



L= SE1 EHT= 2.50 KV WD= 13 mm MAG= X 55.0 PHOTO= 6
500 μ m

Tin Whiskers Growing Inside ~45 Year Old AF114 Germanium Transistors

Parts Analysis by: Chris Greenwell/QSS Group, Inc.

Summary Prepared by: Jay Brusse/QSS Group, Inc.

Parts Donated by: Paul Stenning/UK Vintage Radio



Background



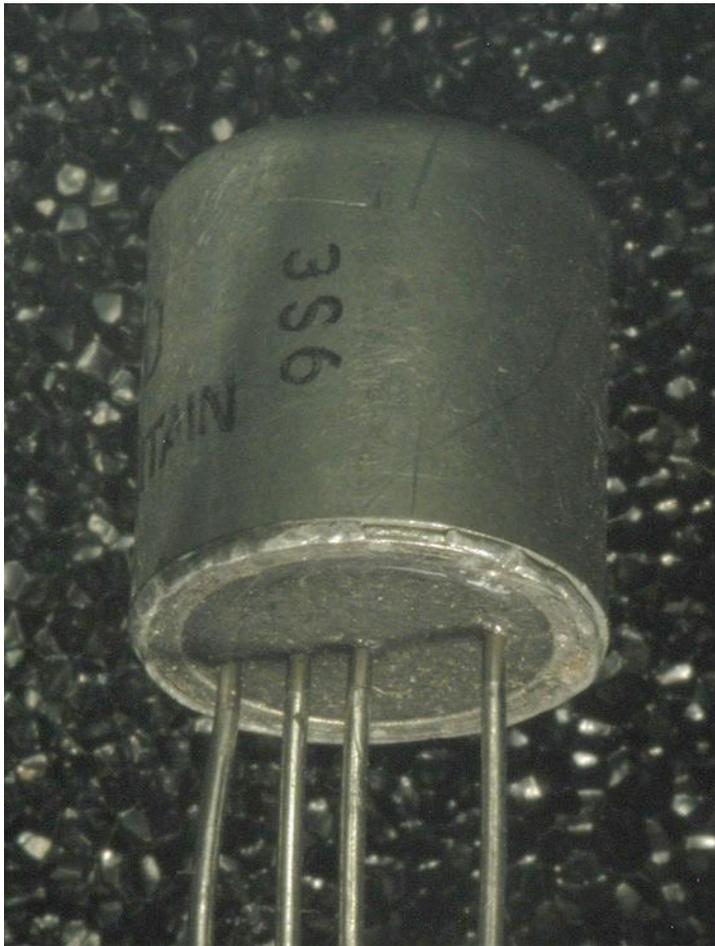
- Sept. 2005 - Mr. Paul Stenning (UK Vintage Radio)
 - Mr. Stenning contacted engineers at NASA Goddard to share images of metal whiskers found growing from the inner package walls of OC170 type transistors made circa 1960.
 - The OC170 transistors had been removed from a “classic” radio by a colleague of Mr. Stenning due to failure of the devices. Ostensibly the failures were noted some 40+ years after parts were assembled into the radios, but it is not known if failures had been occurring intermittently throughout the life of the radio.
 - At least one device had been opened by the restorer of the radio revealing dense metal whisker growth from the inner walls of the TO package. These whiskers were suspected to be the source of the internal shunting paths.
 - Discussion thread found on the UK Vintage Radio Forum suggests that a community of collectors/restorers of classic radios has developed experience that a number of different Germanium Transistors built in this era are known to suffer from internal shorting. Some tricks to provide temporary restoration of function are discussed
Ref: http://www.vintage-radio.com/repair-restore-information/transistor_transistor-faults.html
- Oct. 2005 – Mr. Stenning
 - At request of NASA Goddard, Mr. Stenning supplied four (4) AF114 germanium transistors from his personal inventory for NASA component failure analysis group to determine composition of metal whiskers (if any) growing internally.
 - Mr. Stenning reported that these four parts behaved as if they had internal shunting paths much like the OC170 transistors mentioned above
 - The parts supplied do not possess lot date codes, but it is postulated they were made circa 1960. It also appears that they were never installed into any hardware (e.g., classic radios)
- Nov. 2005 – NASA Goddard Parts Analysis Lab (see following slides)
 - Initiated analysis of four (4) AF114 transistors supplied by Mr. Stenning
 - Analysis included X-ray, curve tracer, external and internal optical microscopy, scanning electron microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS)
 - Slides that follow contain information obtained from analysis at GSFC to date



External Photographs – AF114



No Lot Date Code Information Marked on Devices
Based on Input from Source Assume parts made circa 1960



November 2005

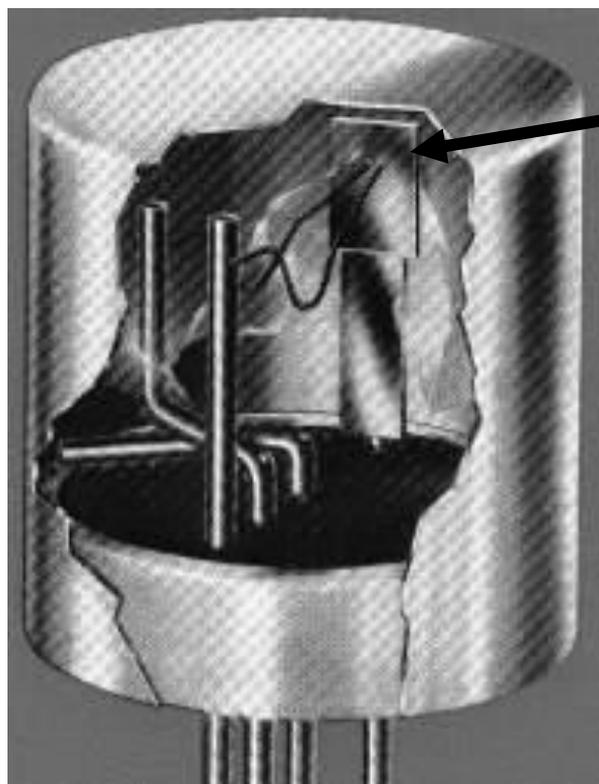
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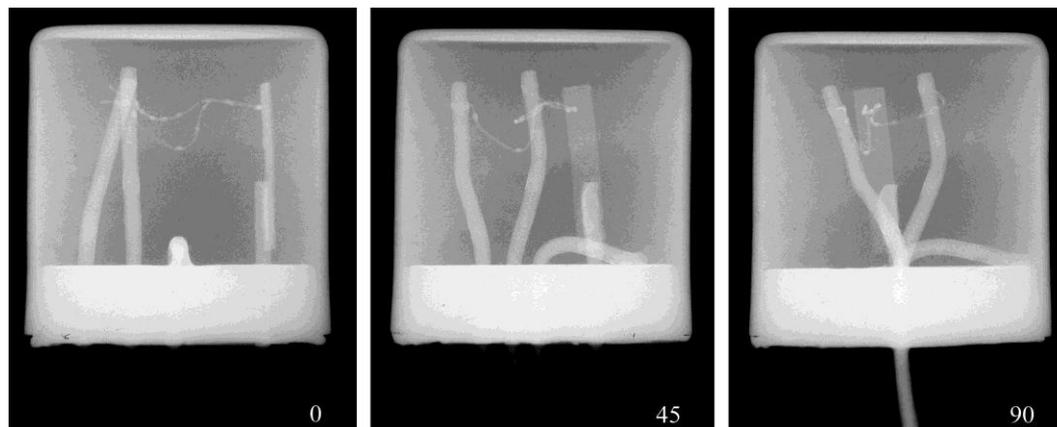
Internal Diagram & X-Ray of AF114

Note that Pin 3 is connected to the case,
but is not connected to the transistor (pins 1, 2 and 4)

Pin 1 = Emitter, 2 = Base, 3 = Case, 4 = Collector



Germanium Transistor



NASA GSFC X-Ray of AF114 Device Received
(3-Views at 0°, 45°, 90°)

1 2 3 4

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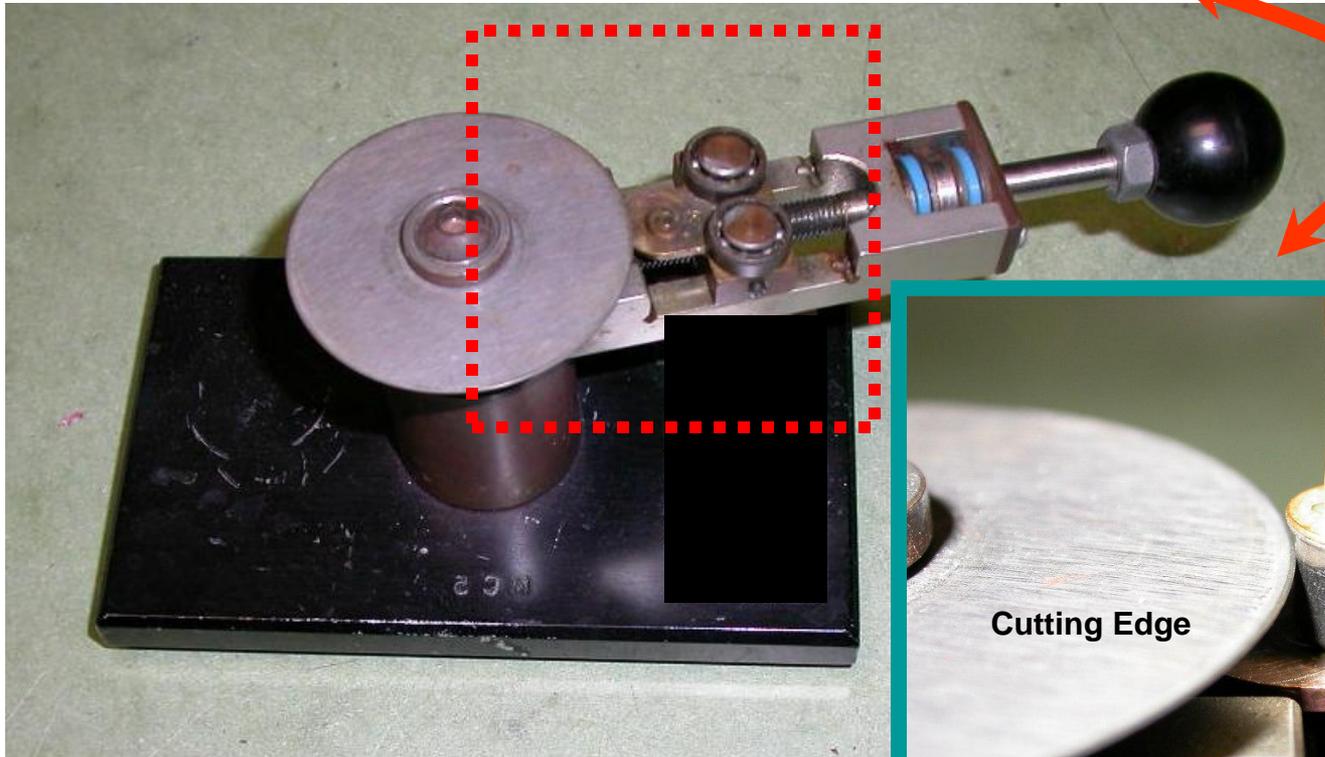


“Can Opener”

Photos to Illustrate type of Tool Used to Open the Transistor Package



Pivoting this Handle Rotates the Device Package Against the Cutting Edge



Roller Bearings



Note: Transistor Shown in this Photo is NOT the AF114 Examined Herein

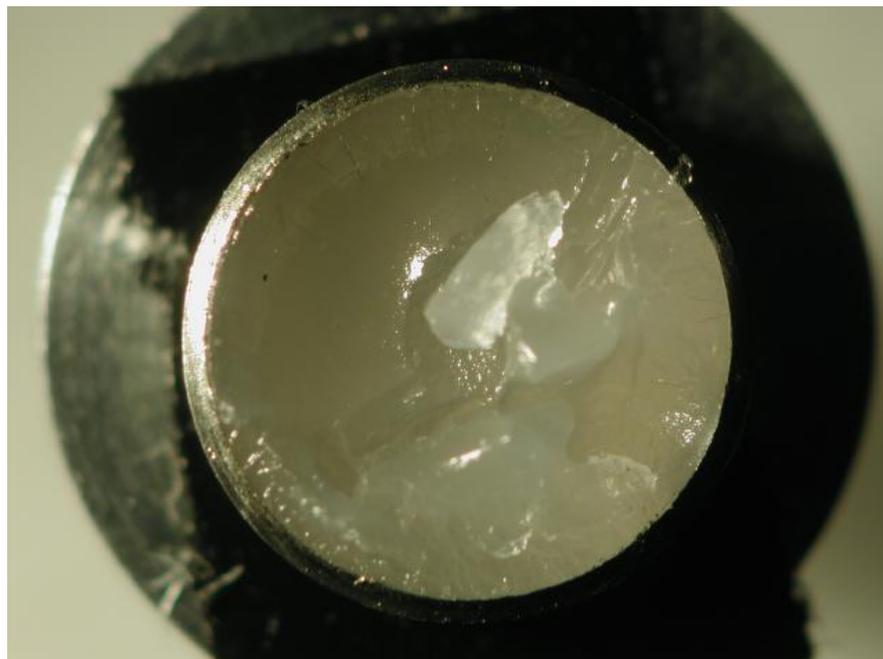


Internal Optical Microscopy of AF114 after Opening TO Package



Inside of Transistor with Top Removed
Whiskers are already evident

Top of Case contains
Jelly-Like Substance
(Somewhat lower viscosity than petroleum jelly,
Suspected to be some type of Silicone)



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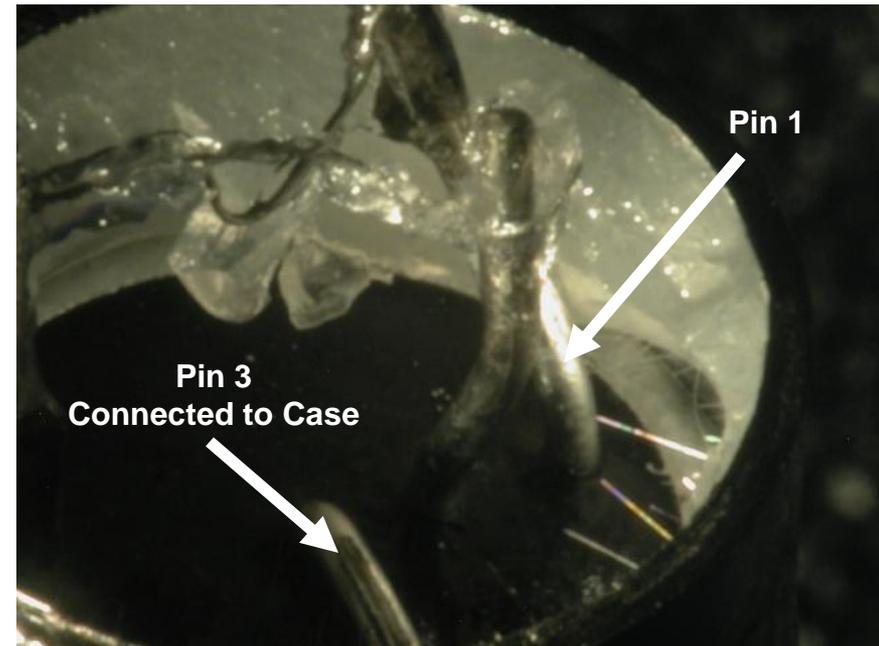
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Internal Optical Microscopy



Whiskers Shorting from Case to Pin 1

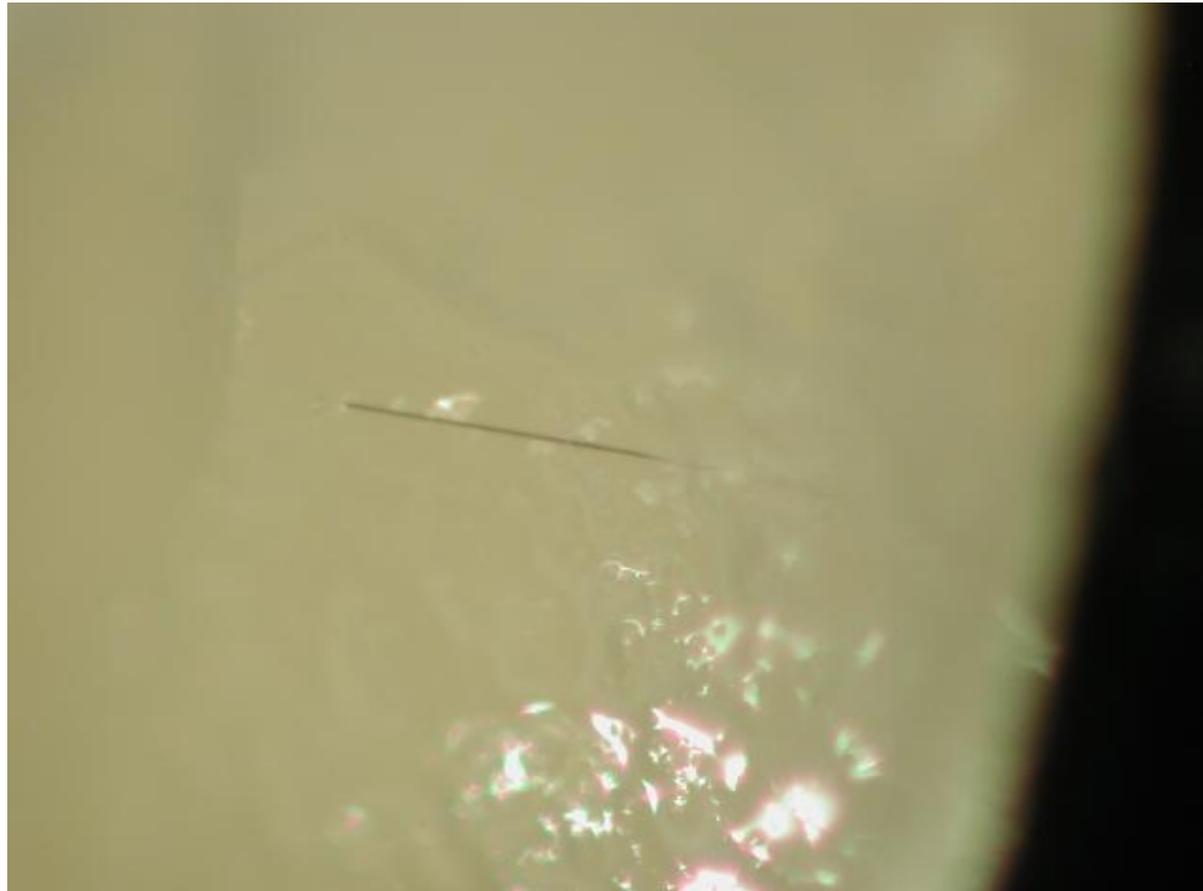




Internal Optical Microscopy



*Whiskers Grow Readily Within and Through the
Jelly-Like Substance.*



November 2005

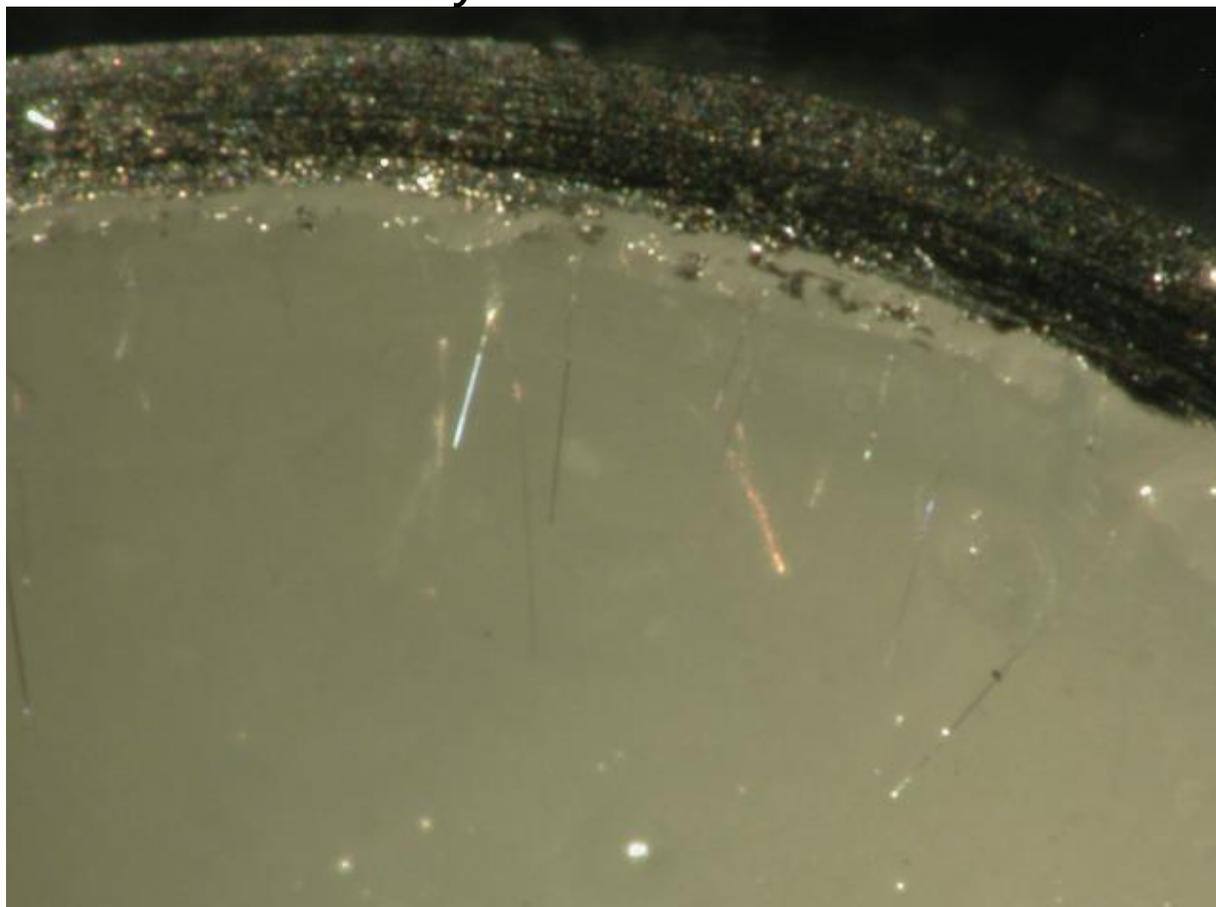
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Internal Optical Microscopy



*Whiskers Grow Readily Within and Through the
Jelly-Like Substance.*



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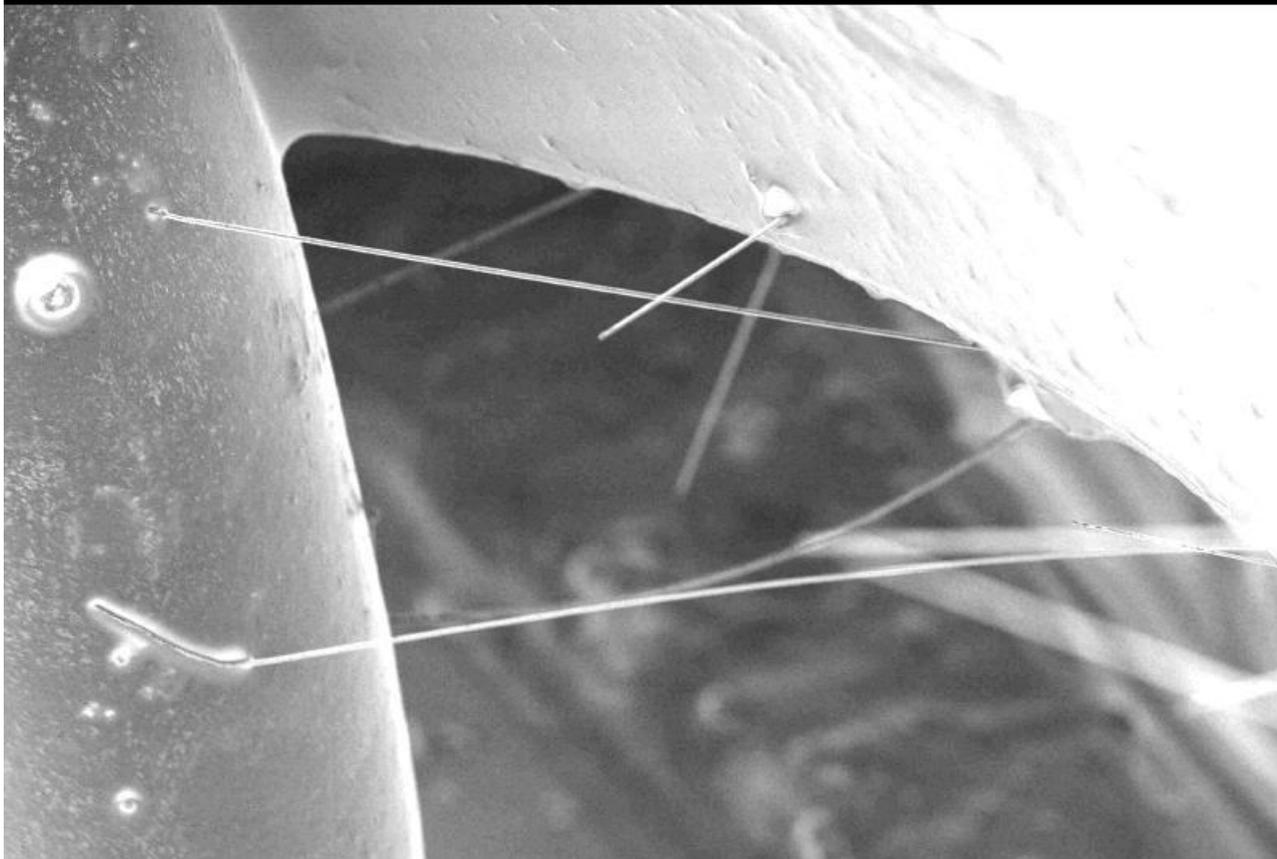


Scanning Electron Microscopy



Whiskers Shorting Case to Pin 1

L= SE1 EHT= 2.50 KV WD= 17 mm MAG= X 107. PHOTO= 2
200 μ m



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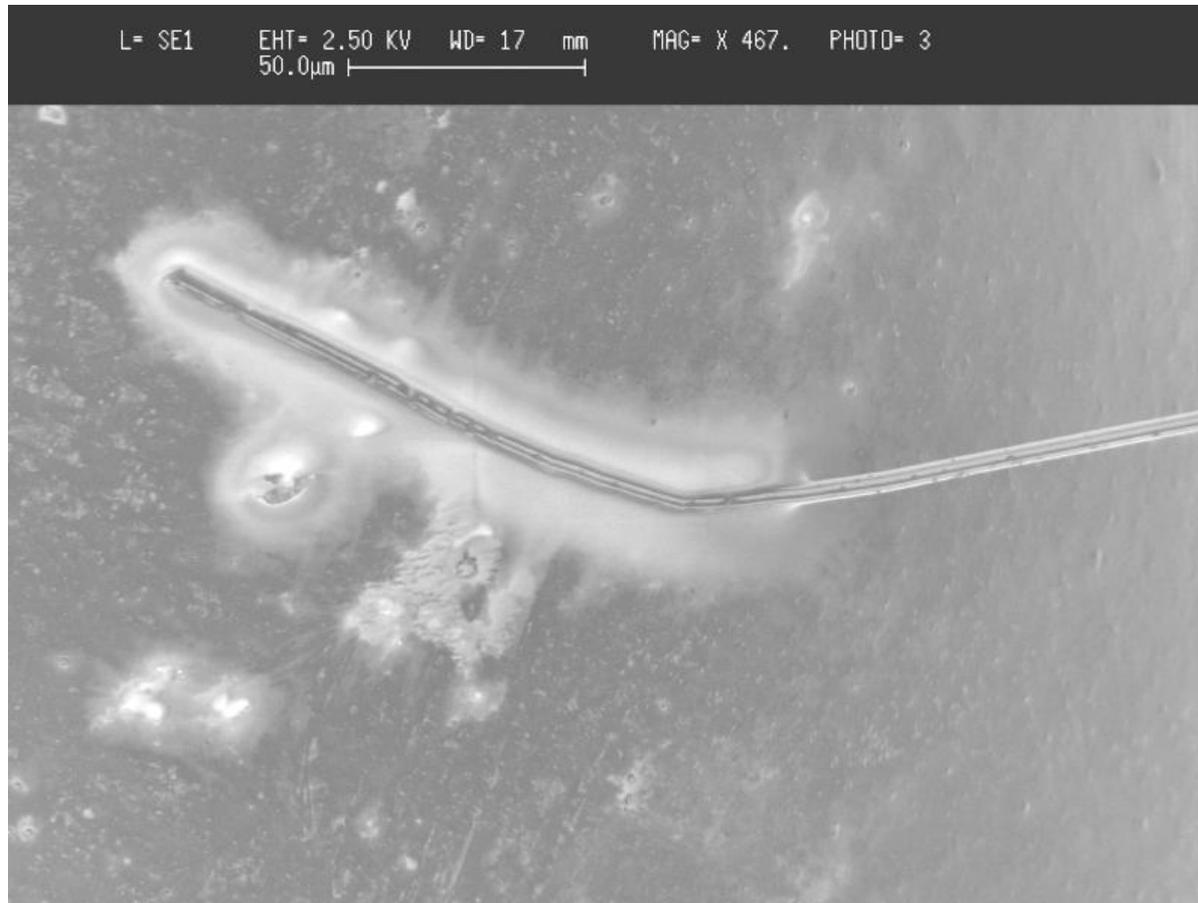
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Whisker Shorting to Pin 1



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Whisker Shorting to Pin 1



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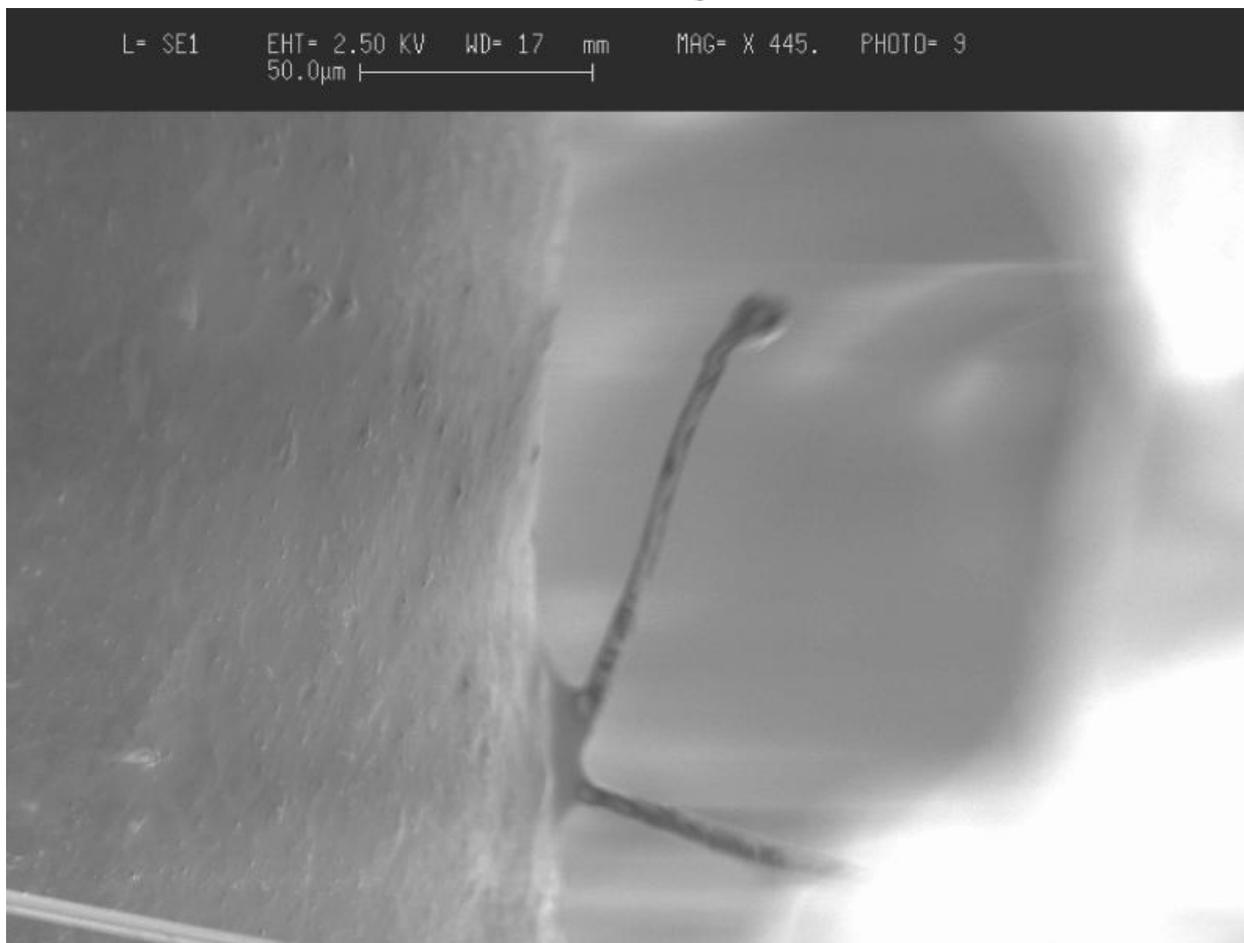
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Whisker Shorting to Pin 1



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Whiskers Growing from Case Wall

L= SE1 EHT= 2.50 KV WD= 13 mm MAG= X 55.0 PHOTO= 6
500 μ m



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Whiskers Growing from Case Wall Towards Internal Pins



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L= SE1 EHT= 2.50 KV WD= 16 mm MAG= X 43.3 PHOTO= 11
500 μ m



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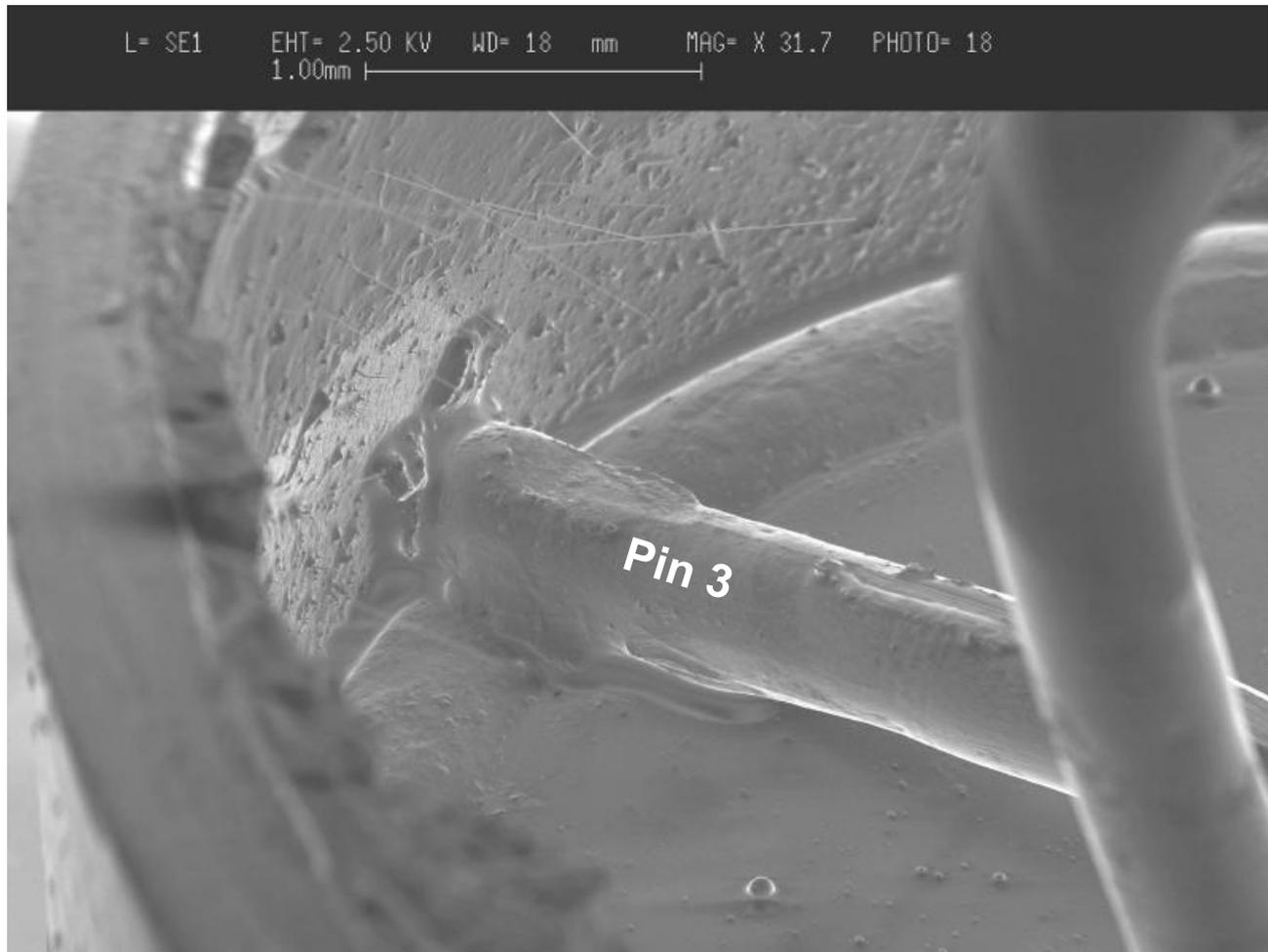
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Pin 3 Connected Internally to Case



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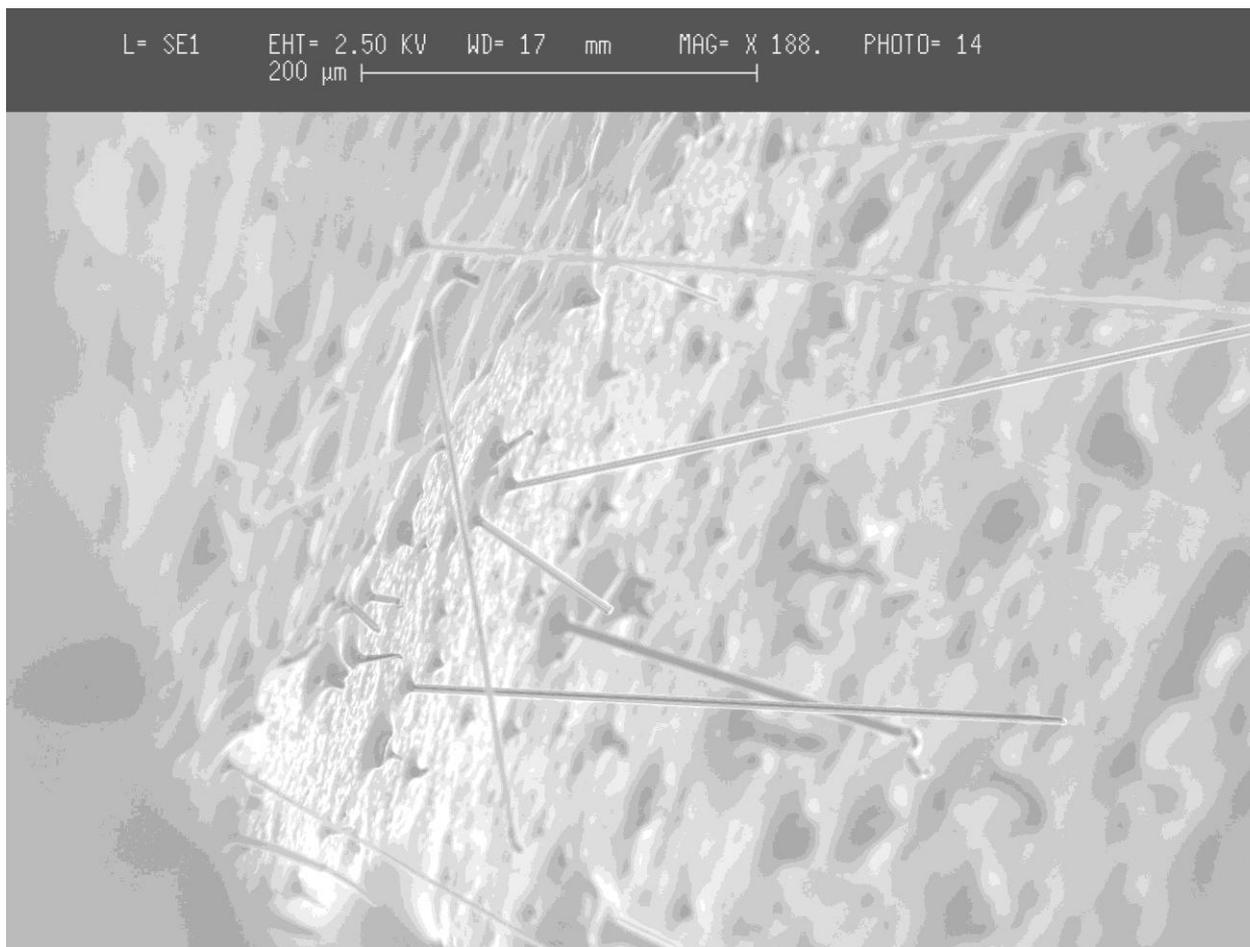
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Filament Type Whiskers + Nodules

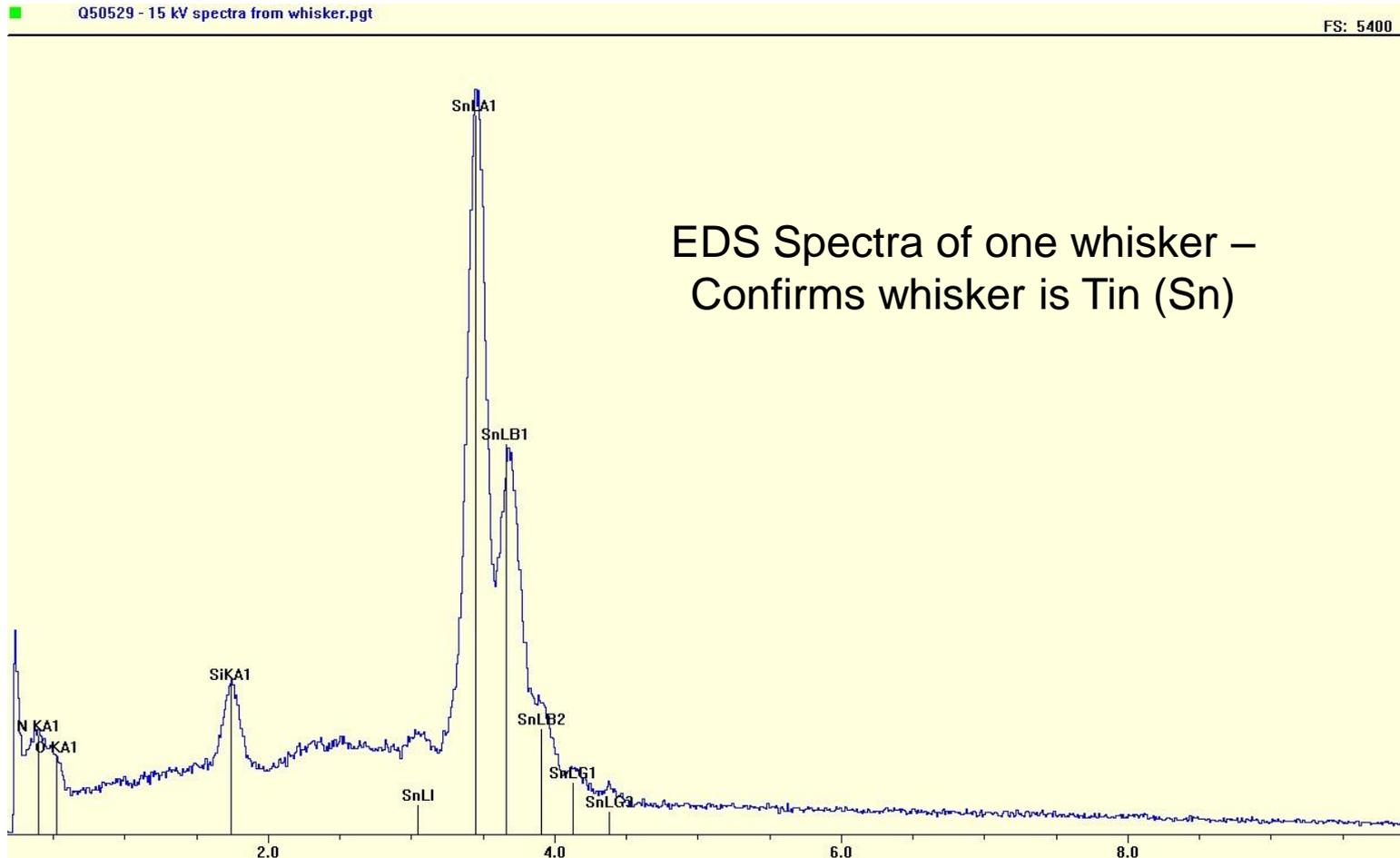


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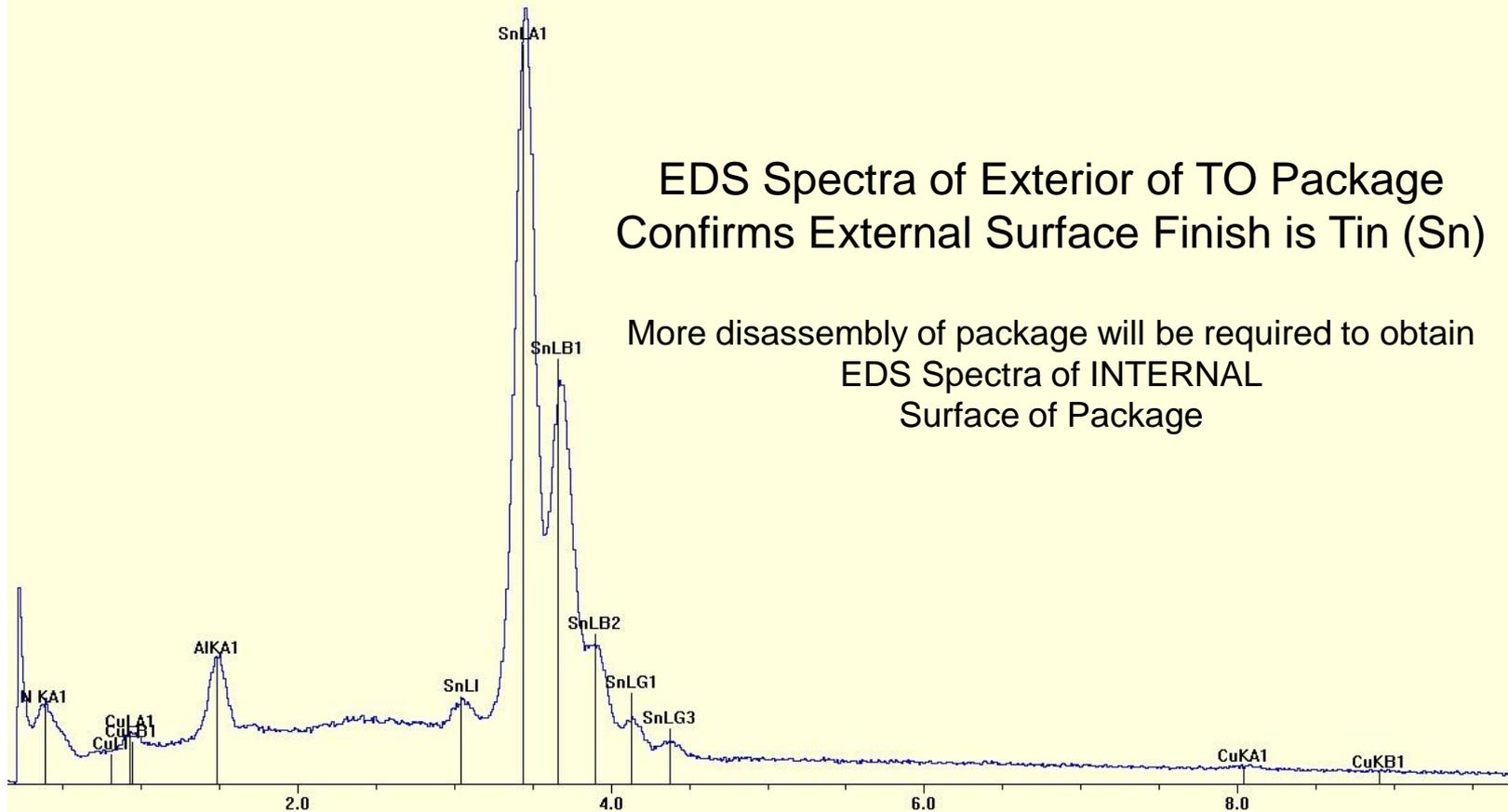


Scanning Electron Microscopy



Q50529 outside can surface 15kV.pgt

FS: 20000



EDS Spectra of Exterior of TO Package
Confirms External Surface Finish is Tin (Sn)

More disassembly of package will be required to obtain
EDS Spectra of INTERNAL
Surface of Package

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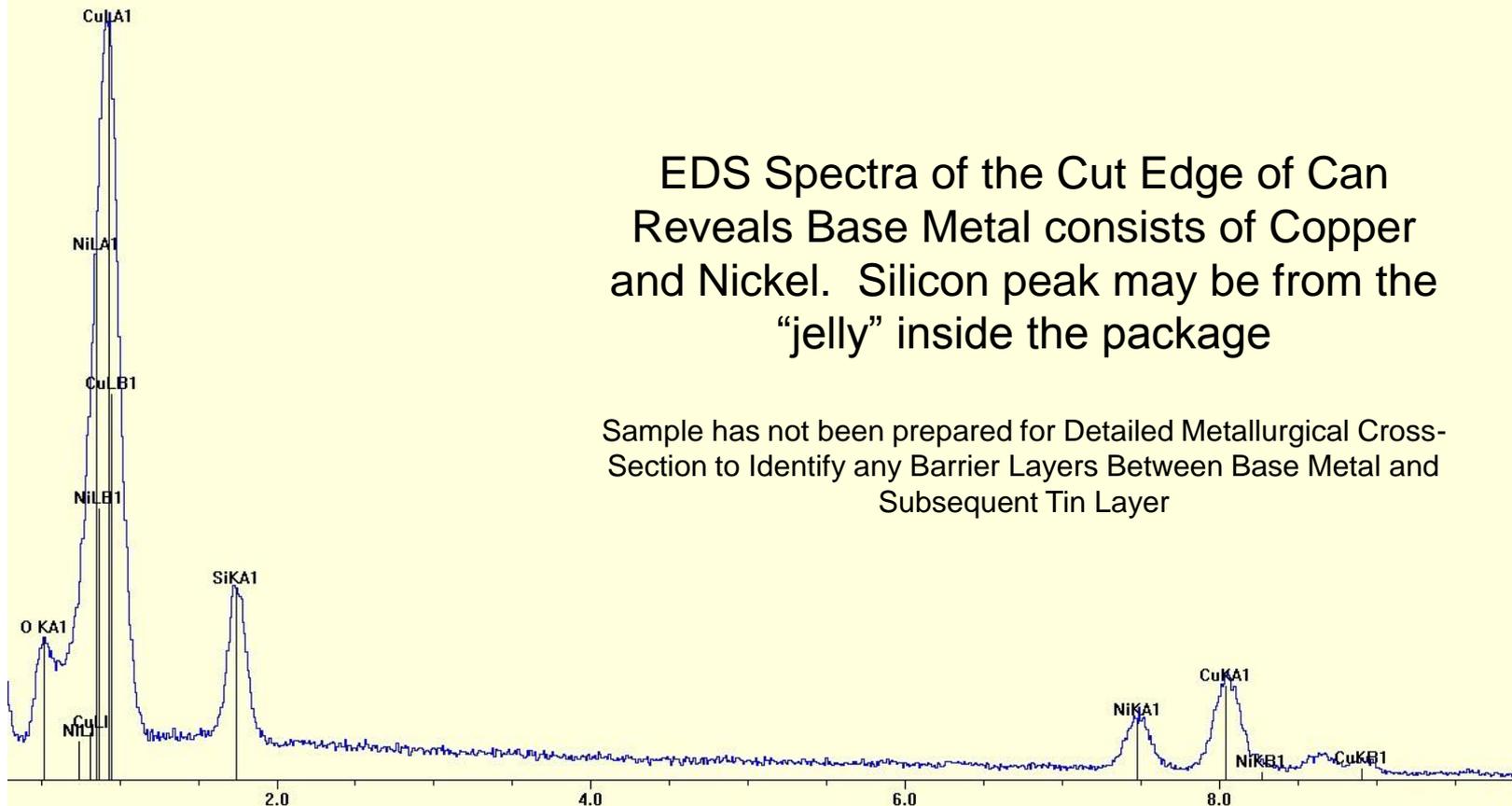


Scanning Electron Microscopy



Q50529 cut surface of can 15kV.pgt

FS: 3600



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Closing Remarks

- This Presentation is Preliminary and Contains a Brief Synopsis of Information Gathered During Initial Phases of Examination
- Intent is to Produce an “Anecdote” of this Information for Posting to the NASA Tin and Other Metal Whisker WWW Site



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<http://nepp.nasa.gov/whisker>