# *STEREO IMPACT*

PROBLEM REPORT
PR-1023
FM1 SWEA LVPS
04 October 2004

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

| | |
|---|---|
| **Assembly : IMPACT SWEA** | **SubAssembly : LVPS** |
| **Component/Part Number:** | **Serial Number: FM1** |
| **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

SWEA FM1 LVPS was working nominally before bakeout. After bakeout (48 hours at 75C) the +5V digital supply was low (~2.5V), and the supply current was high (~300mA). During test the problem was found to be intermittent. Sometimes the supply would wake up in the bad mode, sometimes it would wake up good but go bad after a while (a few minutes).

## Analyses Performed to Determine Cause

The collector 5V digital supply drive transistor collector waveforms look normal when the supply is good, distorted when bad. When bad the drive side is found to be in its current limit mode, but no anomalous load is found on the secondary side. A tuning capacitor across the 5V digital drive was found to be a 50V part across a signal that reaches 56V, but replacing that part with a 100V part did not solve the problem. It was found that cooling the 5V digital supply transformer affected the waveform and output voltage. The characteristic of the drive signals is consistent with the internal shield between primary and secondary transformer turns being shorted to itself, thus making a 1-turn loop that makes a low impedance load to the transformer. Alternatively something other part of the wiring could have developed an intermittent short due to thermal stress. The root cause of this failure remains unknown.

The transformers are built to a drawing (see attached). The transformers are then tested to verify inductance, resistance, turns ratio, resonant frequency and dielectric withstanding voltage. The SWEA LVPS failure would result in the loss of both SWEA in STE-D science.

## Corrective Action/ Resolution

√ Rework ☐ Repair ☐ Use As Is ☐ Scrap

The transformer (STEREO 025) SN001, ref designator T3 was replaced with a spare SN003. The 50V trim capacitors were replaced with 100V parts. That solved the problem, and performance is back to what it was before bakeout. The transformer may have been damaged during the bakeout since it has not been baked out above 60C in the past. We have not baked out any other STEREO electronics that include transformers yet, and will bake the remaining boards with transformers at a lower temperature. The failed transformer was submitted for analysis, but was damaged removing it from the board (to which it was glued). Reference F/A# Q50231 which confirmed that it was likely an intermittent short between 2 wires that may have been in contact with some rough bare solder. The pins involved were either Pin 2 and Pine 3 or Pin 7 and Pin 8.

**Date Action Taken**: 2004-10-05 **Retest Results**: Success

**Corrective Action Required/Performed on other Units:**. Bake out of boards containing transformers not to exceed 60C.

## Closure Approvals

Subsystem Lead: ______________________ Date:____________
IMPACT Project Manager: ______________________ Date ____________
IMPACT QA: ______________________ Date:____________
NASA IMPACT Instrument Manager: ______________________ Date:____________

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## Parts Analysis Laboratory

## *Transformer Failure Analysis*



| | | | |
|---|---|---|---|
| Project: | STEREO | Part Type: | Transformer |
| Subsystem: | IMPACT-SWEA LVPS | Manufacturer: | UCB-Berkeley |
| Requestor: | A. Reyes 286-5927 | Part Description: | SSL Custom Transformer |
| Investigator: | F. Felt 286-9634 | Part Number: | STEREO 025 K41408-04 |
| Date: | 14 June 2005 | Date Code: | TBD |

### *Background*

This transistor, designated SWEA FM1 LVPS was working normally before bake-out. However, after bake-out for 48 hours at 75C the +5V digital supply was low, ~2.5V, and the supply current was high, ~300mA. Testing found that the problem was intermittent. The supply would sometimes wake up in a 'bad' mode, or sometimes it would wake up in a 'good' mode and then go 'bad' after a few minutes. The characteristics of the drive signals seemed consistent with an internal short.

The transformer had been glued to the board, and was severely damaged upon removal. The fragments were forwarded to the NASA GSFC Failure Analysis Laboratory for examination and electrical testing.

### *Part Description*

The transformer was custom-manufactured by Space Sciences Laboratory. A schematic of the device is appended at the end of this report.

### *Analysis and Results*

The transformer was externally examined and photo-documented. As received, extensive damage was noted. The transformer bobbin was broken in two and cracked. All wires had been broken between the bobbin and the housing. The housing pins were bent. (Figures 1 to 8)

The broken wires at the bobbin were straightened and insulation was carefully scrapped from their ends. There were nine of these wires, four at each of two notches in the bobbin, plus an additional wire soldered to copper tape. Electrical resistance was tested between the insulating tape and all eight wires, finding that all were open. For orientation, the labeled side of the bobbin was considered 'top' and the other side of the bobbin was 'bottom'. In each notch, two wires protruded from the bottom of the coil, and two from the top. Electrical measurements showed measurable resistance between one wire on top (labeled 'a'), and one on the bottom (labeled 'b'). Results are shown in the table below. All other wire combinations were open.

Table 1: Resistance between wires

| *Side* | *Wire to Wire* | *Resistance (ohms)* |
|---|---|---|
| 1 | 1a to 1b | 1.6 |
| 1 | 2a to 2b | 1.6 |
| 2 | 0a to 0b | 0.4 |
| 2 | 3a to 3b | 0.4 |

Peter Berg at UCB Space Sciences Laboratory (510 643-9443) was contacted for information regarding the transformer. The wire is heavy armor HAPT, manufactured by MWS Wire. Dielectric withstanding voltage for the 34-gage wire, single strength is 1500VAC, and 2975VAC for 34-gage heavy armor. For 36-gage wire the values are 1200VAC and 2525VAC, respectively. However, at worst case there is approximately a 100-volt difference between the primary winding and the core of the transformer. Therefore, for the purposes of this analysis, DWV testing at 500VAC was deemed adequate. The results shown in Table 2 below found no failures.

Table 2: Dielectric Withstanding Voltage

| *Wire* | *to Wire* | *DWV* (500VAC) |
|---|---|---|
| 0 | 1 | okay |
| 0 | 2 | okay |
| 0 | 3 | okay |
| 0 | shield | okay |
| 1 | 2 | okay |
| 1 | 3 | okay |
| 1 | shield | okay |
| 2 | 3 | okay |
| 2 | shield | okay |
| 3 | shield | okay |

Copper tape around the bobbin was removed and the wire was inspected and photo-documented. The windings consisted of a single outer layer, separated from a three-layer inner winding. The wire diameters of both windings were identical. Optical inspection of top and bottom of wires found no anomalies. (Figures 9 to 11)

The external housing was re-inspected. The wires soldered to external pins were noted and examined. Two of these wires appeared crossed. Matching grooves were found in the adhesive or coating nearby, indicating that the wires had been touching, or nearly so. One of the grooves was slightly deeper than the other, by approximately a wire diameter. In addition, close optical inspection found blobs of solder on one wire in the location where the wires crossed. (Figures 13 to 16)

SEM inspection was performed. The position of the grooves confirmed that the crossed wires were originally in close proximity. Displacement during removal of the transformer from the board had shifted the wires' position slightly. Close inspection found that the suspect solder blob on the vertical wire appeared metallic and un-insulated. EDS dot mapping identified the solder as composed of tin. The wire was copper. (Figures 17 to 20)

Comparison of the external photographs of the housing to the schematic showed that the pin connecting to the vertical wire was either Pin 3 or Pin 8, and that the crossing wire was either from Pin 2 or Pin 7, respectively.

***Conclusion***

The transformer was received in a badly damaged condition, with the bobbin broken from the external housing. Electrical testing did not confirm the failure. However, grooves in the polymer on the external housing showed that two wires attached externally to pins were routed across each other, and had probably been in physical contact. Bare solder with a rough surface found in the location near where the wires crossed, suggested that the wires may also have been in electrical contact, and intermittently shorted as contact was made. Comparison with the transformer schematic found that the pins involved were either Pin 2 and Pin 3, or Pin 7 and Pin 8.

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|---|---|---|---|
| Part Type | Transformer, Custom | Part Number | STEREO 025 K41408-04 |
| Manufacturer | UCB-Berkeley | Lot Code | TBD |

Appended Photographs:

Figure 1. External photo of transformer as received in the laboratory. Extensive damage was noted, presumably due to removing the transformer from the board.

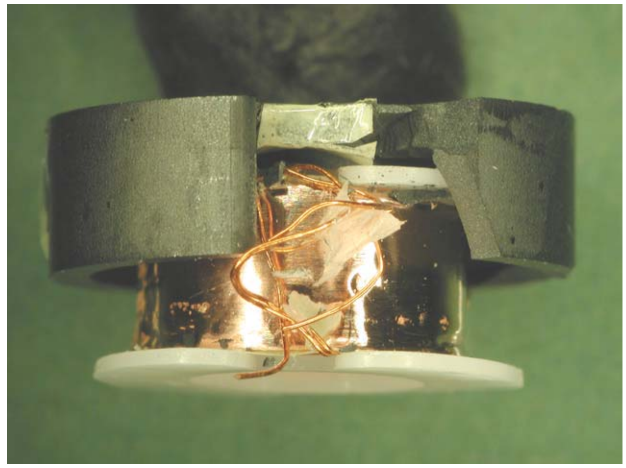

Figure 2. External photo of damaged transformer.

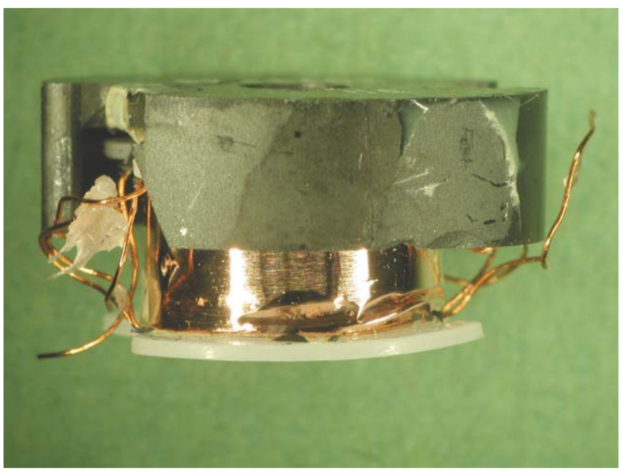

Figure 3. External photo of damaged transformer.

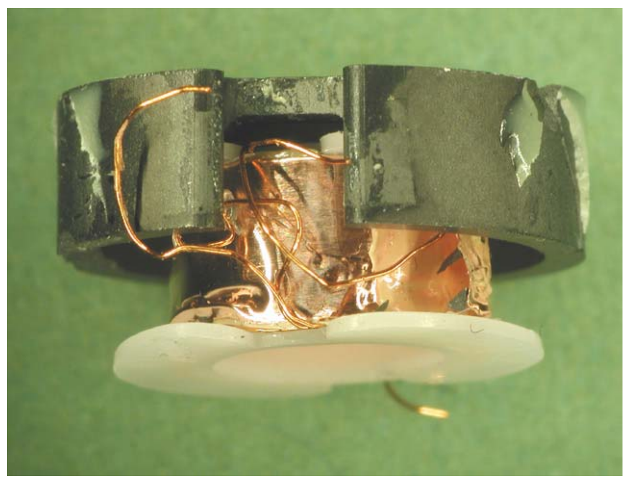

Figure 4. External photo of damaged transformer.

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Appended Photographs:

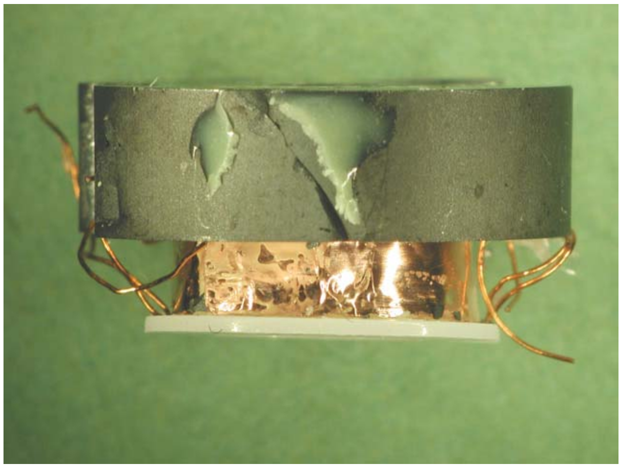

Figure 5. External photo of damaged transformer. Note crack.


Figure 6. External photo of damaged transformer. Note cracks.

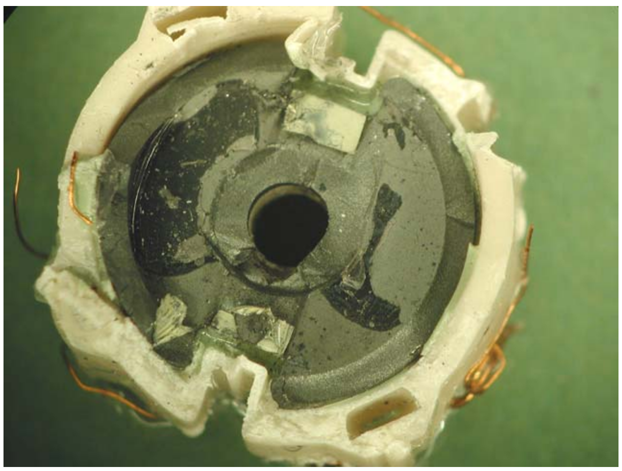

Figure 7. External photo of transformer housing.

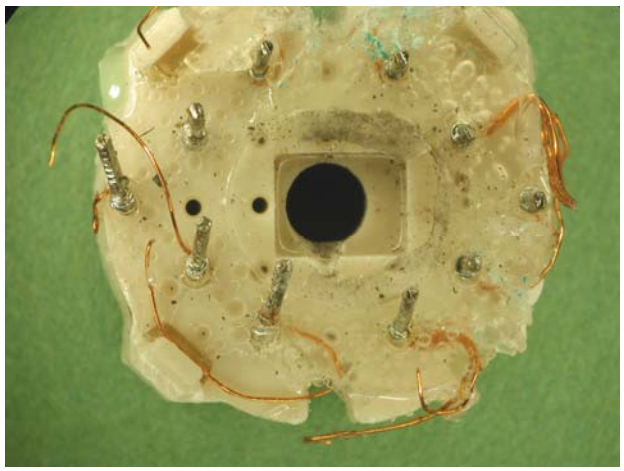

Figure 8. The underside of the transformer housing shows ten pins, each soldered to a copper wire. Wire routing does not appear controlled.

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Appended Photographs:

Figure 9. The copper tape is peeled back in this image, exposing a section of the outer winding.

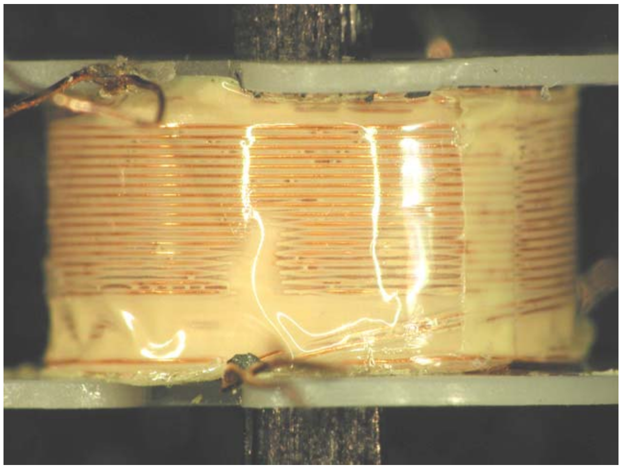

Figure 10. The copper tape has been completely removed, revealing windings covered with a polymer layer.

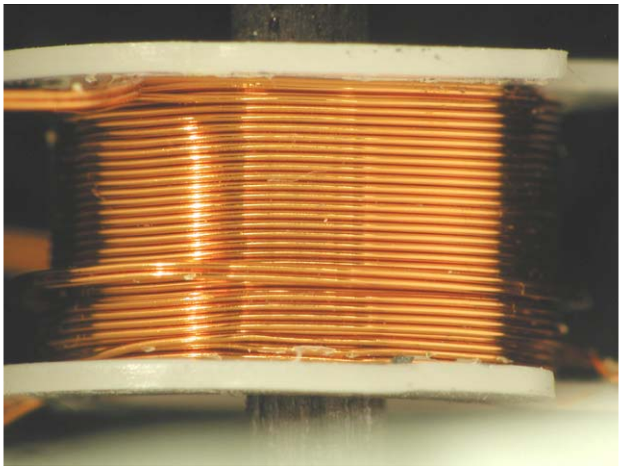

Figure 11. In this image the polymer layer was removed and the wire partially unwound.

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Figure 12. No image.

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Appended Photographs:

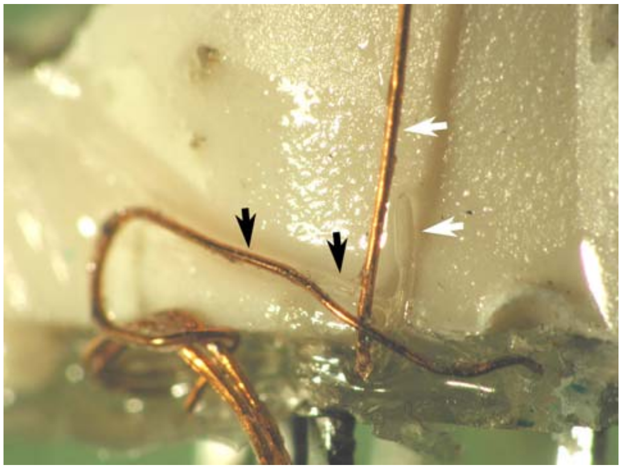

Figure 13. Crossed wires were found near the transformer pins. Black arrows point to one wire and its matching groove in the conformal coating. White arrows point at a second wire and its groove. The grooves criss-cross, indicating the wires were originally in close, or near contact.

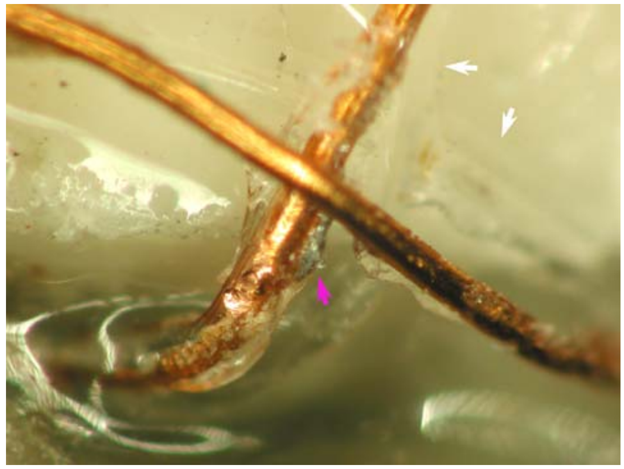

Figure 14. White arrows mark crossing grooves in the background. The pink arrow points to an apparent blob of solder on one wire.

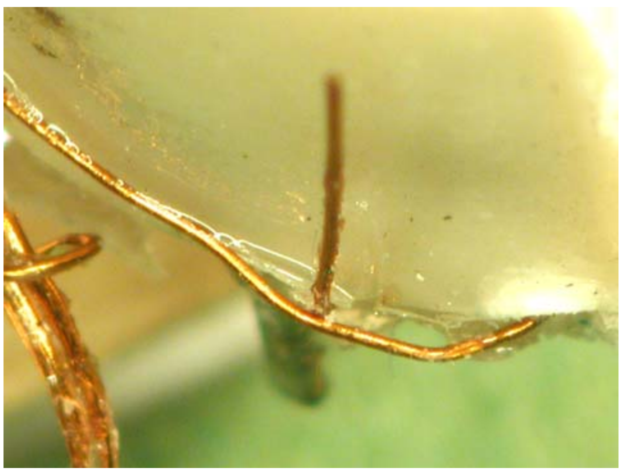

Figure 15. An end view of the crossed wires, showing the wires displaced slightly from their original positions, probably due to removal of the transistor from the board.

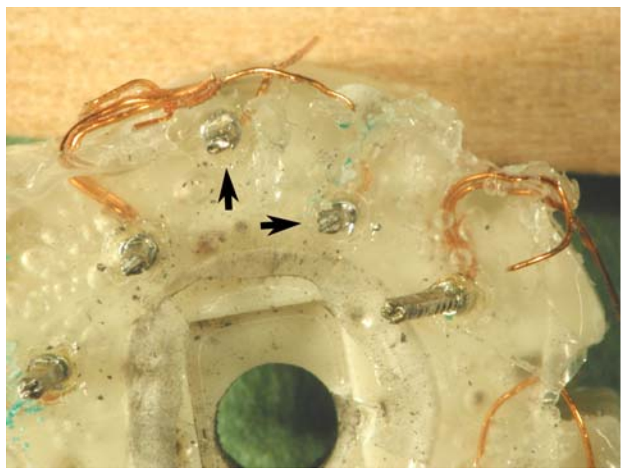

Figure 16. Black arrows document the two pins attached to the crossing wires. Comparison to the schematic suggests they were either Pins 2 and 3, or Pins 7 and 8.

Appended Photographs:

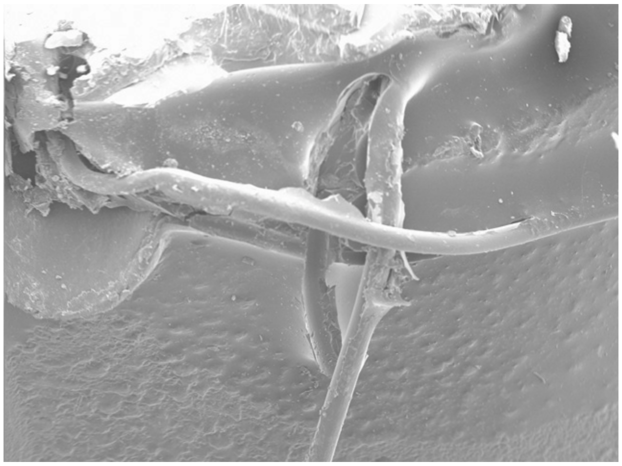

Figure 17. A SEM micrograph shows the crossed wires and their respective grooves. Note that the polymer at top shows evidence of lateral displacement. Displacement of the vertical wire has affected the other wire, pulling it out of the conformal coating.

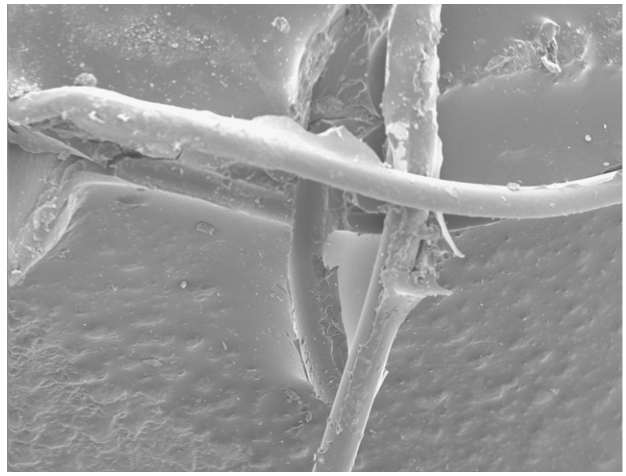

Figure 18. The groove for the vertical wire is seen deeper than the groove for the horizontal wire, and appears to be separated by only a wire diameter.

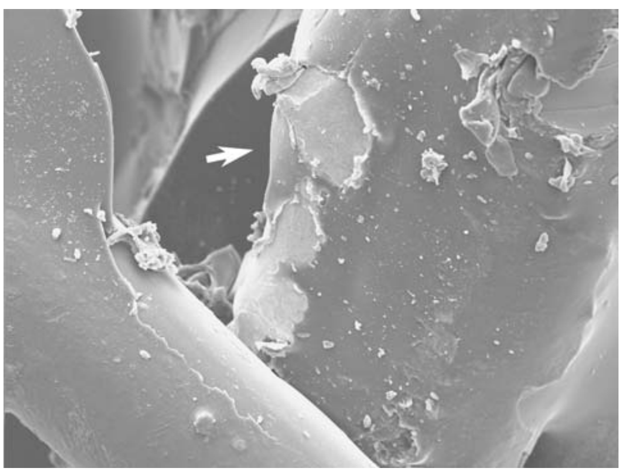

Figure 19. A close-up view of the crossed wires. The arrow points to exposed metal, possibly solder.

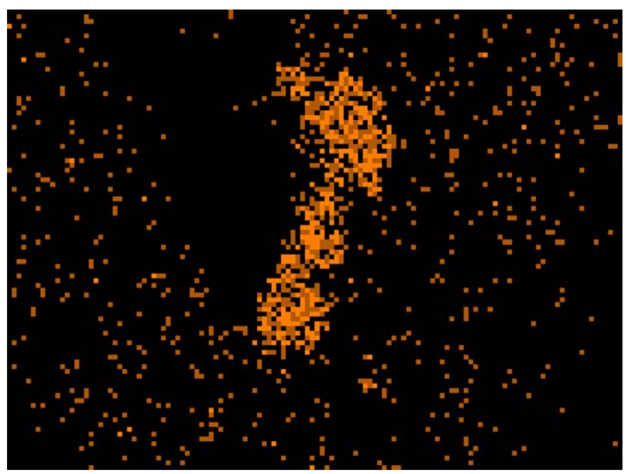

Figure 20. An EDS dot-map of the area of Figure 19 shows tin (Sn) in orange. The area matches the exposed metal seen at left.

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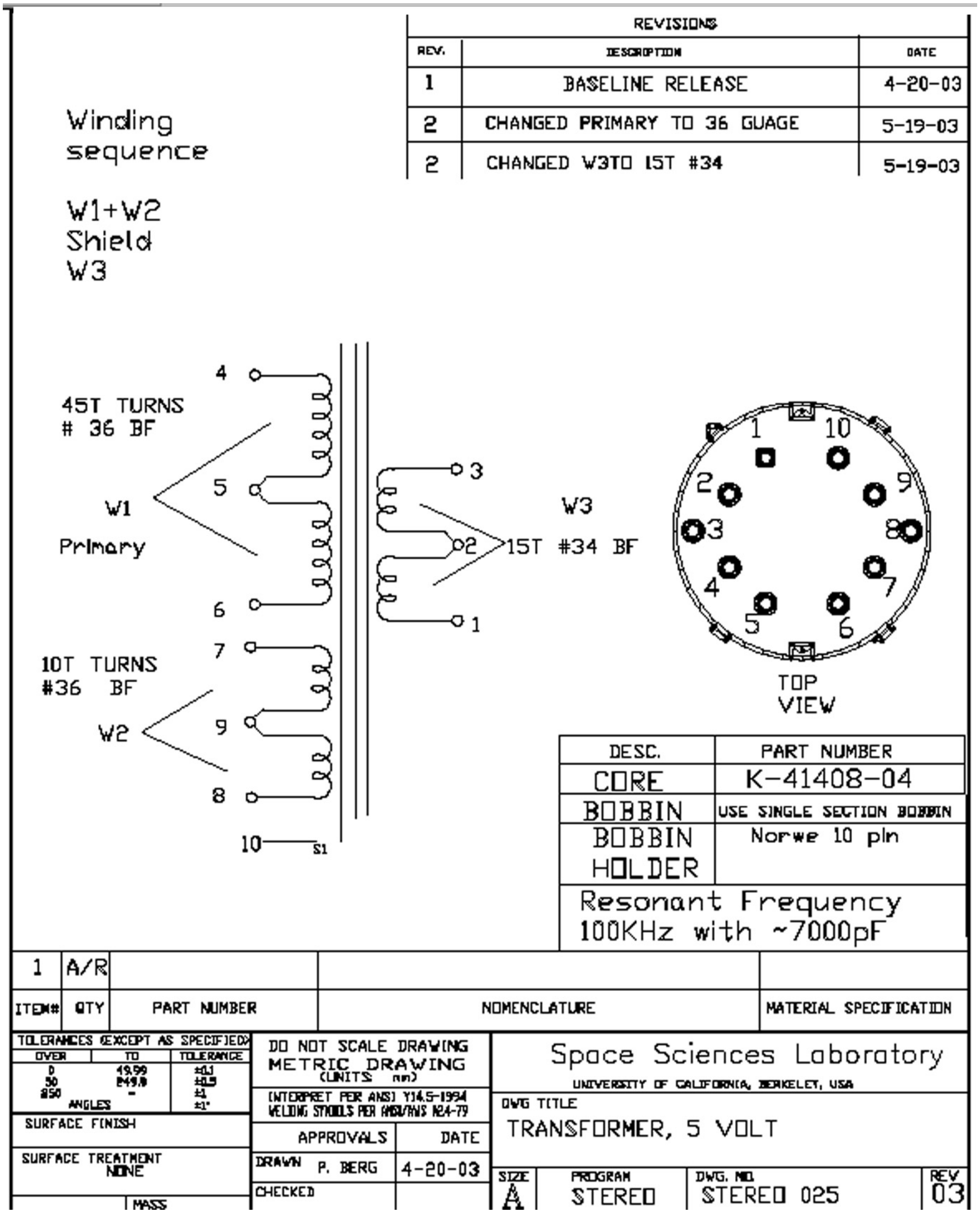
Transformer Schematic:

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