# STEREO IMPACT

PROBLEM REPORT
PR-1035
FM2 SWEA Anode 12
2005-02-17

**PR Numbers: 1xxx=UCB, 2xxx=Caltech/JPL, 3xxx=UMd, 4xxx=GSFC/SEP, 5xxx=GSFC/Mag, 6xxx=CESR, 7xxx=Keil, 8xxx=ESTEC, 9xxx=MPAe**

| | |
|---|---|
| **Assembly :** SWEA/STE-D | **SubAssembly :** |
| **Component/Part Number:** | **Serial Number:** FM2 |
| **Originator:** David Curtis | **Organization:** U.C. Berkeley |
| **Phone :** 510-642-5998 | **Email :** dwc@ssl.berkeley.edu |

**Failure Occurred During (Check one √)**

√ Functional test ☐ Qualification test ☐ S/C Integration ☐ Launch operations

**Environment when failure occurred:**

☐ Ambient ☐ Vibration ☐ Shock ☐ Acoustic
☐ Thermal √ Vacuum ☐ Thermal-Vacuum ☐ EMI/EMC

## Problem Description

During SWEA/STE-D FM2 Calibrations Anode 12 (counting from zero) failed to count both anode events and test pulser events for about a 24-hour period in the middle of the test. There was no obvious correlation of the start and stop of the failure to any operations or conditions of the test.

## Analyses Performed to Determine Cause

We were unable to induce the system to fail again. We disassembled the instrument and probed the signal and found the pulses from Anode 12 were only 3V in amplitude (compared to the nominal 5V pulses from the other anodes). Replacing the flight pedestal electronics with the ETU made the problem go away, indicating the problem is in the pedestal electronics. A measurement of the impedance of the anode signal between SWEA and the pedestal electronics showed 205 ohms to ground for anode 12, and high impendence (~2Mohms) for the other anode signals. The anode signals go into the DAC board, through a 100-ohm series resistor, and then into an Actel. The impedance on the Actel side of the series resistor to ground was 105 ohms, consistent with a 105-ohm resistance to ground for this input signal in the Actel. The signal between the (surface mount) series resistor and the Actel is all on the top layer of the board and easily inspectable; no problems were found. The effected leg of the Actel was lifted from the board and the board impedance went open (normal) while the Actel input impedance was 105 ohms.

Later a problem was found on the MCP high voltage output filter capacitor that could have stressed the Actel (see PFR1037). That problem has been fixed, and only applies to the FM2 SWEA unit.

## Corrective Action/ Resolution

√ Rework ☐ Repair ☐ Use As Is ☐ Scrap

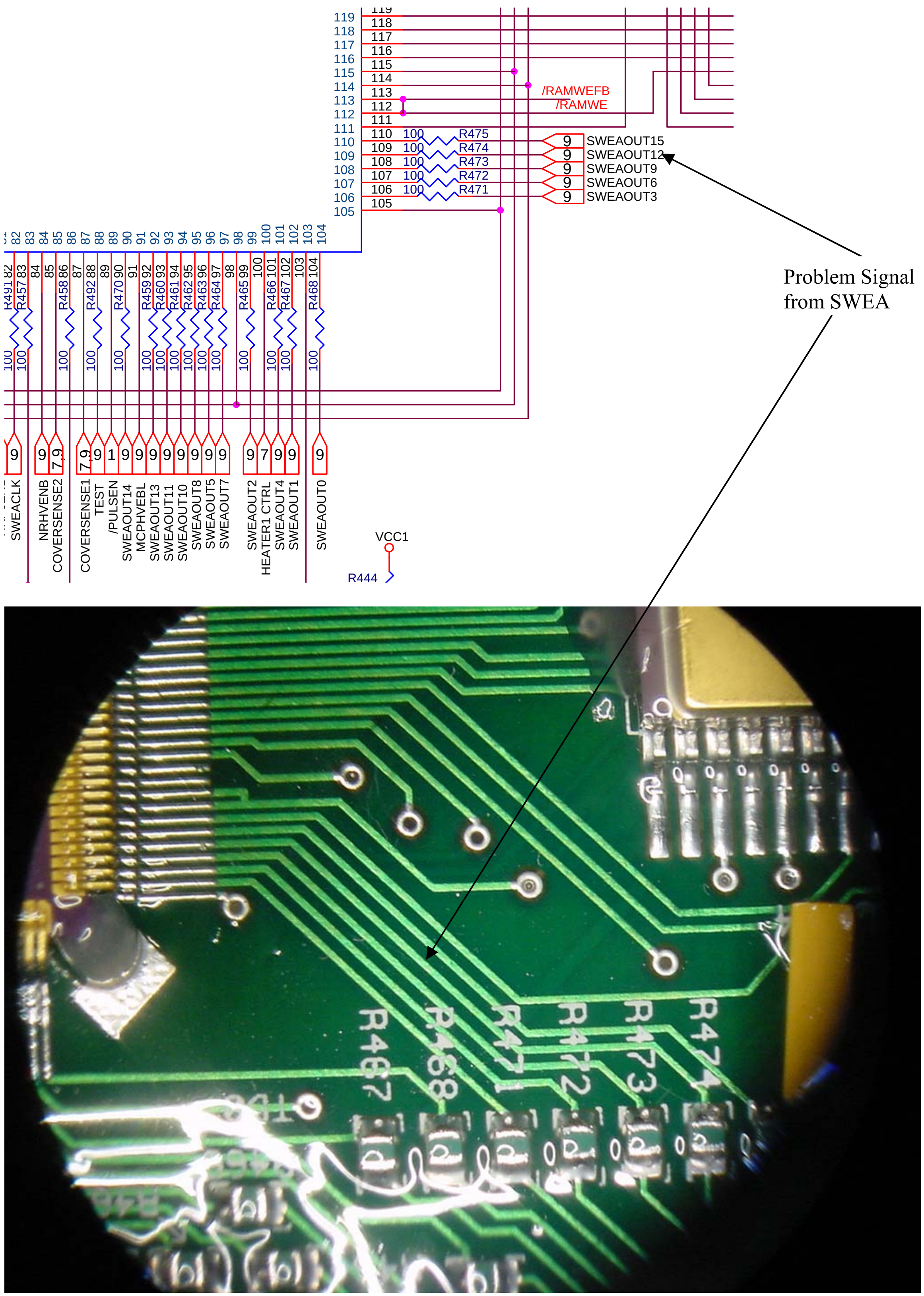
The Actel was replaced with a new one (UMC style this time) programmed at GSFC. The impedance and signal levels are now nominal, and on re-assembly the anode counts correctly. The failed Actel was sent to GSFC (Actel) for failure analysis; the result was electrical overstress, compatible with the PFR 1037 cause, or possibly ESD during assembly.

**Date Action Taken**: 2005-03-03 **Retest Results**: OK

**Corrective Action Required/Performed on other Units** ☐ Serial Number(s): n/a

## Closure Approvals

| | | |
|---|---|---|
| Subsystem Lead: | ____________ | Date:________ |
| IMPACT Project Manager: | ____________ | Date ________ |
| IMPACT QA: | ____________ | Date:________ |
| NASA IMPACT Instrument Manager: | ____________ | Date:________ |



/RAMWEFB
/RAMWE
R475
R474
R473
R472
R471
SWEAOUT15
SWEAOUT12
SWEAOUT9
SWEAOUT6
SWEAOUT3
Problem Signal from SWEA
SWEACLK
NRHVENB
COVERSENSE2
COVERSENSE1
TEST
/PULSEN
SWEAOUT14
MCPHVEBL
SWEAOUT13
SWEAOUT11
SWEAOUT10
SWEAOUT8
SWEAOUT5
SWEAOUT7
SWEAOUT2
HEATER1 CTRL
SWEAOUT4
SWEAOUT1
SWEAOUT0
VCC1
R444
R467
R468
R471
R472
R473
R474

# GODDARD SPACE FLIGHT CENTER

## Failure Analysis Report



Charge Sensitive Pre-Amp & Discriminator Hybrid
Mfr.: Amptek, Inc.
P/N: A111F
DC: 0048
SN: 239

Project
STEREO
System
IMPACT-SWEA/STE-D (FM-2)
Requester
A. Reyes (562)

Investigator
C. Greenwell (562)

Report Date
05/21/2005

## Background

This device failed in circuit location U12 of the SWEA FM-2 assembly. This device replaced the previous failed device (SN 228) from the same location.

Shortly before the first failure (reference Q50148FA) there was some type of anomalous event with the MCP high voltage supply. Housekeeping (electronics) indicated the high voltage supply pegged at the top of range, higher than the supply can generate. The supply was shut down. Later the supply came up normally and the preamp seemed to work fine for a while, then failed

GSFC Parts Analysis Lab Reports Q50006FA and Q50148FA document previous failures of the other A111F devices. The first failure (SN 206) appeared to be caused by workmanship errors. The second failure (SN228) most likely failed due to electrical overstress in the form of fast transients involving pins 2, 4, 5 and/or 6. SN 228 had a blown output protection diode among other EOS damaged circuit elements.

## Part Description

The Amptek A111F is a commercial charge sensitive preamplifier, discriminator and pulse shaper developed especially for instrumentation employing microchannel plates (MCP) and other low capacitance charge producing detectors.

The device is built using standard hybrid microelectronic construction. A single sided ceramic substrate with laser-trimmed thick film resistors has several diodes, transistors, capacitors and a surface mount resistor, mounted to it with conductive and non-conductive epoxies. The discrete devices are interconnected with 1.25-mil gold bond wires. The device is provided in a hermetic, 6-pin, single in-line, metal package.

## Analysis and Discussion

Optical and radiographic inspections revealed no anomalies. The device passed hermeticity and PIND tests.

Pin-to-pin curve tracer characterization was performed. Results for SN 239 were compared to results for SNs 206 and 228. Aside from the obvious problem with SN 228 involving pin combinations with V+ (pin 5), characteristics involving the output (pin 6) for SNs 228 and 239 suggested similarity between these two devices (SNs 228 and 239). In hindsight it appears that SN 206 did not display any anomaly.

External pin-to-pin curve tracing will not likely reveal anomalies associated with circuit nodes that are not directly tied to external pins. This appears to have been the case for SN 206.

Due to the nature of the curve trace data it was decided to test SN 239 using the test fixture provided by Amptek. When powered up in the test fixture the device immediately exceeding the specified power supply current. The current went to approximately 13mA; the current specification is 1.3mA +/- 0.2mA. It is now believed that 13mA is a current limited value of the test circuit as this is the same value that SN 206 ran to when tested on the same test circuit. The device under test may have run away further without built in current limiting.

SN 239 was delidded for internal examination. It was immediately observed that the Q9/Q10 transistor die in this device was of the same pedigree as the one in SN 206. The Q9/Q10 transistor die in SN 228 was a different pedigree (as noted in Q50148FA). Figure 1 shows the internal construction and identifies the location of circuit elements discussed in this report.

It was also observed that the same wire bonds that were poorly placed at the Q9/Q10 transistors in SN 206 were likewise poorly placed in SN 239. Optical inspection appeared to show that the base and emitter ball-bonds at Q10 were touching the unpassivated die edge and that the emitter ball-bond at Q9 was touching the unpassivated die edge. SEM inspection further documented these observations. Figures 2 and 3 show these findings.

SEM inspection revealed an area of localized damage to output protection diode CR6 (similar damage was found on CR6 in SN 228). Figure 4 shows this damage area.

Optical inspection found silver-filled die attach epoxy on the top die surface of Q1. This is an unacceptable workmanship defect, but did not play a part in the device failure. Figure 5 shows this finding.

Transistors Q9 and Q10 were isolated from the circuit by pulling the interconnect bond wires. Each transistor was then individually probed and characterized, with the gold ball bonds in place. Next, the three ball bonds that appeared to be touching the unpassivated die edge were removed and the transistors were characterized again.

Prior to removing the ball bonds from Q9 and Q10, the emitter, base and collector all had non-linear type characteristics, in the range of 3 to 4-MΩ, between the bond pad and the backside substrate of the die. After the ball bonds were removed, these characteristics went away and essentially zero leakage current was observed between these circuit elements. Changes in the characteristics of the emitter-base and collector base diodes were less significant, nonetheless, the forward bias collector-base showed the most improvement.

CR6 was isolated and probed, and found to be shorted. The other output protection diode as well as the two input protection diodes were isolated and probed and found to be OK. Also, output transistor Q11 was tested and found to be OK.

| | | | |
|---|---|---|---|
| Part Type: | Hybrid | Part No: | A111F |
| Manufacturer: | Amptek | Date Code: | 0048 |

## Conclusion

The failure of the Amptek A111F amplifier was confirmed. During attempts at functional testing there was no output and the power supply current draw was excessive.

Internal examination found ball bonds at the Q9/Q10 die placed such that the base and emitter circuit elements were shorted to the die substrate (and thus ground). These shorts were found to be in the 3 to 4-MΩ range (at the limited test current). It is not known if these values would cause a malfunction of the circuit.

Internal examination also found electrical overstress damage to output protection diode CR6. Electrical characterization confirmed CR6 was shorted to essentially zero ohms. It appears that the device suffered a fast transient, low energy, electrical overstress event between the output and ground, pins 6 and 2, respectively.

Internal examination revealed an unrelated manufacturing workmanship defect that deposited silver filled die attach epoxy on one of the die surfaces. This condition was not related to device failure.

N A S A G O D D A R D S P A C E F L I G H T C E N T E R

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|---|---|---|---|
| Part Type: | Hybrid | Part No: | A111F |
| Manufacturer: | Amptek | Date Code: | 0048 |

Appended Images:

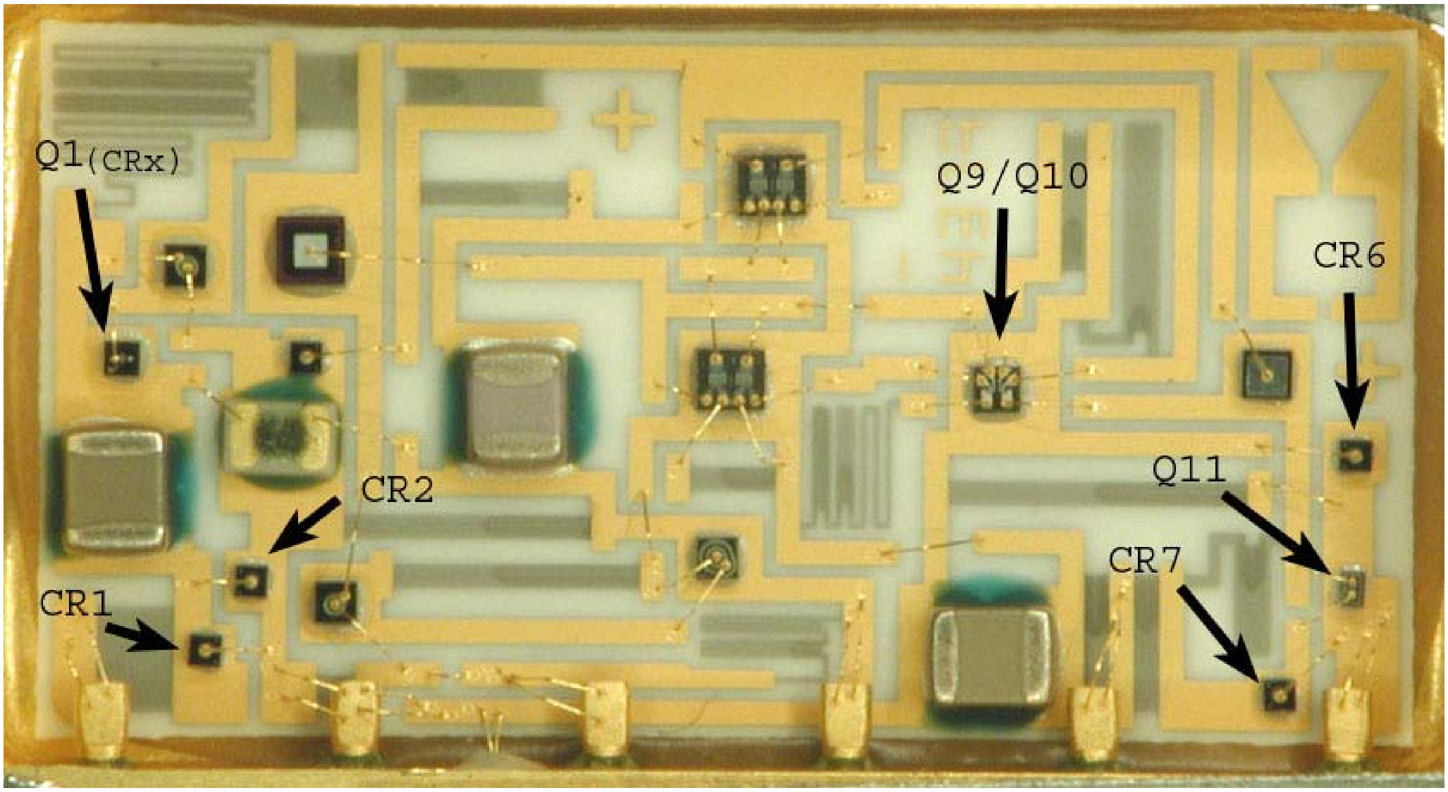


Figure 1. Overall view of the A111F (SN 206) substrate with several circuit elements identified. CR1 and CR2 are input protection diodes (to ground). CR6 and CR7 are output protection diodes, to ground and V+, respectively. Q1 is a transistor die with only the base wire bonded, using the collector-base diode as a circuit element. Q11 is the output transistor.

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| Part Type: | Hybrid | Part No: | A111F |
| --- | --- | --- | --- |
| Manufacturer: | Amptek | Date Code: | 0048 |

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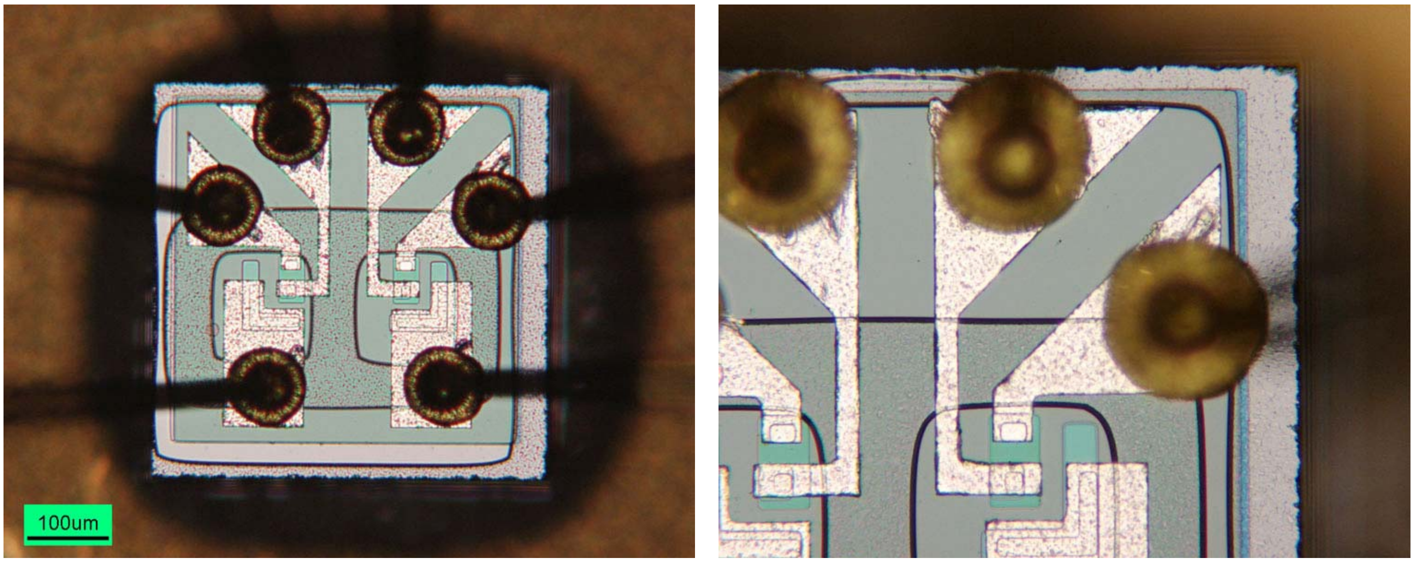


Figure 2. Optical images show Q9/Q10 transistor(s) die and poorly placed gold wire ball bonds.

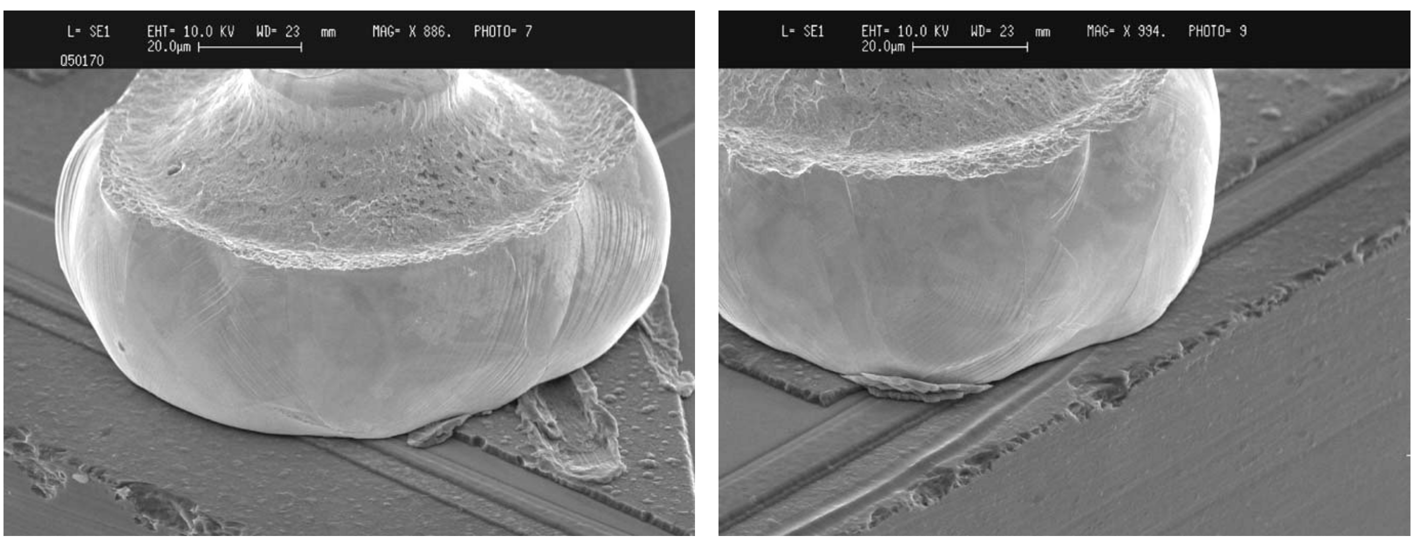


Figure 3. SEM images of ball-bonds touching the unpassivated die edge. Left – Q10-base, right – Q9-emitter.

Appended Images:

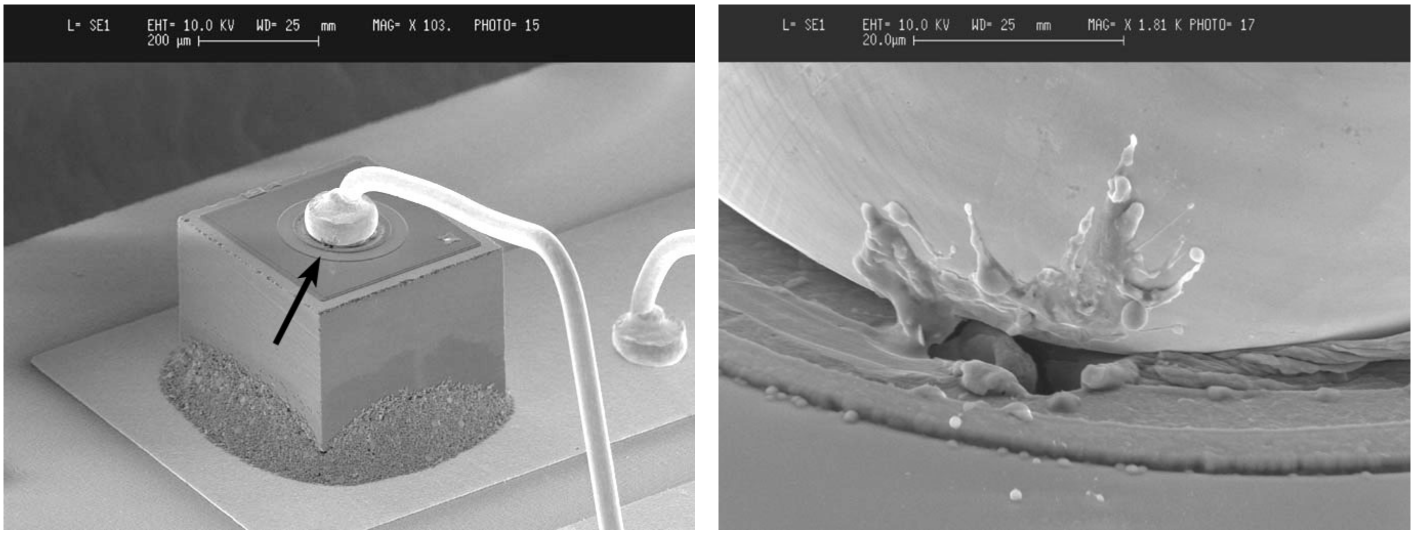


Figure 4. SEM images show damage site on output protection diode CR6.

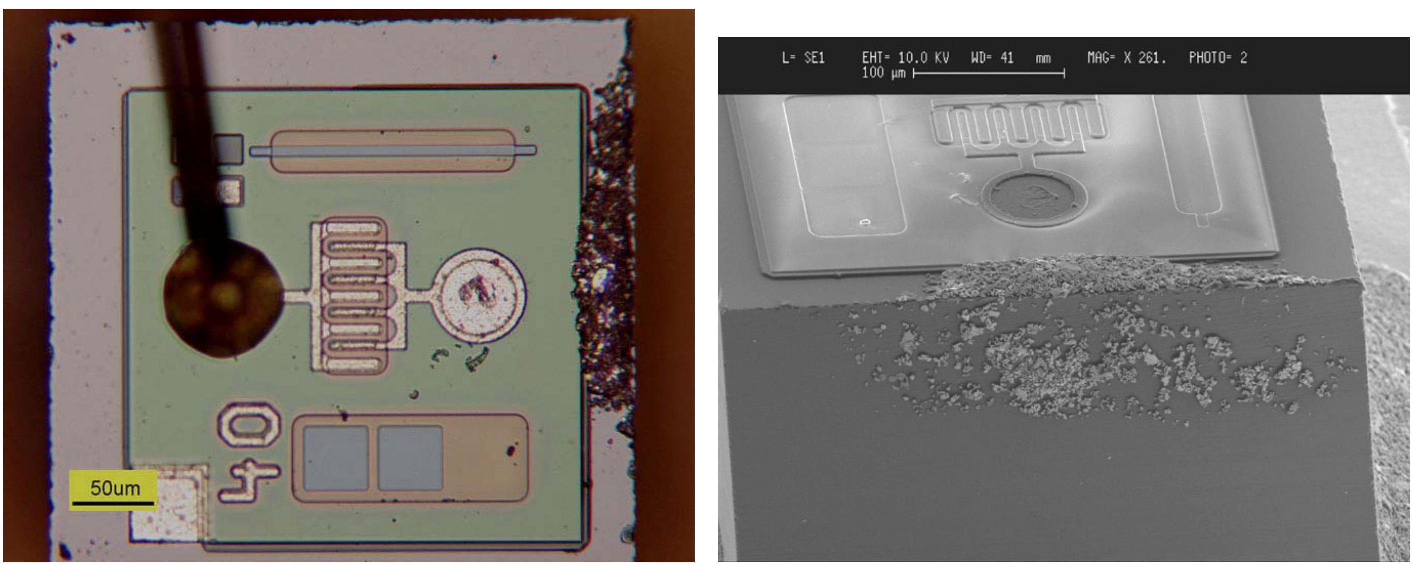


Figure 5. Optical and SEM images show silver-filled die attach epoxy on the top surface of transistor die Q1.