Goddard Space Flight Center

GSFC NASA ADVISORY

1. Advisory Number	2. Subject
NA-GSFC-2002-01	Installation and Application Concerns With JANTXV1N4148UR-1 Surface Mount Diodes As a Consequence of Cracked Die Failures

3. Manufacturer	4. Manufacturer CAGE Code	5. Federal Stock Code
Compensated Devices, Inc. (CDI) 22 Corey Street Melrose, MA 02176	55801	5961

6. Part/Material/Process Number	7. Lot Date Code/Batch Code/Serial Number	8. Controlling Spec/Document Number
1N4148UR-1	9918	MIL-PRF-19500/116

9. References

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11. Problem Description and Details: *(Use continuation sheet if necessary)*

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PURPOSE:

The purpose of this NASA Goddard Space Flight Center (GSFC) Advisory is to inform the NASA community of several important issues related to the selection, installation and application of 1N4148UR-1 surface mount type silicon switching diodes made in accordance with MIL-PRF-19500/116. These issues have been brought to light as a result of a recent Solar Radiation and Climate Experiment (SORCE) Project experience where three JANTXV1N4148UR-1 diodes with lot date code (LDC) 9918, made by Compensated Devices, Inc. (CAGE Code: 55801), failed open during board level testing. Failure analysis revealed the mechanism of failure to be cracks in the active area of the silicon die underneath the contact button area. CDI performed accelerated thermal cycle evaluation of NASA's residual uninstalled parts from this same lot. The results of this testing produced 7 failures out of 62 samples. CDI has since evaluated 44 different assembly lots of this same device type from their inventory and observed 6 diode failures out of 968 parts tested. The 6 failures represent 5 of the 44 assembly lots. The failure investigation also included an evaluation of the flight board processing which suggested hand soldering without preheat might have contributed to the failures observed. (continued on page 2)

12. Action Taken: *(Use continuation sheet if necessary)*

Refer to suggested actions in text of this Advisory.

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14. Date Prepared
April 17, 2002

16. Released by: ***(Signature)***
Original signed by
GSFC NASA Advisory Coordinator

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17. Date Released
May 1, 2002

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11. Problem Description and Details: *(Continued from page 1)*

This Advisory will provide:

- Details of the failure investigation
- **Guidelines for the selection of alternate diode types in lieu of 1N4148 for future NASA missions**
- Overview of the risk of introducing damage due to installation practices (emphasis on surface mount device types)

NASA GSFC wishes to commend CDI for their support during this failure investigation.

Note: Subsequent to the start of this failure investigation, CDI was bought by Microsemi Corporation and now operates as Microsemi CDI with the same CAGE Code.

FAILURE INVESTIGATION SUMMARY:

Recently, the SORCE Project at the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado experienced three board-level test failures (opens) of a silicon switching diode of the following description:

Part Number:	*JANTXV1N4148UR-1*
LDC:	*9918*
Manufacturer:	*Compensated Devices, Inc. (CDI) [CAGE Code: 55801], Now known as Microsemi CDI*
Procurement Specification:	*MIL-PRF-19500/116*

The JANTXV1N4148UR-1 is a silicon switching diode made using a metallurgically bonded, double plug construction. It is a surface mount device packaged in a DO-213AA hermetically sealed glass case. The diode is specified to withstand operation and storage from -65°C to +200°C. Prior to receipt by the Project, the failing diodes had successfully passed all MIL-PRF-19500 screens at CDI which included the following tests on 100% of the devices sold: temperature cycle (20 cycles, -55°C to +175°C), thermal impedance, burn-in and electrical parametric measurements.

Each of the three failures was found during board level testing of various SORCE instruments, and each occurred on various power boards. The first failure occurred at initial power up, the latter two failed during test and integration. Electrical parametric testing of the failed devices revealed a forward voltage (V_F) characteristic far in excess of the specification limit of 0.8 V maximum. Curve tracer characterization of the failures indicated the V_F "knee" to be in the range of 5 to 8 Volts. Thermal impedance testing produced no results since the tester was unable to find the "knee" of normal diode operation. An external visual inspection did show some indication of cracking along the backside edges of the die and a possible crack across the diode body. Subsequent cross sectioning through the middle of the diode revealed the cause of failure to be a crack in the active area of the silicon die completely underneath the button.

The contractor who installed these diodes was consulted to determine the method and conditions of installation. It was discovered that these surface mount diodes had been installed via hand soldering techniques with soldering iron temperatures of approximately 500°F without preheating the part. Moreover, the devices were soldered one termination at a time rather than using a bifurcated soldering tip that would heat the two terminations simultaneously. Although this method of installation was immediately considered to be a primary suspect causing the failures, this same contractor used the same procedure to install 1N4148UR-1 diodes from other manufacturers on other SORCE instrument boards without any reported failures to date.

However, in order to determine if a lot-related manufacturing defect could have contributed to the failures, the SORCE Project provided CDI with 63 residual diodes from inventory of the suspect lot (LDC 9918) for evaluation. CDI electrically tested the diodes upon receipt and discovered one parametric failure for forward voltage (V_F) at 10mA. The reject was noted to have solder residue on both end caps. The cause of this failure, or reason for solder on the end caps was determined to be unknown. Subsequently, CDI subjected the remaining 62 diodes to a (air to air) thermal cycle test in accordance with MIL-STD-750 Method 1051.5, 20 cycles from -55°C to +175°C. This testing resulted in 7 failures out of 62 parts tested. Three failed V_F and 4 failed both V_F and reverse current (I_R).

To further support this investigation, CDI retrieved samples from 44 different 1N4148 lots to determine if there might be a systemic concern with this diode type. The test specimens were sample parts from lots that had previously undergone and passed CDI's (liquid to liquid) thermal "shock" inspection from 0°C to 100°C which is required per Group B sample inspection of MIL-PRF-19500. Of the 44 lots tested by CDI, 5 lots produced 6 electrical failures out of 968 samples. These test results have prompted CDI to immediately introduce thermal cycle (air to air) as an internal group B2 test immediately following the thermal shock (liquid to liquid) test. In addition, CDI has initiated action with DSCC to request a change to the specification for this diode type to add thermal cycle to the Group B inspection requirements.

To date, the source of the cracks found in the LDC 9918 specimens has not been conclusively identified.

PROJECT ACTIONS:

The affected GSFC Project has taken steps to mitigate the risk of further failures by replacing the diodes from the suspect lot with similar JANTXV1N4148UR-1 diodes from a different manufacturer. In addition, process controls have been implemented for the rework to ensure that thermally induced stresses from the installation method are minimized and within manufacturer recommended guidelines.

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INSTALLATION GUIDELINES:

Many low volume production applications still use traditional hand soldering techniques for surface mount assembly. The failure experience described by this Advisory has shown the potential sensitivity of glass body surface mount diodes to thermally induced damage. Other component types (e.g., chip capacitor and resistors) may also be equally sensitive to potential damage from thermal stress during board assembly. Inappropriate installation processes can introduce excessive thermal gradients that may lead to stress fractures in components. In addition, overheating may damage sensitive elements of the device. Therefore, the following basic guidelines are offered to help minimize the potential for installation damage for all surface mount components:

- Always refer to manufacturer recommendations for installation guidance, such as Microsemi's *Care and Handling of Diodes* (http://www.microsemi.com/micnotes/05.pdf).
- For solder installation of surface mount devices, reflow soldering processes are the preferred method of assembly. In general, hand soldering is NOT preferred.
- Use the lowest temperature possible for the solder alloy being used.
- Preheating is strongly recommended to reduce thermal gradients.

ALTERNATE DEVICE TYPES

Future revisions of the NASA Parts Selection List (NPSL) will no longer recommend the 1N4148-1 diode types due to construction features that make these devices particularly susceptible to thermal damage. For high reliability applications, the 1N6642 diodes made in accordance with MIL-PRF-19500/578 are recommended because they offer identical electrical performance characteristics and a more robust construction. As a tradeoff, the 1N6642US surface mount devices are moderately (30%) larger than the equivalent 1N4148UR-1 devices and are, therefore, NOT a direct form/fit replacement. For through-hole applications, however, the axial leaded 1N6642 and 1N4148-1 devices are the same size.

Some interpretations of the language in both MIL-PRF-19500/116 (1N4148) and /578 (1N6642) may give the impression that spaceflight applications should only use JANS quality level discrete semiconductors. Such guidance is NOT the general policy of NASA. Indeed, many NASA missions utilize JANTXV devices extensively. Selection of a particular quality level device is based on a variety of factors including the Project's acceptable risk level and design risk mitigation strategies. Selection of an appropriate quality level device is the responsibility of each Project in conjunction with the appropriate quality assurance and parts engineering organizations. Therefore, the recommendation in this Advisory to use the 1N6642 device in lieu of the 1N4148-1 should NOT be construed as a recommendation that only JANS quality level devices are approved for NASA applications.

SUGGESTED ACTIONS:

NASA GSFC suggests the following actions be considered with respect to the subject diode types:

- Do not use JANTXV1N4148UR-1 with LDC 9918 from CDI in critical or single point failure applications. The findings of the investigation with respect to the root cause of the cracks suggests that high reliability applications should err on the side of caution rather than use parts from this LDC.
- **For future NASA designs, the NASA EEE Parts Assurance Group (NEPAG) will make changes to the NASA Parts Selection List (NPSL) to warn users of the concerns associated with the 1N4148-1 diode types and to recommend the 1N6642 per MIL-PRF-19500/578 as the preferred part.**
  - **For surface mount, the 1N6642US diodes are direct electrical replacements for the 1N4148UR-1, but they are physically larger and, therefore, cannot be easily interchanged.**
  - **For through-hole applications, the axial leaded 1N6642 diodes are direct replacements for the axial leaded 1N4148-1 types.**
- Users are strongly advised to familiarize themselves with the manufacturer's recommended installation practices. Specific emphasis must be placed on process controls that minimize thermally induced stresses. This is particularly important for assembly facilities who intend to use hand soldering techniques to install surface mount devices of any component type.

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