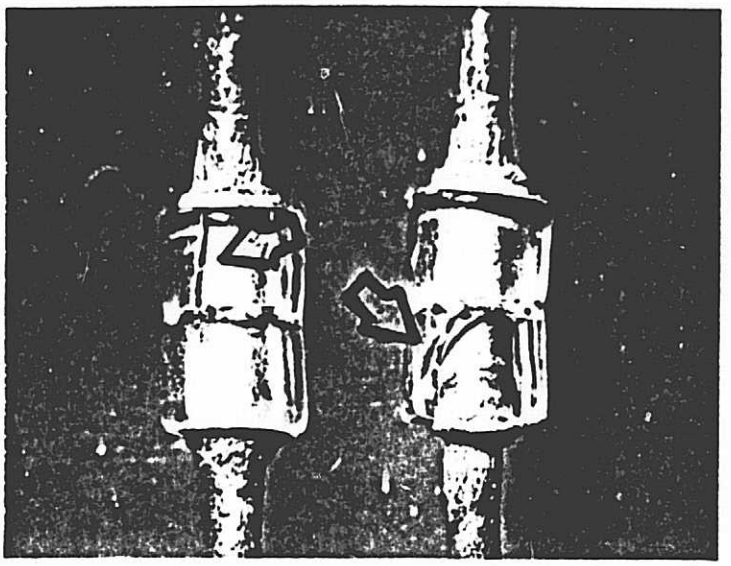


FIGURE B-1
S/N 7258 (left) and 7260 (right), Micro Semiconductor, 8X.
Arrows indicate cracked glass.

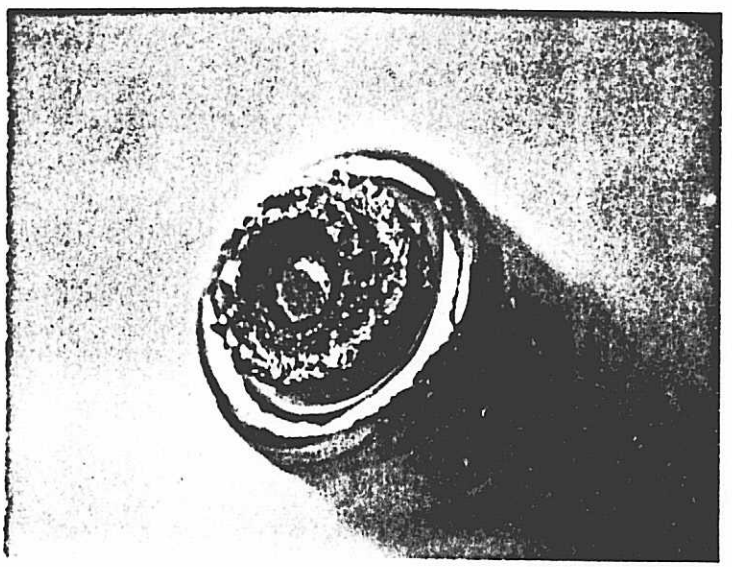


FIGURE B-2
S/N 7568, Micro Semiconductor, 20X.
Typical diode after loss of external wire lead.