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# DIODE

# STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX 1N645-1

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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 transistors, 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 diode JANTXIN645-1 manufactured by Semtech and Micro Semiconductor.
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 of 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 this 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 MRP for a total of 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 MRP in increments 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 MRP 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 a total of 2150 hours of Group I Testing before the lot was stopped because 50% of the lot failed. The first failure occurred 150 hours into the 100% MRP step. Serial Number 7176 failed the maximum $I_R$ limit. The next two failures occurred 150 hours into the 150% MRP step. Serial Numbers 7150 and 7151 failed the maximum $I_R$ limit. The next failure occurred 250 hours into the 150% MRP step. Serial Number 7148 failed the maximum $I_R$ limit. The next failure occurred 500 hours into the 150% MRP step. The last two failures occurred 150 hours into the 175% MRP step. Serrial Numbers 7146 and 7147 failed the maximum $I_R$ limit. Serial Number 7174 was removed from the testing at this point as a visual reject due to handling.

Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 207.48μA from an initial mean of 18.74nA to a final mean of 207.50μA.

2) The mean value for $V_F$ changed 11.4mV from an initial mean of 932.8mV to a final mean of 944.2mV.

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 the entire 2500-hour Group I Testing with a total of five catastrophic

failures. The five failures occurred 50 hours into the 100% MRP step. Serial Numbers 7201, 7202, and 7204 failed the maximum $I_R$ limit. Serial Numbers 7203 and 7205 were removed from the testing as visual catastrophic failures because of a detached anode lead due to the stress. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 1.25nA from an initial mean of 856.9pA to a final mean of 2.10nA.

2) The mean value for $V_F$ changed 5.8mV from an initial mean of 907.6mV to a final mean of 901.8mV.

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 Semtech and Micro Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Semtech. The Semtech sample lot completed a total of 640 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first three failures occurred 160 hours into the 125°C-temperature step. Serial Numbers 7159, 7181, and 7182 failed the maximum $I_R$ limit. The last six failures occurred 160 hours into the 150°C-temperature step. Serial Numbers 7153, 7154, 7155, 7156, 7157, and 7158 failed the maximum $I_R$ limit. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 91.83μA from an initial mean of 12.21nA to a final mean of 91.84μA.
2) The mean value for $V_F$ changed 2.9mV from an initial mean of 953.9mV to a final mean of 951.0mV. 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 the entire 2500-hour Group II Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:
1) The mean value for $I_R$ changed 31.99nA from an initial mean of 4.75nA to a final mean of 36.74nA.
2) The mean value for $V_F$ changed 9.2mV from an initial mean of 915.3mV to a final mean of 906.1mV. The control units for this sample lot remained constant throughout the entire Group II testing.

3.2.3 Statistical Summary - Group II. Table 5 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 48 hours of Group III testing before the lot was stopped because 50% of the devices failed. The eight failures occurred 16 hours into the 200°C-temperature step. Serial Numbers 7160, 7161, 7162, 7163, 7164, 7165, 7166 and 7167 failed because of excessive $I_R$ leakage. Typical

characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed 1.3mA from an initial mean of 18.42nA to a final mean of 1.3mA.

2) The mean value for $V_F$ changed 57.4mV from an initial mean of 930.7mV to a final mean of 873.3mV.

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

3.3.2 Micro Semiconductor. The Micro Semiconductor lot completed the entire 112-hour Group III Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for $I_R$ changed .66nA from an initial mean of 1.47nA to a final mean of 811.90pA.

2) The mean value for $V_F$ changed 6.6mV from an initial mean of 904.7mV to a final mean of 898.1mV.

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

3.3.3 Statistical Summary - Group III. Table 7 outlines the results of Group III - Temperature Stress II Testing for each of the electrical parameters and all of the measurement points pertaining to both Semtech and Micro Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statisticaly 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 I - 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 temperature $T_1$ 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 was 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

All three stress groups proved detrimental to Semtech, whereas Micro Semiconductor's lot performed well throughout the testing. An apparent $I_R$ failure mode can be seen in each of the three groups for Semtech. The Semtech diodes are constructed with glass encapsulation which is painted with black paint. After stripping the paint, the $I_R$ leakage decreases to less than one micro ampere. This suggests that the devices failed because of a static charge on the surface of the glass encapsulant which developed from the thermal decomposition of the paint. Most or all of the harmful decomosition produced was removed with the paint.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Semtech sample lot (Figures 2 and 3), but a plot for the Micro Semiconductor sample lot could not be drawn due to an absence of failure points in the Groups II

and III Testing (Figures 4 and 5). Figures 2 and 3 display the data for the Semtech sample lot used to calculate an activation energy of 1.36eV.
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 failure point. The regression line was drawn using the least square method.

The activation energy was calculated from the formula:

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

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 $^{\circ}C$ of 16% failure for Group II.

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

NOTE:

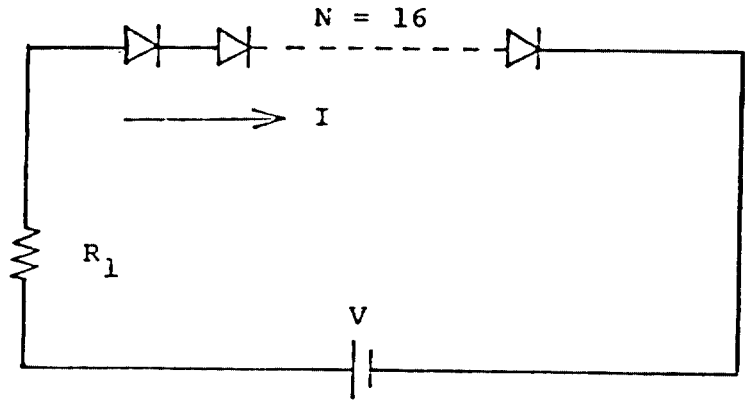
*Conditions for failure:

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

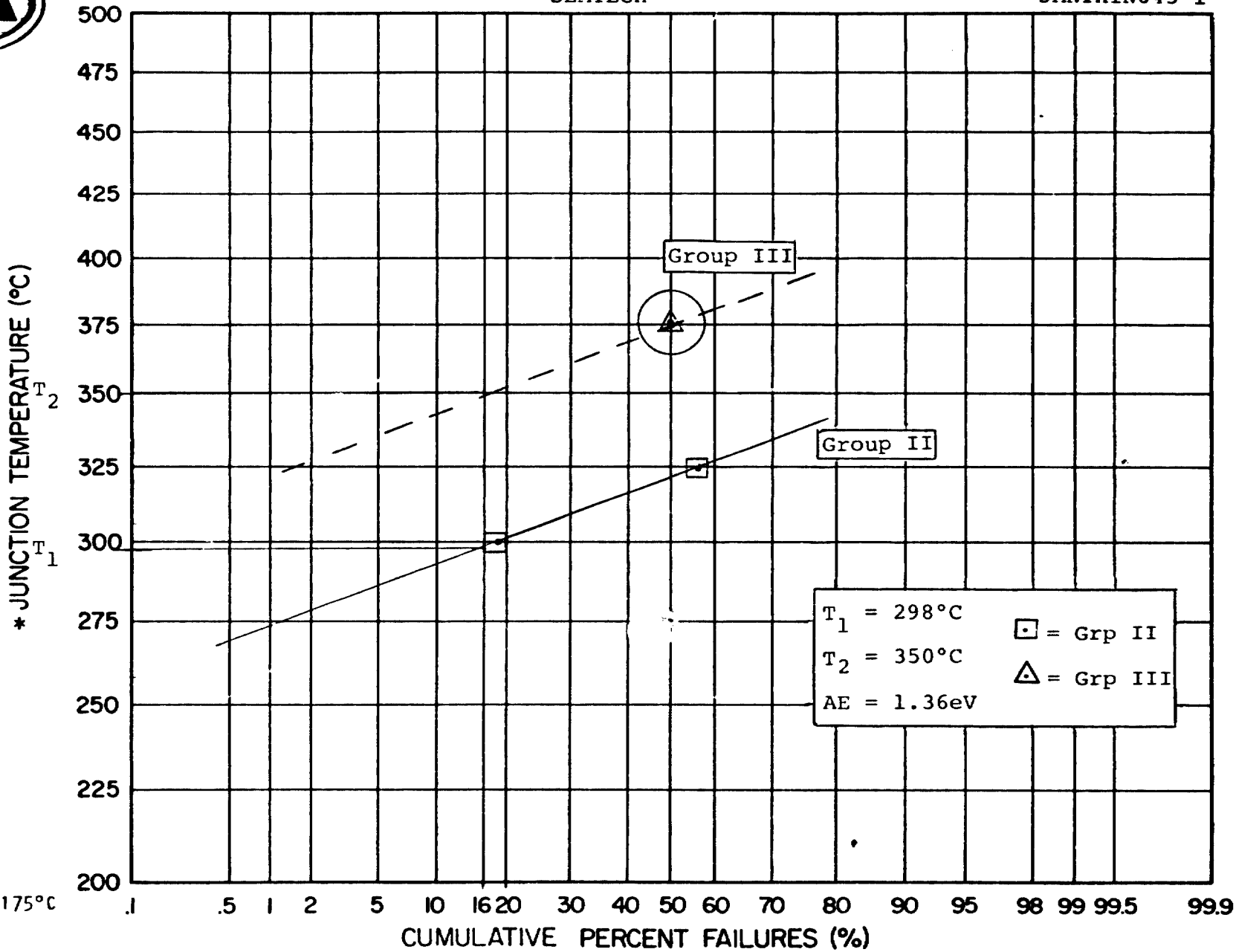



$R_1 = 1V/I \pm 1\%$

$P_d = IE$

FIGURE 1

Power and Temperature Stress Circuit for JANTX1N645-1



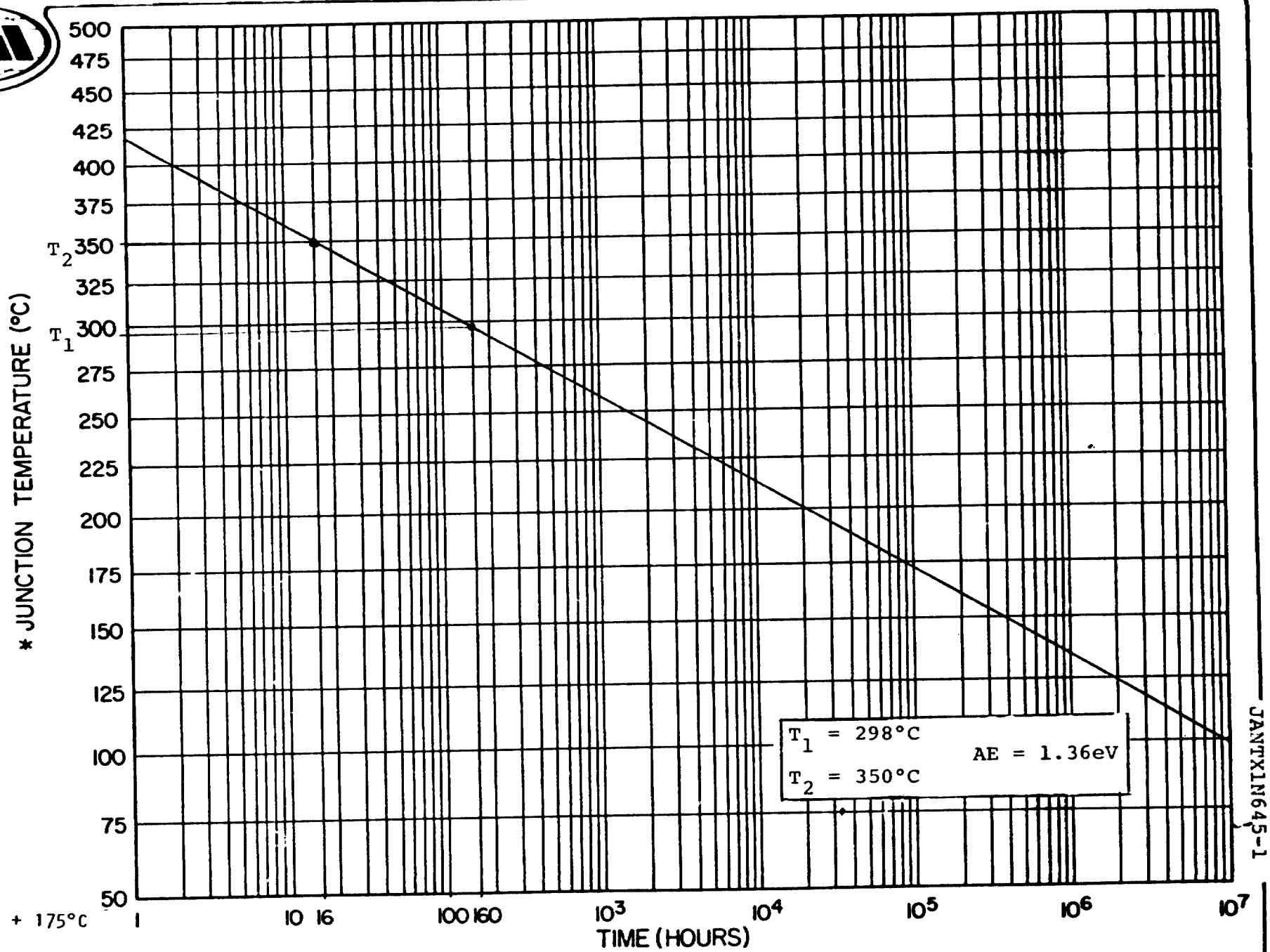

*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Semtech



JANTX1N645-1

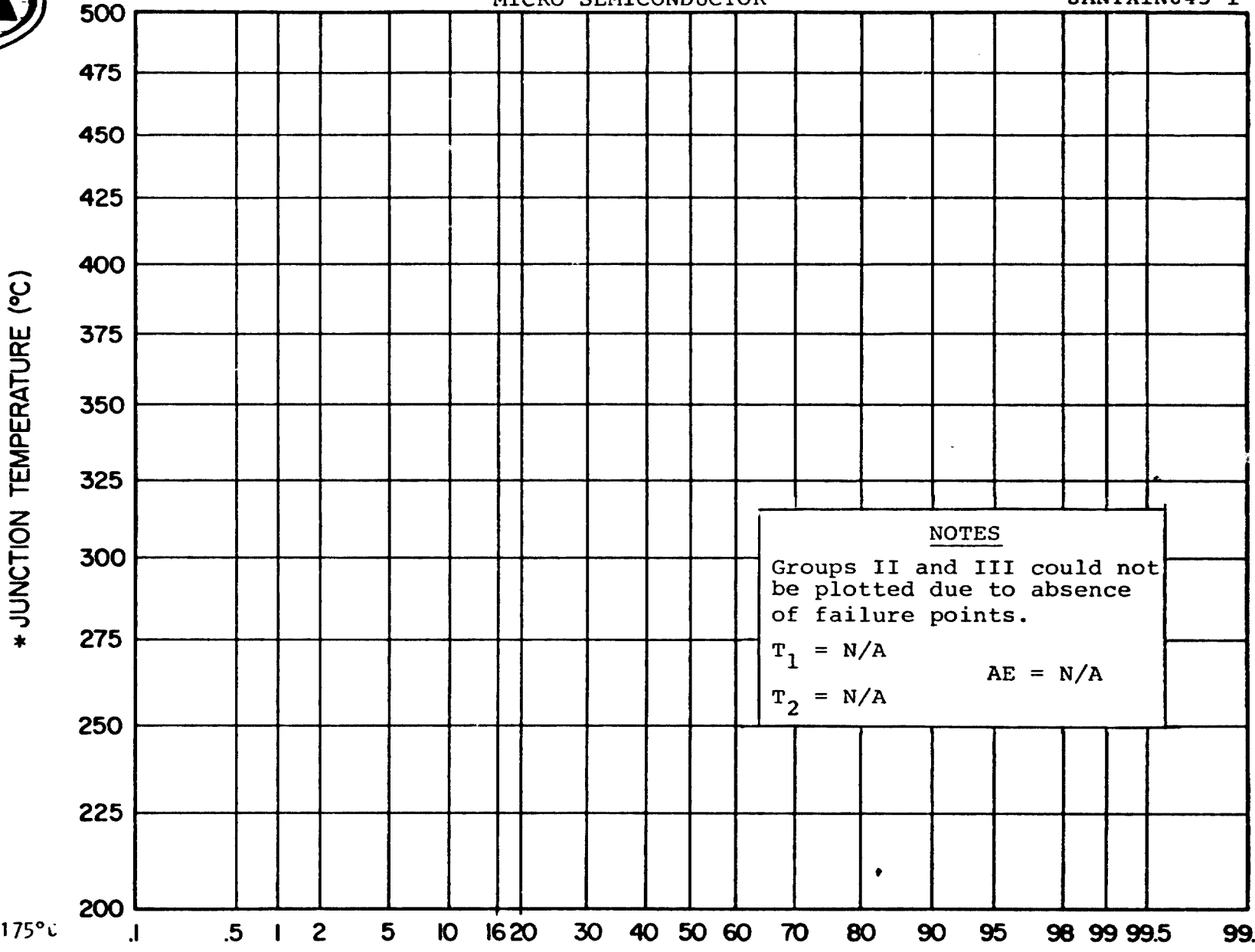



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 3

Time Steps Versus Junction Temperature, Semtech




*NOTE

$T_J \simeq T_A + 175°C$

FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor

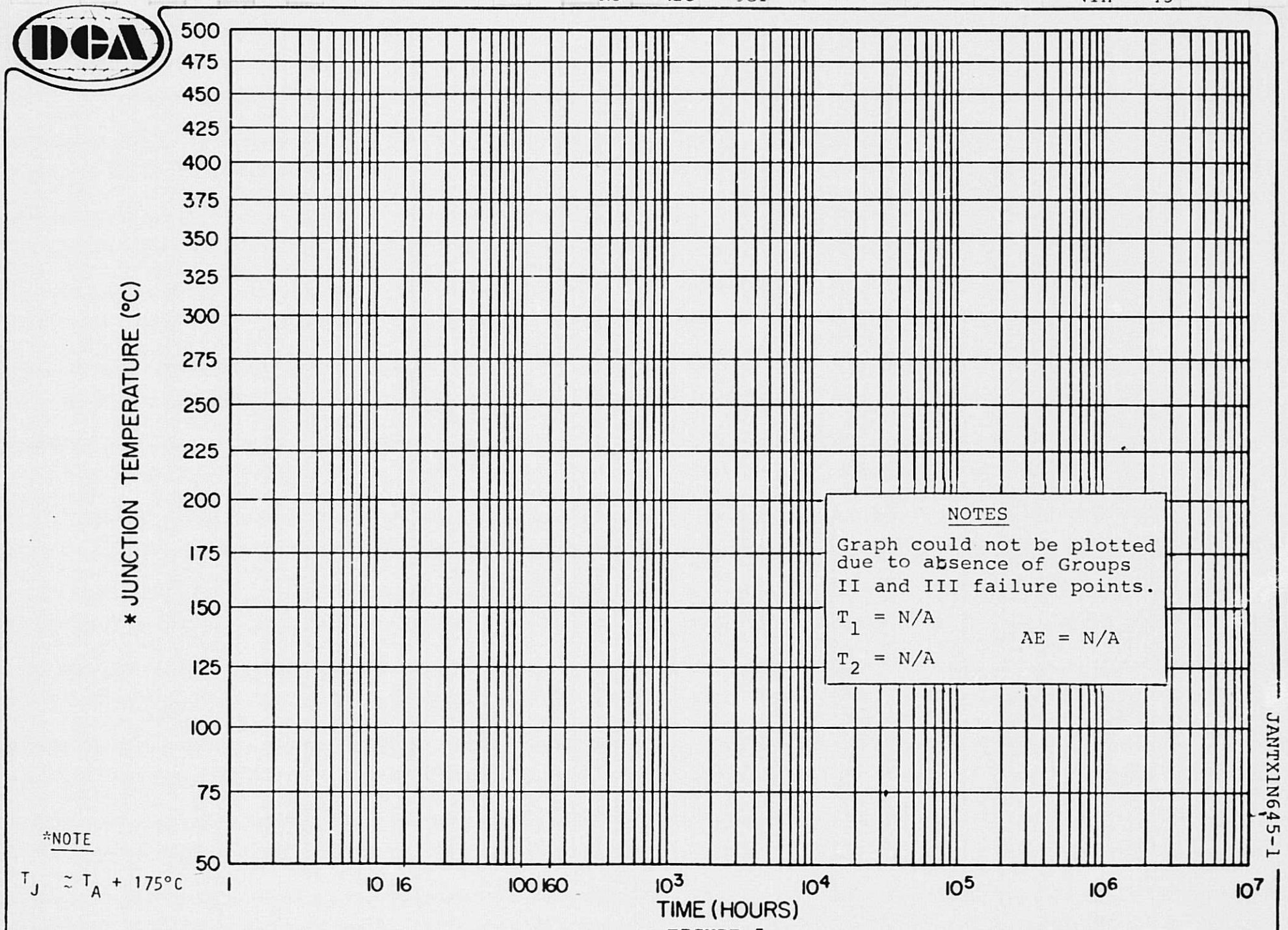
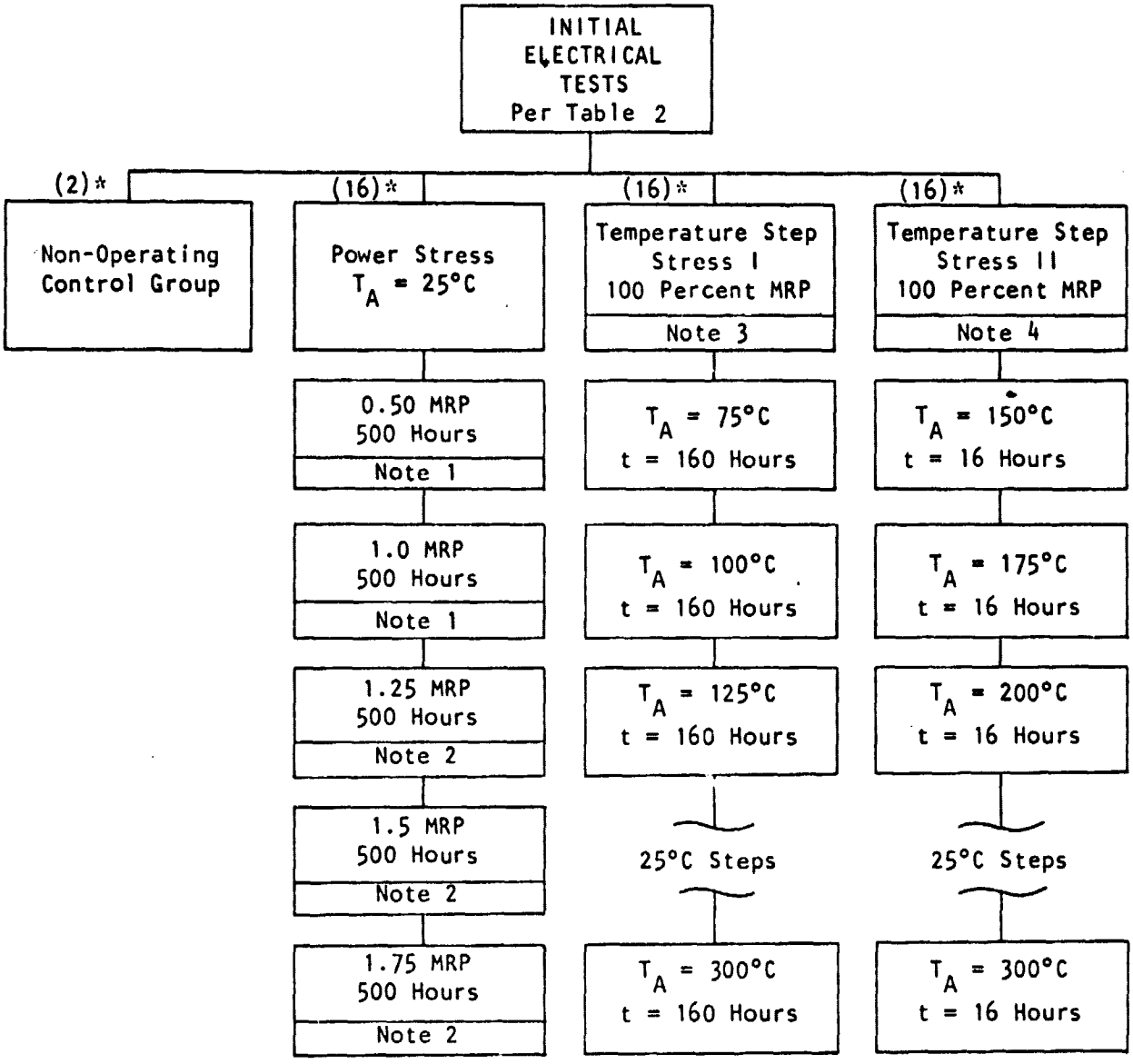



FIGURE 5
Time Steps Versus Junction Temperature, Micro Semiconductor

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 made at the end of each 16 hours.

TABLE 2
PARAMETERS AND TEST CONDITIONS

| PARAMETER | CONDITIONS | SPEC. LIMIT | | CAT. LIMIT | | UNITS |
|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | |
| $I_R$ | @ $V_R$ = 225V | | .05 | | 5 | µA |
| $V_F$ | @ $I_F$ = 400.0mA (PULSED) | | 1.0 | | 1.5 | 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 $P_D$ |
| .24 A | 50 |
| .48A | 100 |
| .60A | 125 |
| .72A | 150 |
| .84A | 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 | $I_R$ = .05μA (MAX) | | $V_F$ = 1.0 V (MAX) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMIT | @ $V_R$ = 225 V | | @ $I_F$ = 400 mA (PULSED) | | | | | |
| IDENTIFICATION | SEM | MSC | SEM | MSC | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 5.55nA | 240.00pA | 911.0mV | 904.0mV | | | | |
| MAX VALUE | 38.30nA | 2.17nA | 970.0mV | 916.0mV | | | | |
| MEAN | 18.74nA | 856.90pA | 932.8mV | 907.6mV | | | | |
| STD DEV | 10.84nA | 635.40pA | 17.3mV | 2.9mV | | | | |
| INTERIM DATA | | | | | | | | |
| POWER 50 TO 125%<br>Δ MEAN VALUE | | | | | | | | |
| 50% POWER | | | | | | | | |
| 50 HRS | -1.68nA | 123.7pA | -5.7mV | -0.1mV | | | | |
| 150 HRS | -2.56nA | 48.7pA | 4.0mV | 3.3mV | | | | |
| 250 HRS | 0.33nA | 292.1pA | 0.7mV | -1.3mV | | | | |
| 500 HRS | 1.52nA | 574.1pA | 1.6mV | 0.5mV | | | | |
| 100% POWER | | | | | | | | |
| 550 HRS | 11.52nA | 429.1pA | 1.8mV | -6.8mV | | | | |
| 650 HRS | 1.79nA | 491.1pA | 4.9mV | 1.6mV | | | | |
| 750 HRS | 10.34nA | 530.1pA | 2.5mV | 0.8mV | | | | |
| 1000 HRS | 17.29nA | 498.1pA | 3.6mV | 0.6mV | | | | |
| 125% POWER | | | | | | | | |
| 1010 HRS | 52.74nA | 498.1pA | -4.6mV | -8.6mV | | | | |
| 1025 HRS | 388.86nA | 264.1pA | 3.3mV | -1.4mV | | | | |
| 1050 HRS | *687.86nA | 144.1pA | 8.7mV | 2.1mV | | | | |
| 1150 HRS | -2.17nA | 1.1nA | 6.8mV | 1.3mV | | | | |
| 1250 HRS | -1.98nA | 500.1pA | 9.3mV | 2.2mV | | | | |
| 1500 HRS | -0.99nA | 570.1pA | 3.1mV | 2.1mV | | | | |

(continued on second sheet)

TABLE 4 (Cont'd)

(continued from first sheet) GROUP I – POWER STRESS DATA SUMMARY



| PARAMETER | $I_R$ = .05μA (MAX) | | $V_F$ = 1.0V (MAX) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | @ $V_R$ = 225V | | @ $I_F$ = 400mA (PULSED) | | | | | |
| IDENTIFICATION | SEM | MSC | SEM | MSC | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 5.55nA | 240.00pA | 911.0mV | 904.0mV | | | | |
| MAX VALUE | 38.30nA | 2.17nA | 970.0mV | 916.0mV | | | | |
| MEAN | 18.74nA | 856.90pA | 932.8mV | 907.6mV | | | | |
| STD DEV | 10.84nA | 635.40pA | 17.3mV | 2.9mV | | | | |
| INTERIM DATA | | | | | | | | |
| POWER 150 TO 175% Δ MEAN VALUE | | | | | | | | |
| 150% POWER | | | | | | | | |
| 1510 HRS | -0.72nA | 715.1pA | 6.6mV | 1.8mV | | | | |
| 1525 HRS | 5.23nA | 207.1pA | 3.6mV | -1.9mV | | | | |
| 1550 HRS | 34.13nA | 1.2nA | 5.3mV | -2.9mV | | | | |
| 1650 HRS | *9.76μA | 598.1pA | -0.4mV | -9.8mV | | | | |
| 1750 HRS | *124.28μA | 688.1pA | 9.6mV | -0.6mV | | | | |
| 2000 HRS | *17.23μA | 662.1pA | 4.5mV | -6.0mV | | | | |
| 175% POWER | | | | | | | | |
| 2010 HRS | 21.38μA | 415.1pA | -10.3mV | -4.9mV | | | | |
| 2025 HRS | 37.31μA | 793.1pA | 8.7mV | -4.2mV | | | | |
| 2050 HRS | 74.23μA | 507.1pA | 11.0mV | 0.9mV | | | | |
| 2150 HRS | *207.48μA | 948.1pA | 11.4mV | -1.2mV | | | | |
| 2250 HRS | JOB STOPPED | 1.3nA | JOB STOPPED | -3.9mV | | | | |
| 2500 HRS | JOB STOPPED | 1.25nA | JOB STOPPED | -5.8mV | | | | |
| FINAL DATA | | | | | | | | |
| MIN VALUE | 13.50nA | 300.00pA | 916.0mV | 897.0mV | | | | |
| MAX VALUE | 1.41mA | 5.89nA | 999.0mV | 907.0mV | | | | |
| MEAN | 207.50μA | 2.10nA | 944.2mV | 901.8mV | | | | |
| STD DEV | 435.00μA | 1.83nA | 30.2mV | 2.95mV | | | | |

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

| PARAMETERS | $I_R$ = .05μA (MAX) | | $V_F$ = 1.0V (MAX) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | @ $V_R$ = 225V | | @ $I_F$ = 400mA (PULSED) | | | | | |
| IDENTIFICATION | SEM | MSC | SEM | MSC | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 4.99nA | 2.21nA | 929.0mV | 908.0mV | | | | |
| MAX VALUE | 29.70nA | 8.26nA | 979.0mV | 920.0mV | | | | |
| MEAN | 12.21nA | 4.75nA | 953.9mV | 915.3mV | | | | |
| STD DEV | 6.09nA | 1.65nA | 15.4mV | 3.3mV | | | | |
| INTERIM DATA (INITIAL TO FINAL) | | | | | | | | |
| Δ MEAN VALUE | | | | | | | | |
| TOTAL HRS TEMP ($T_A$) | | | | | | | | |
| 160 75°C | 2.35nA | -2.64nA | -8.1mV | -9.8mV | | | | |
| 320 100°C | 16.03nA | -1.99nA | -4.5mV | -5.9mV | | | | |
| 480 125°C | *73.39μA | -2.21nA | -3.5mV | -10.6mV | | | | |
| 640 150°C | *91.83μA | -2.97nA | -2.9mV | -8.0mV | | | | |
| 800 175°C | JOB STOPPED | -2.53nA | JOB STOPPED | -11.3mV | | | | |
| 960 200°C | JOB STOPPED | -3.76nA | JOB STOPPED | -12.2mV | | | | |
| 1120 225°C | JOB STOPPED | -3.64nA | JOB STOPPED | -9.5mV | | | | |
| 1280 250°C | JOB STOPPED | -3.41nA | JOB STOPPED | -9.0mV | | | | |
| 1440 275°C | JOB STOPPED | 0.77nA | JOB STOPPED | -8.2mV | | | | |
| 1600 300°C | JOB STOPPED | 31.99nA | JOB STOPPED | -9.2mV | | | | |
| FINAL DATA | | | | | | | | |
| FINAL TEMP ($T_A$) | 150°C | 300°C | 150°C | 300°C | | | | |
| MIN VALUE | 9.73nA | 550.00pA | 924.0mV | 898.0mV | | | | |
| MAX VALUE | 461.00μA | 124.00nA | 974.0mV | 912.0mV | | | | |
| MEAN | 91.84μA | 36.74nA | 951.0mV | 906.1mV | | | | |
| STD DEV | 146.90μA | 39.45nA | 15.8mV | 3.6mV | | | | |

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

| PARAMETERS | $I_R$ = .05μA (MAX) | | $V_F$ = 1.0V (MAX) | | | | | |
|---|---|---|---|---|---|---|---|---|
| CONDITIONS AND LIMITS | @ $V_R$ = 225V | | $I_F$ = 400mA | | | | | |
| IDENTIFICATION | SEM | MSC | SEM | MSC | | | | |
| INITIAL DATA | | | | | | | | |
| MIN VALUE | 5.70nA | 240.00pA | 914.0mV | 899.0mV | | | | |
| MAX VALUE | 42.70nA | 6.93nA | 958.0mV | 912.0mV | | | | |
| MEAN | 18.42nA | 1.47nA | 930.7mV | 904.7mV | | | | |
| STD DEV | 10.97nA | 1.75nA | 11.9mV | 3.3mV | | | | |
| INTERIM DATA (INITIAL TO FINAL) | | | | | | | | |
| Δ MEAN VALUE | | | | | | | | |
| TOTAL HRS / TEMP ($T_A$) | | | | | | | | |
| 16 / 150°C | 2.88nA | -0.34nA | 3.7mV | 1.6mV | | | | |
| 32 / 175°C | 1.43nA | 0.19nA | 1.1mV | 1.1mV | | | | |
| 48 / 200°C | *1.30mA | 0.48nA | 57.4mV | -6.1mV | | | | |
| 64 / 225°C | JOB STOPPED | 0.78nA | JOB STOPPED | -3.8mV | | | | |
| 80 / 250°C | JOB STOPPED | 0.92nA | JOB STOPPED | 0.1mV | | | | |
| 96 / 275°C | JOB STOPPED | 0.31nA | JOB STOPPED | -4.2mV | | | | |
| 112 / 300°C | JOB STOPPED | 0.66nA | JOB STOPPED | -6.6mV | | | | |
| FINAL DATA | | | | | | | | |
| FINAL TEMP ($T_A$) | 200°C | 300°C | 200°C | 300°C | | | | |
| MIN VALUE | 15.70nA | 180.00pA | 0.0mV | 890.0mV | | | | |
| MAX VALUE | 3.94mA | 2.46nA | 960.0mV | 904.0mV | | | | |
| MEAN | 1.30mA | 811.90pA | 873.3mV | 898.1mV | | | | |
| STD DEV | 1.46mA | 588.50pA | 225.8mV | 4.1mV | | | | |

*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 |
| $I_R$ | | .05 | μA | | *+20.536 | +.00059 | *+41.310 | +.00096 | *+433.33 | -.00034 |
| $V_F$ | | 1.0 | V | | +.00375 | -.00178 | -.00475 | -.00937 | -.01753 | -.00256 |
| | | | | | | | | | | |
| | | | | | | | | | | |

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N645-1

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 | – | 3/2 | A/B |
| 100 hr. | 1 | A | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 125% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 1 | A | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 150% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 2 | A | 0 | – |
| 100 hr. | 1 | A | 0 | – |
| 250 hr. | 1 | A | 0 | – |
| 175% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 2 | A | 0 | – |
| 100 hr. | JOB STOPPED | | 0 | – |
| 250 hr. | JOB STOPPED | | 0 | – |

GROUP II 160 HR. TEMP. STEPS

| TEST STEP $T_A$ | MFR A | | MFR B | |
|---|---|---|---|---|
| | QTY. | NOTE | QTY. | NOTE |
| 75° C | 0 | – | 0 | – |
| 100° C | 0 | – | 0 | – |
| 125 °C | 3 | A | 0 | – |
| 150 °C | 6 | A | 0 | – |
| 175 °C | JOB STOPPED | | 0 | – |
| 200 °C | JOB STOPPED | | 0 | – |
| 225 °C | JOB STOPPED | | 0 | – |
| 250 °C | JOB STOPPED | | 0 | – |
| 275 °C | JOB STOPPED | | 0 | – |
| 300 °C | JOB STOPPED | | 0 | – |

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 | 8 | A | 0 | – |
| 225 °C | JOB STOPPED | | 0 | – |
| 250 °C | JOB STOPPED | | 0 | – |
| 275 °C | JOB STOPPED | | 0 | – |
| 300 °C | JOB STOPPED | | 0 | – |

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

NOTES: A - $I_R$ >5.0μA

B - VISUAL FAILURE (OTHER THAN HANDLING)

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N645-1

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. | 1 | A | 0 | – |
| 100 hr. | 1 | A | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 125% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 0 | – | 0 | – |
| 100 hr. | 1 | A | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 150% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 1 | A | 0 | – |
| 100 hr. | 1 | A | 0 | – |
| 100 hr. | 3 | A | 0 | – |
| 250 hr. | 0 | – | 0 | – |
| 175% 10 hr. | 0 | – | 0 | – |
| 15 hr. | 0 | – | 0 | – |
| 25 hr. | 0 | – | 0 | – |
| 100 hr. | 2 / 1 | A / B | 0 | – |
| 100 hr. | JOB STOPPED | | 0 | – |
| 250 hr. | JOB STOPPED | | 0 | – |

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 | 0 | – | 0 | – |
| 150 °C | 0 | – | 0 | – |
| 175 °C | JOB STOPPED | | 0 | – |
| 200 °C | JOB STOPPED | | 0 | – |
| 225 °C | JOB STOPPED | | 0 | – |
| 250 °C | JOB STOPPED | | 0 | – |
| 275 °C | JOB STOPPED | | 0 | – |
| 300 °C | JOB STOPPED | | 0 | – |

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 | 0 | – | 0 | – |
| 225 °C | JOB STOPPED | | 0 | – |
| 250 °C | JOB STOPPED | | 0 | – |
| 275 °C | JOB STOPPED | | 0 | – |
| 300 °C | JOB STOPPED | | 0 | – |

MFR "A" - SEMTECH

MFR "B" - MICRO SEMICONDUCTOR

NOTES: A - $I_R$ MAXIMUM LIMIT FAILURE

B - S/N 7174 REMOVED FROM TESTING AS A VISUAL REJECT DUE TO HANDLING

# APPENDIX

# FAILURE ANALYSIS

# FAILURE ANALYSIS

**Date** 23 March 1978

**J/N** 2CN242-12C **P/N** 1N645-1 **MFR** SEMTECH

## FAILURE VERIFICATION:

| S/N | | PIV | $I_R$ @ 225 V.dc | $V_F$ @ 400 mA dc | INITIAL REJ. AT TEST SEQUENCE NO.: | INITIAL REJ. FOR: |
|---|---|---|---|---|---|---|
| 161 | | 590** | 4.5 mA | 0.52 | 07 (200°C) | $I_R$ |
| 164 | | 660** | 4.8 mA | 0.53 | 07 (200°C) | $I_R$ |
| 166 | | 700** | 1.75 mA | 0.52 | 07 (200°C) | $I_R$, $V_F$ |
| | | | | NOTE: All samples are valid $I_R$ failures. There are no opens or shorts. | | |

INTERNAL VISUAL INSPECTION:

These diodes are constructed with glass encapsulation which is painted with black paint. There is no visual evidence which could explain their excessive reverse leakage. (See Figures 1 and 2.)

OTHER TESTS:

After stripping the paint, the reverse leakage decreased markedly, so that Peak Inverse Voltages (PIV) could be measured. The leakages were reduced to less than 1μA.

CONCLUSION:

These samples failed because of a static charge on the surface of the glass encapsulant which developed from the thermal decomposition of the paint. Most or all of the harmful decomposition was removed with the paint, implying that the die and internal ambient surface of the device were damaged by the stress test.

** Could not reach Peak Inverse Voltage (PIV) on samples as received due to excess leakage and overheating. PIV readings taken after stripping coating.

*$h_{FE}$ 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

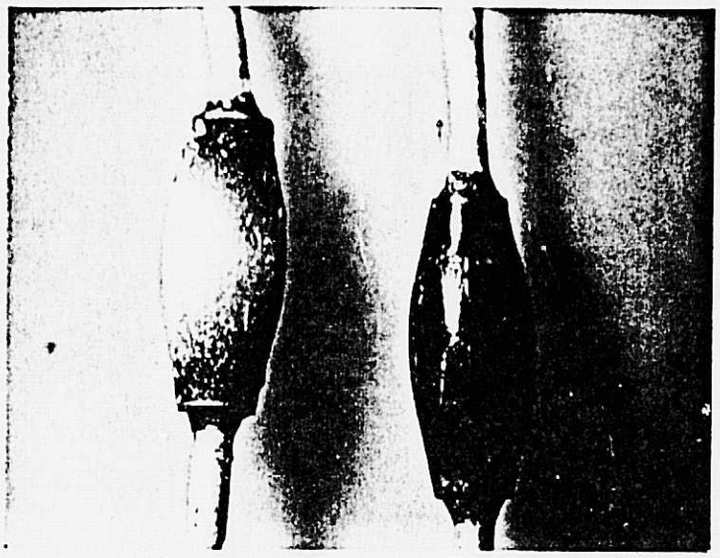


FIGURE 1

TYPICAL SEMTECH DIODE AS RECEIVED (LEFT)
COMPARED TO DIODE STRIPPED OF
PAINT (RIGHT) AT 18X.

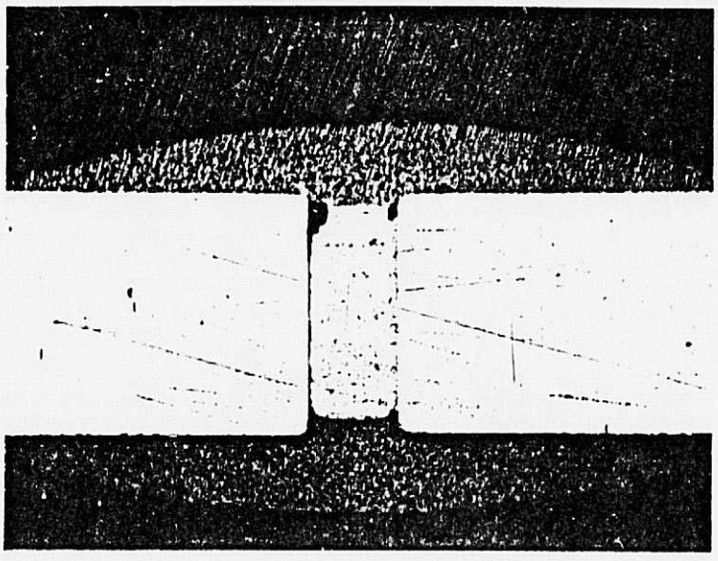


FIGURE 2

S/N 91, CROSS-SECTIONAL VIEW OF SEMTECH DIODE, 40X .
No significant visual defects.