PRELIMINARY

A More Comprehensive Summary of this Information is Planned for

Posting to the NASA Metal Whisker WWW Site in the Near Future

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 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

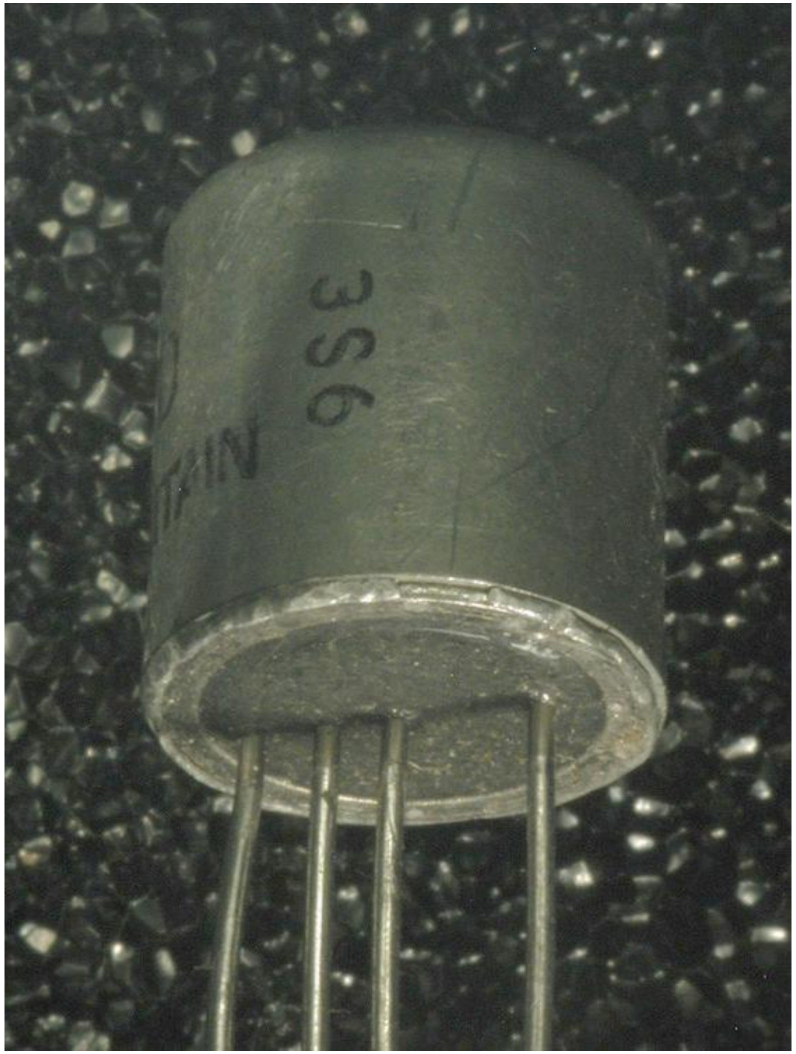
    Ref: http://www.vintage-radio.com/repair-restore-information/transistor_transistor-faults.html

- 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
  - 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

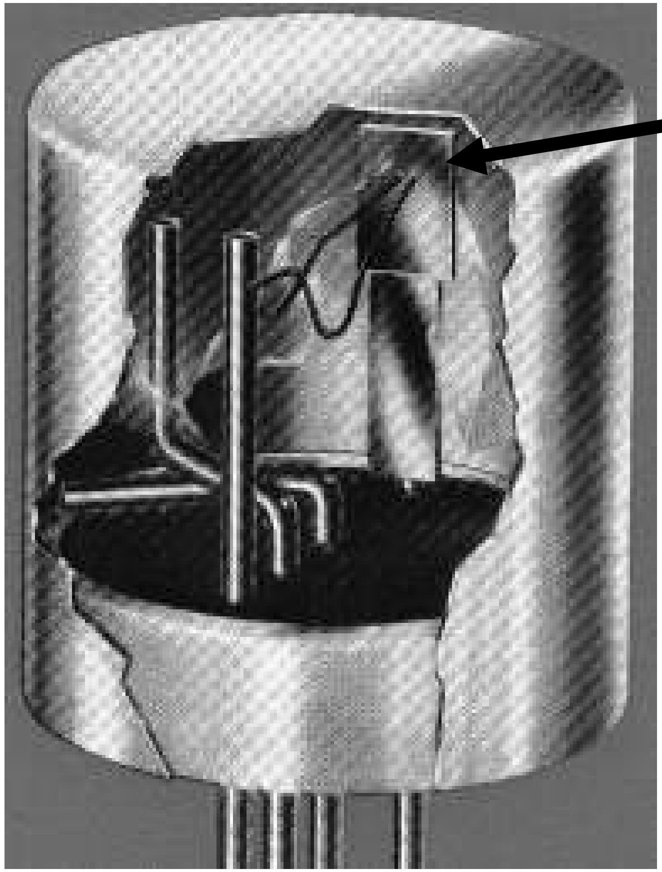
External Photographs – AF114

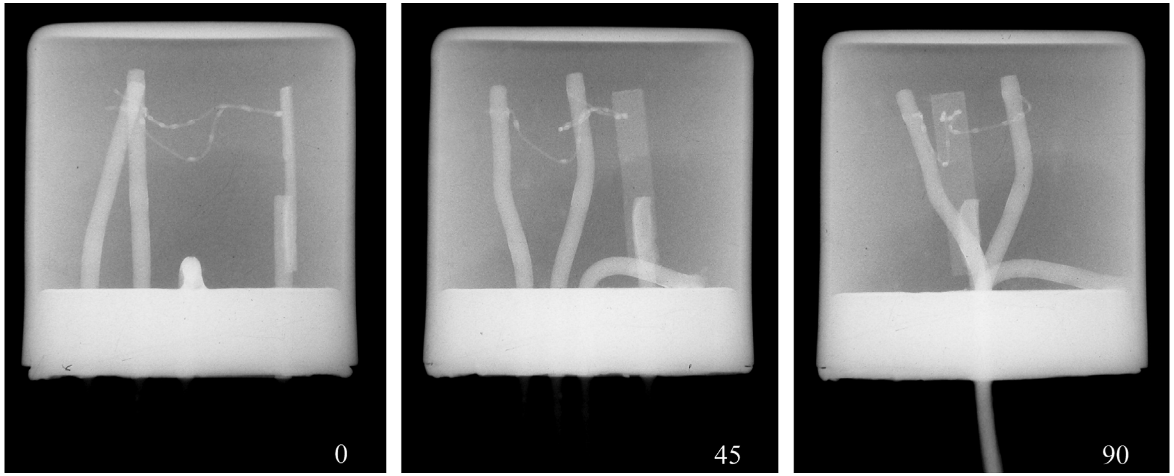
No Lot Date Code Information Marked on Devices
Based on Input from Source Assume parts made circa 1960



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

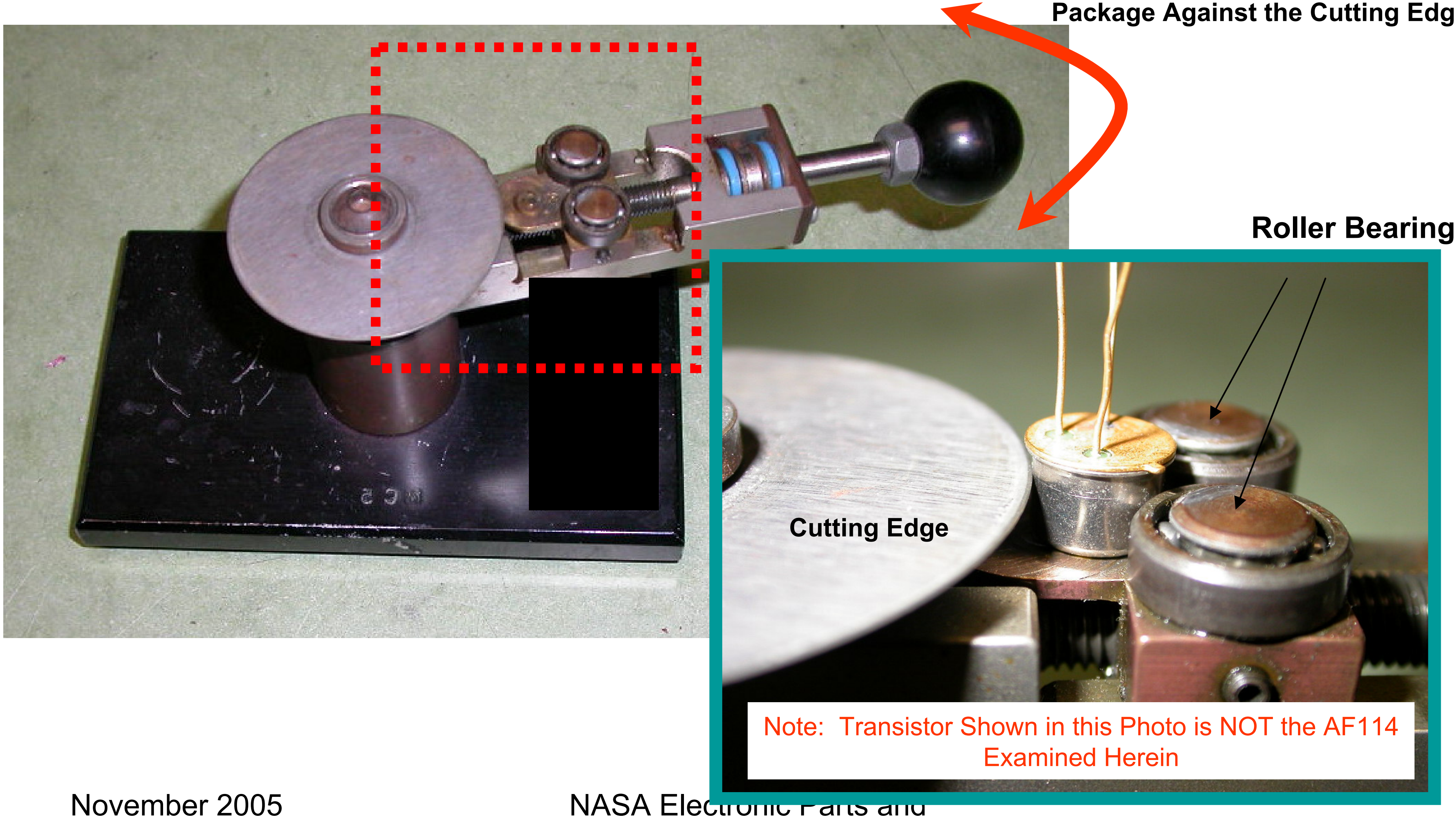




NASA GSFC X-Ray of AF114 Device Received
(3-Views at 0°, 45°, 90°)

“Can Opener”

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



[redacted]

Pivoting this Handle Rotates the Device Package Against the Cutting Edge

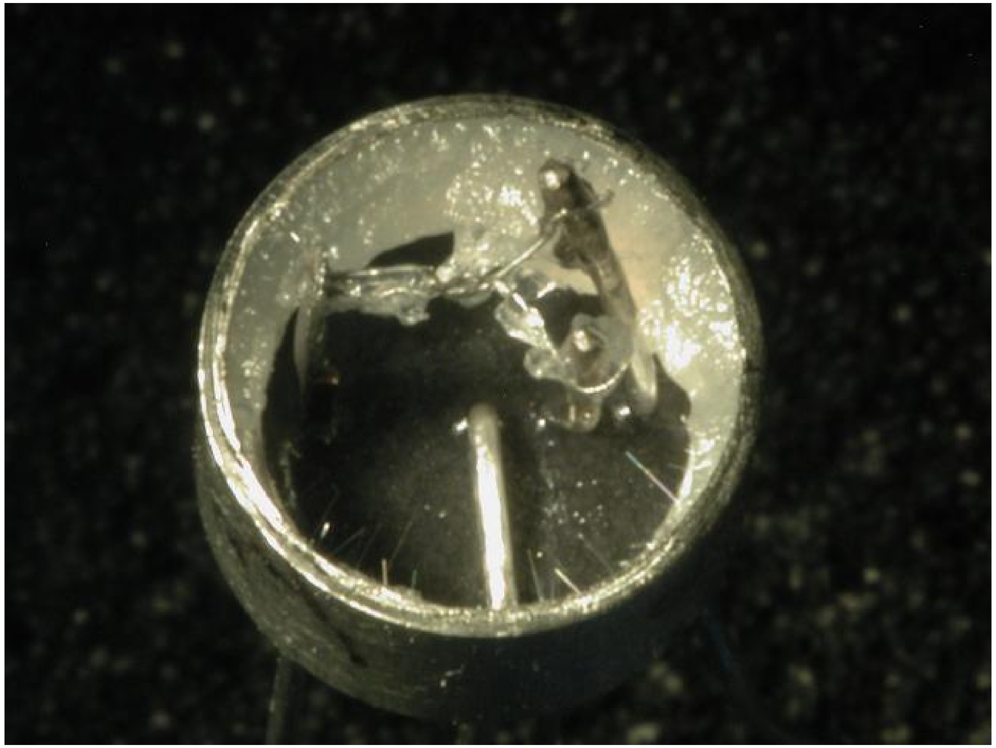
Roller Bearings

Cutting Edge

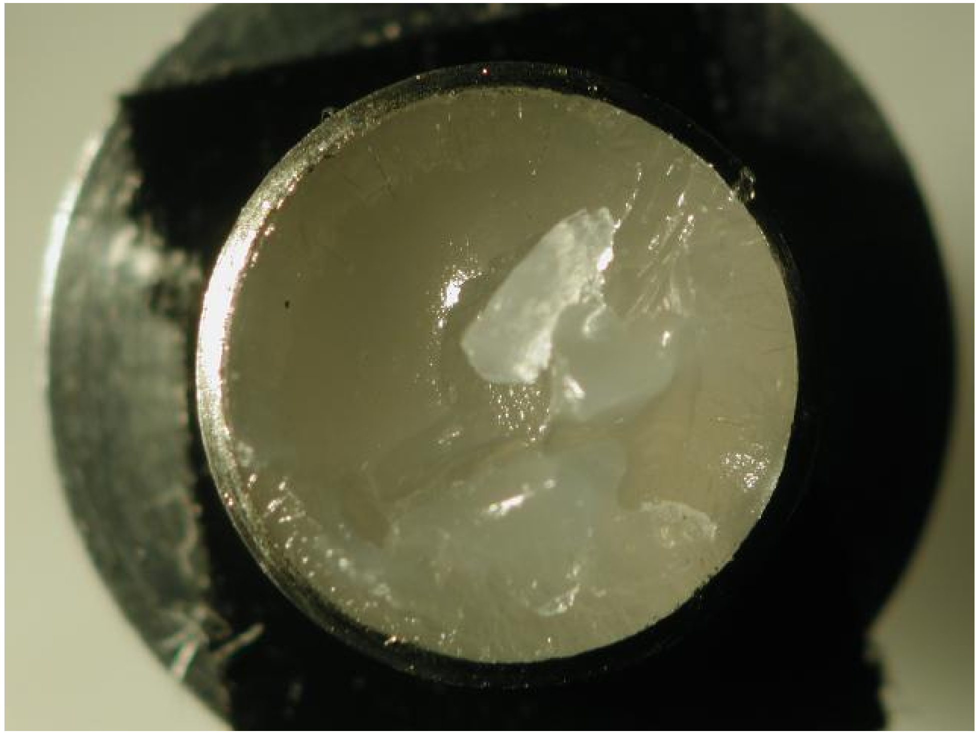
Note: Transistor Shown in this Photo is NOT the AF114 Examined Herein

Internal Optical Microscopy of AF114 after Opening TO Package

Inside of Transistor with Top Removed
Whiskers are already evident

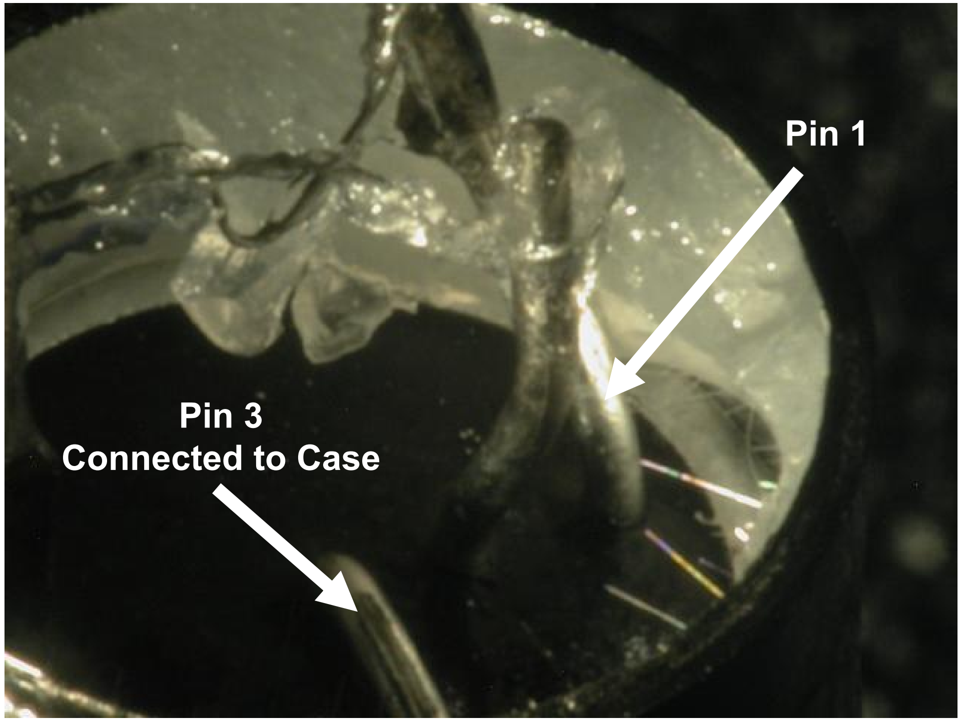


Top of Case contains
Jelly-Like Substance
(similar to petroleum jelly in viscosity,
Suspected to be some type of Silicone)



Internal Optical Microscopy

Whiskers Shorting from Case to Pin 1



Internal Optical Microscopy

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

Internal Optical Microscopy

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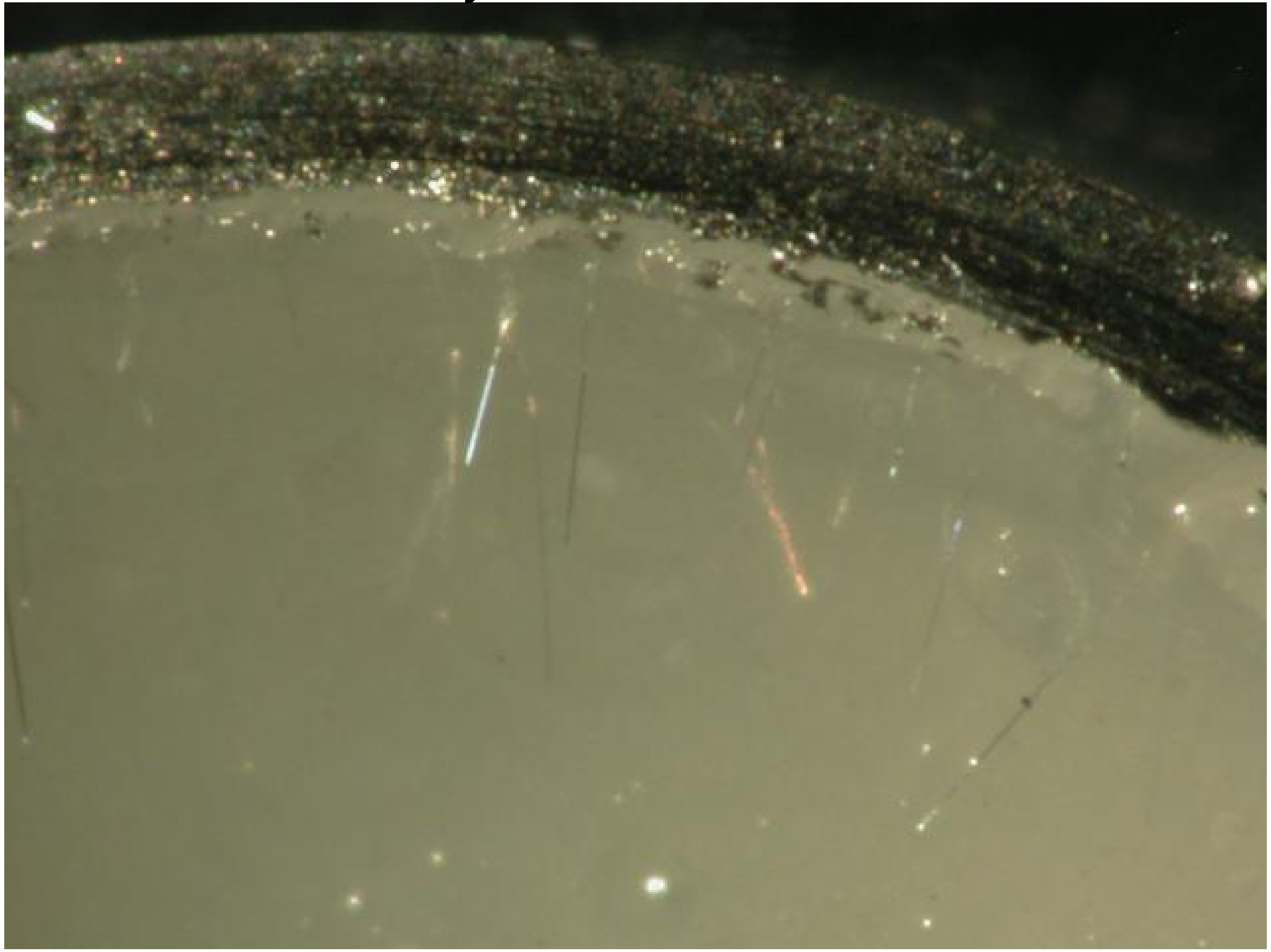
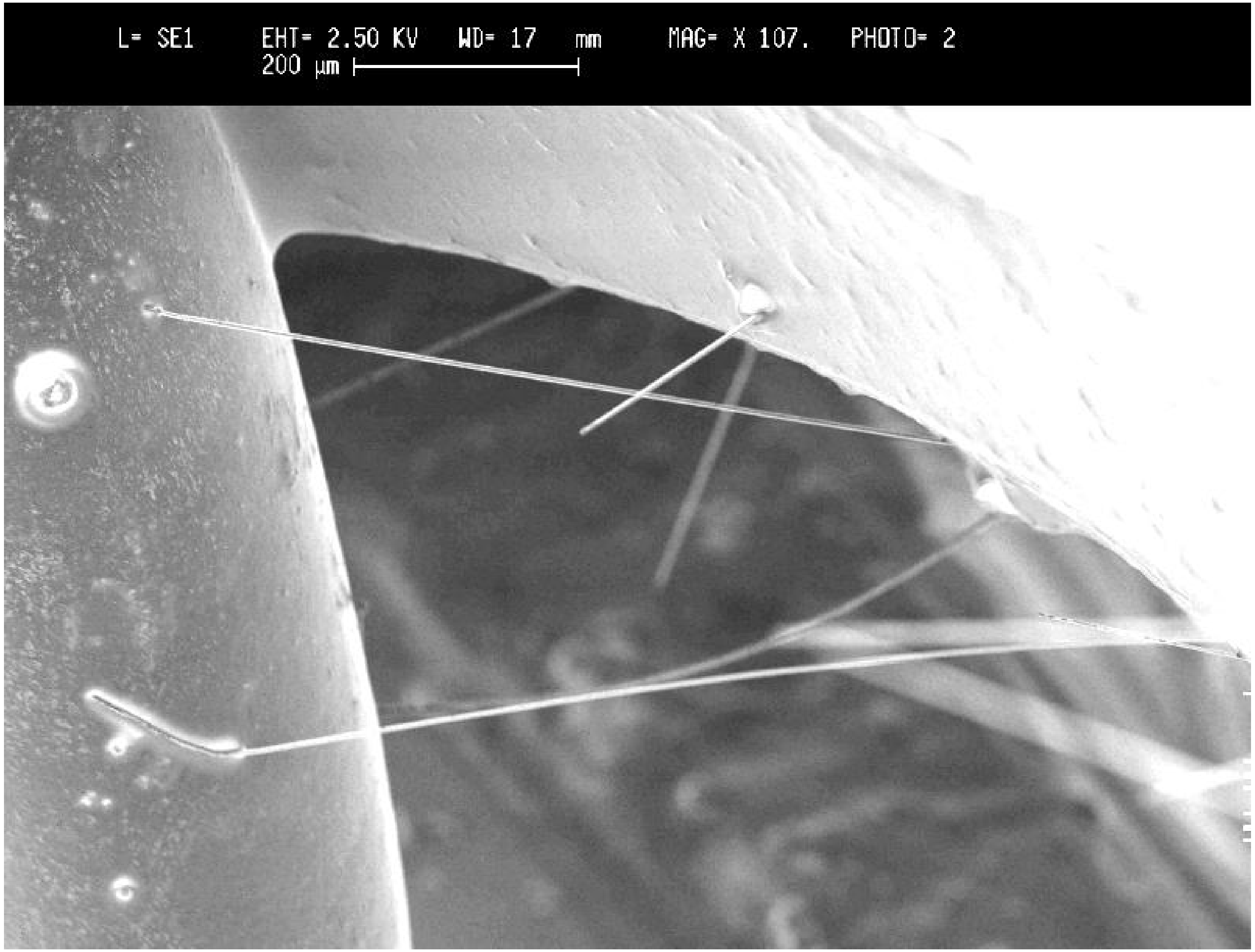


Scanning Electron Microscopy

Whiskers Shorting Case to Pin 1



Scanning Electron Microscopy

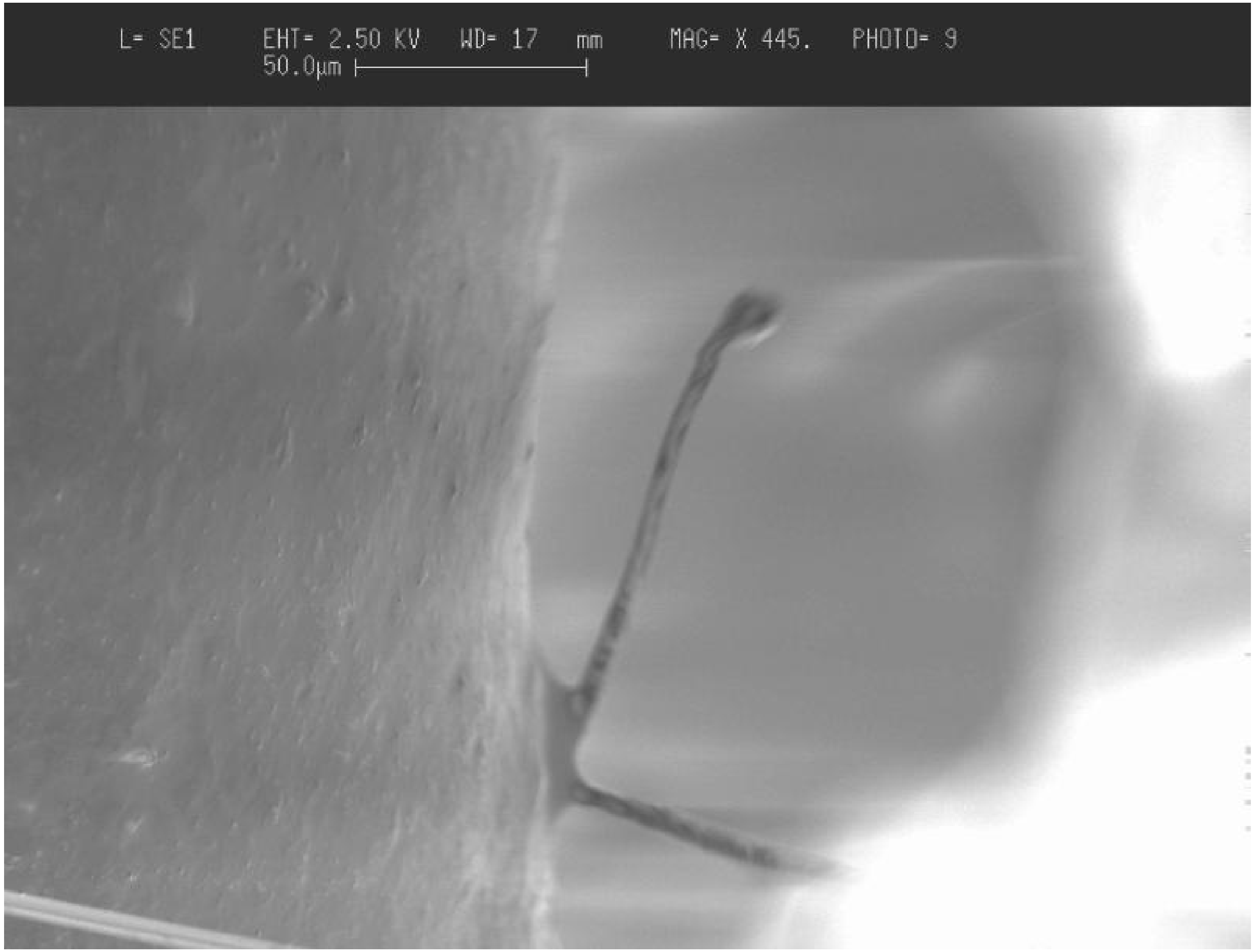
Whisker Shorting to Pin 1

Scanning Electron Microscopy

Whisker Shorting to Pin 1

Scanning Electron Microscopy

Whisker Shorting to Pin 1



Scanning Electron Microscopy

Whiskers Growing from Case Wall

Scanning Electron Microscopy

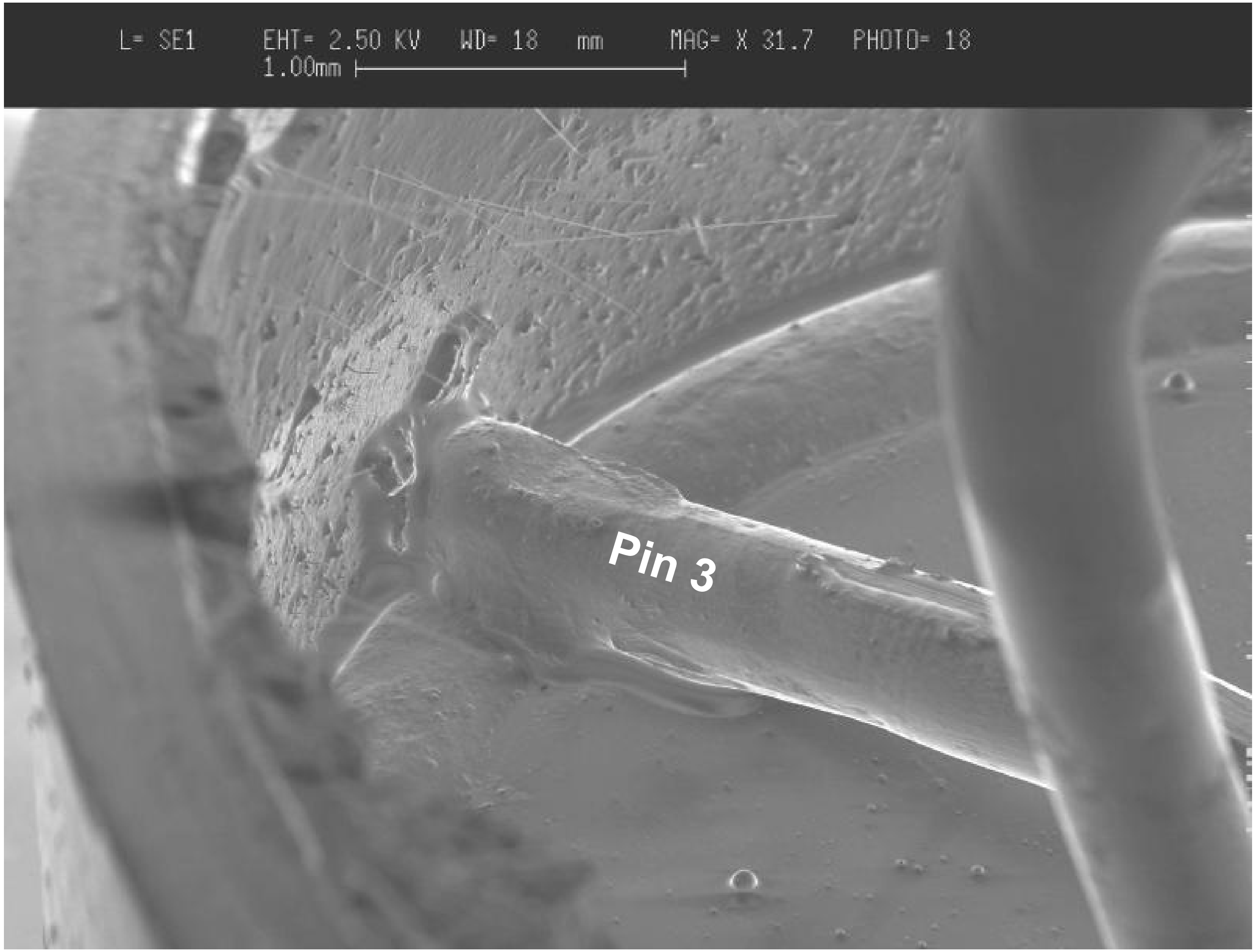
Whiskers Growing from Case Wall Towards Internal Pins

Scanning Electron Microscopy

Scanning Electron Microscopy

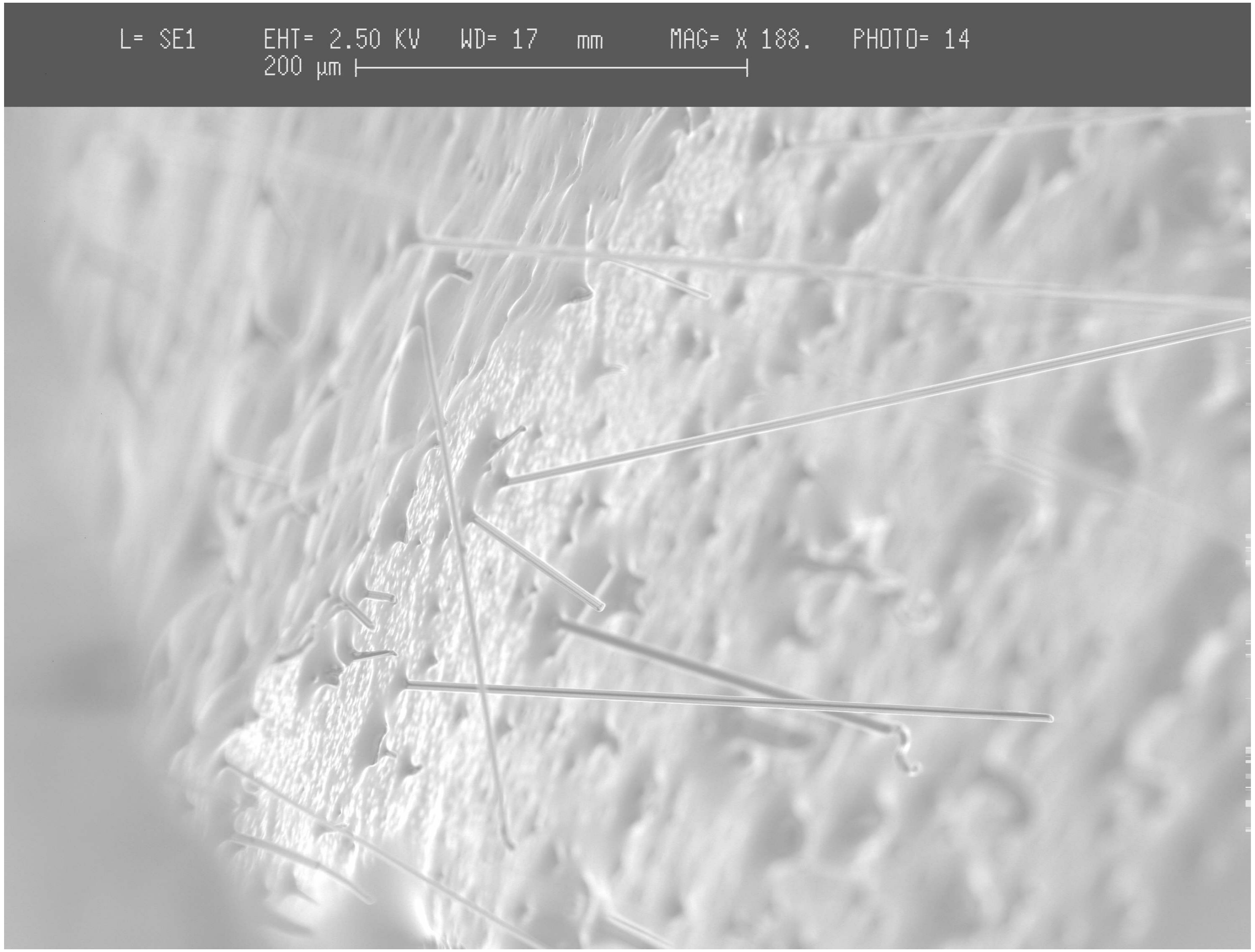
Scanning Electron Microscopy

Pin 3 Connected Internally to Case



Scanning Electron Microscopy

Filament Type Whiskers + Nodules



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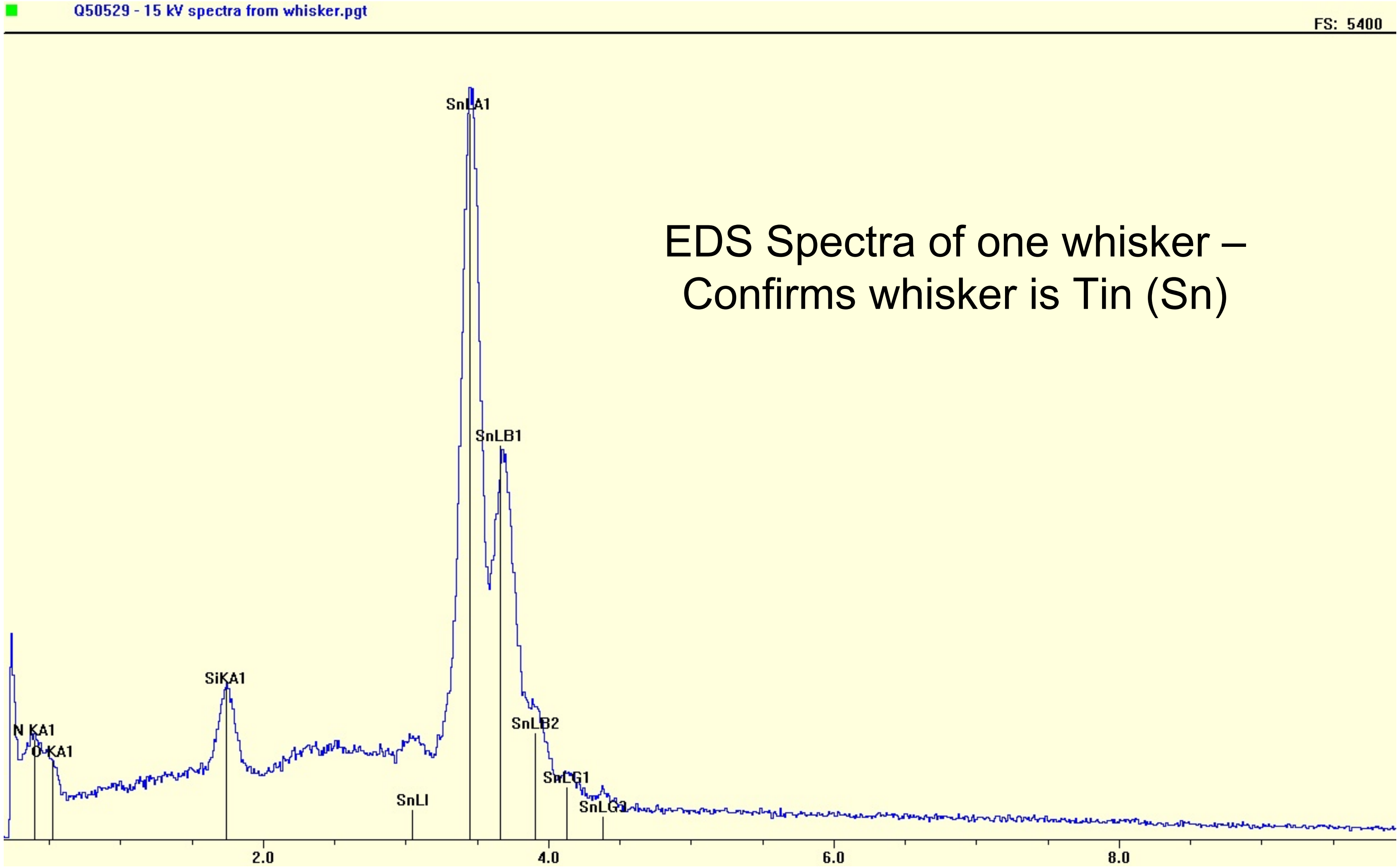
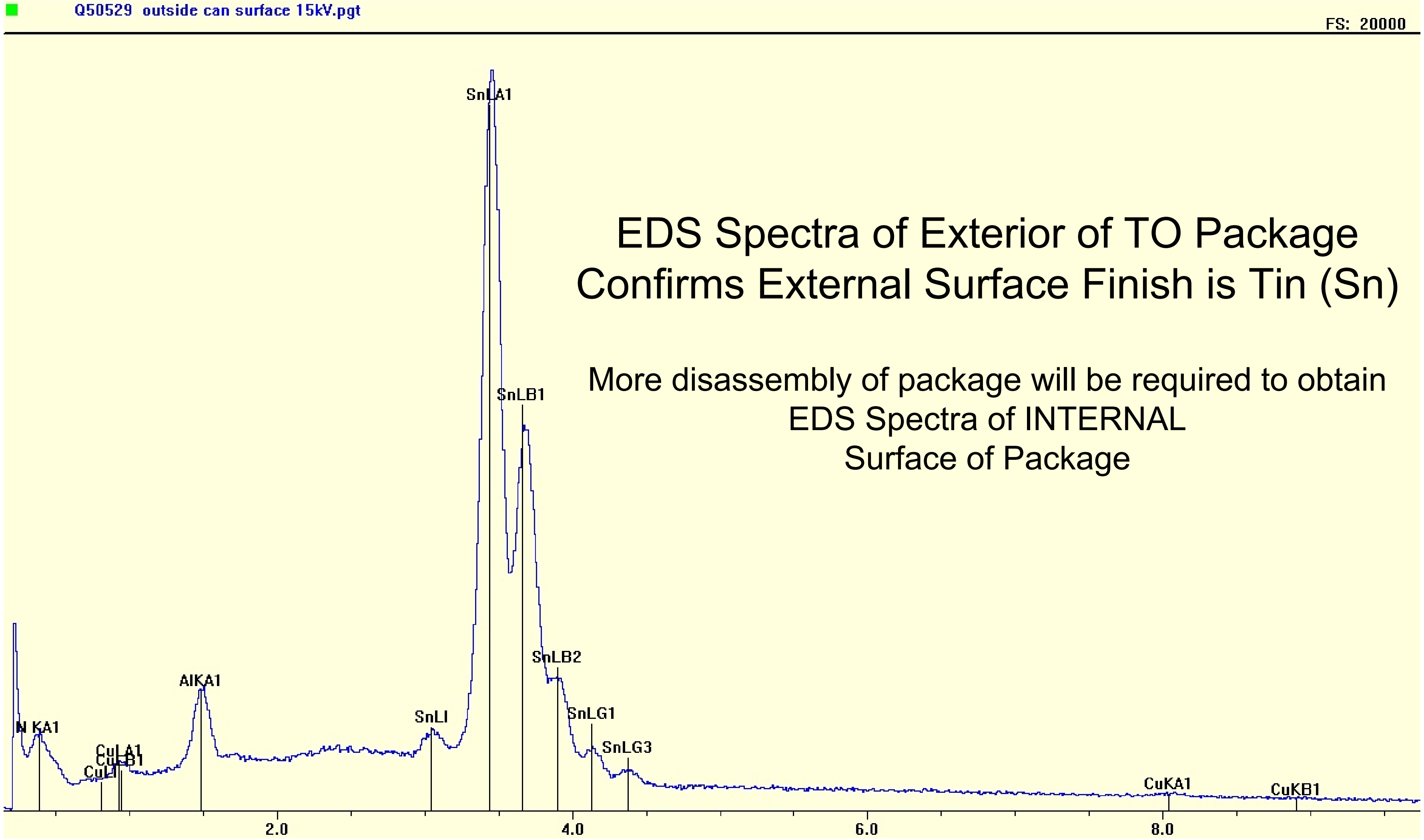


EDS Spectra of one whisker – Confirms whisker is Tin (Sn)

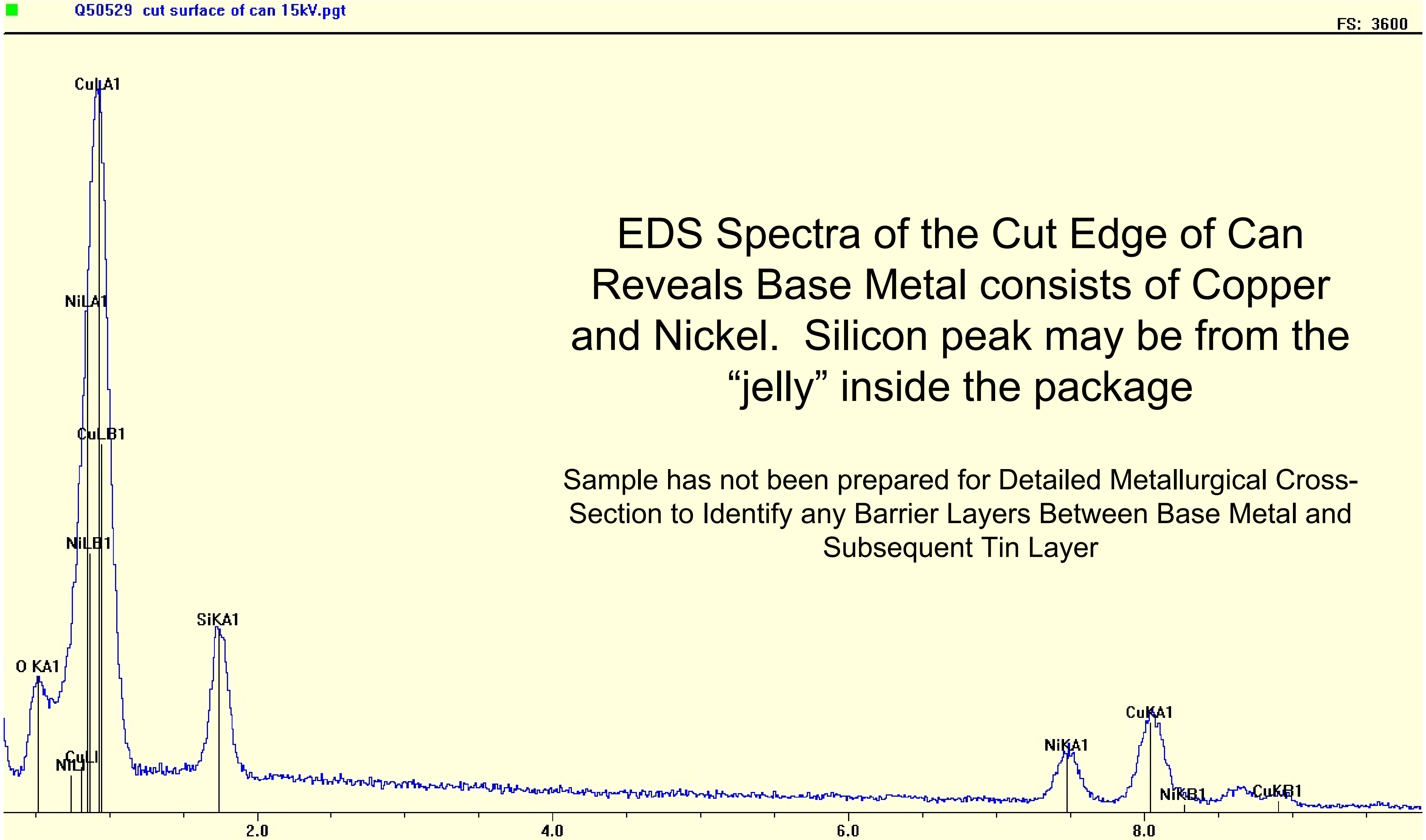
Scanning Electron Microscopy



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

Scanning Electron Microscopy



EDS Spectra of the Cut Edge of Can Reveals Base Metal consists of Copper and Nickel. Silicon peak may be from the “jelly” inside the package

Sample has not been prepared for Detailed Metallurgical Cross-Section to Identify any Barrier Layers Between Base Metal and Subsequent Tin Layer

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 in the Near Future

Contact Info

Jay Brusse
Sr. Components Engineer
QSS Group, Inc. at NASA Goddard Space Flight Center
Jay.A.Brusse.1@gsfc.nasa.gov

Chris Greenwell
Component Failure Analyst
QSS Group, Inc. at NASA Goddard Space Flight Center
cgreenwe@pop300.gsfc.nasa.gov

http://nepp.nasa.gov/whisker