



***A US-based Manufacturer and Specialist
in the Electronic Components Industry***



Key Products

- **Manufacturer of High Reliability QPL MIL-PRF-23419/12 and /13 Fuses (and planned /14).**
- **Manufacturer of High Reliability P600L, P700L, P800L, SM1206 Series Fuses and Modules.**
- **Sn/Pb Conversion (for Tin Whisker Mitigation / Gold Embrittlement Mitigation) and Electrical/Mechanical Screening of Passive and Active Components.**
- **Manufacturer of High Reliability DSCC 03024 Series Chip Beads.**



AEM Quality Management Systems

- **AS9100 Rev. C registered (TUV Rheinland of North America).**
- **ISO 9001:2008 registered (TUV Rheinland of North America).**
- **MIL-STD 790 certified by DLA as MIL-PRF-23419/12 QPL Supplier.**
- **MIL-STD-202 Environmental Laboratory reviewed/approved by DLA as a part of MIL-STD-790 certification/retention process.**
- **AEM's Quality Management System has been reviewed and approved by nearly every major aerospace OEM in the world.**
- **DDTC Registered. Although AEM is a supplier of EAR99 classified components, many customer supplied drawings can be considered "ITAR Technical Data". Secured facility with badge entry access.**



AEM Inc.'s Heritage

- **AEM has a longstanding history as a premier component provider into manned and unmanned aircraft, space systems, missile systems and advanced technologies critical to aerospace mission success.**
- **AEM's components have been in orbit for 30-plus years with zero reported failures.**
- **A list of programs AEM, Inc. has supplied to can be found in the link below.**

<http://aem-usa.com/about-us/aem-heritage/>

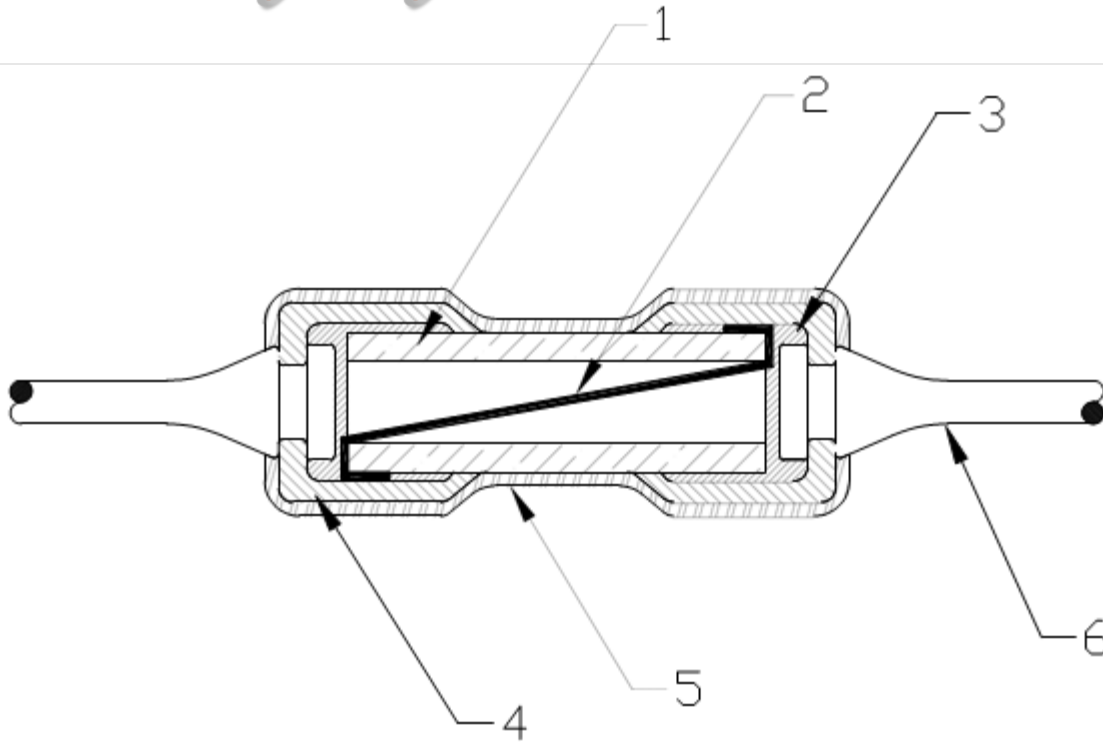


Hi-Rel Fuse Background

- **Historically, Two Primary Construction Approaches Utilized for MIL-PRF-23419 Series Fuses:**
 - **Cavity Style (“wire-in-air”)**
 - **Example is FM08 Type**
 - **Solid-Body Style**
 - **Example is FM12/P600L Type**



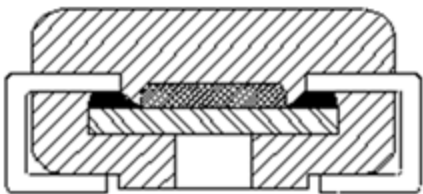
Cavity Style Fuse Overview



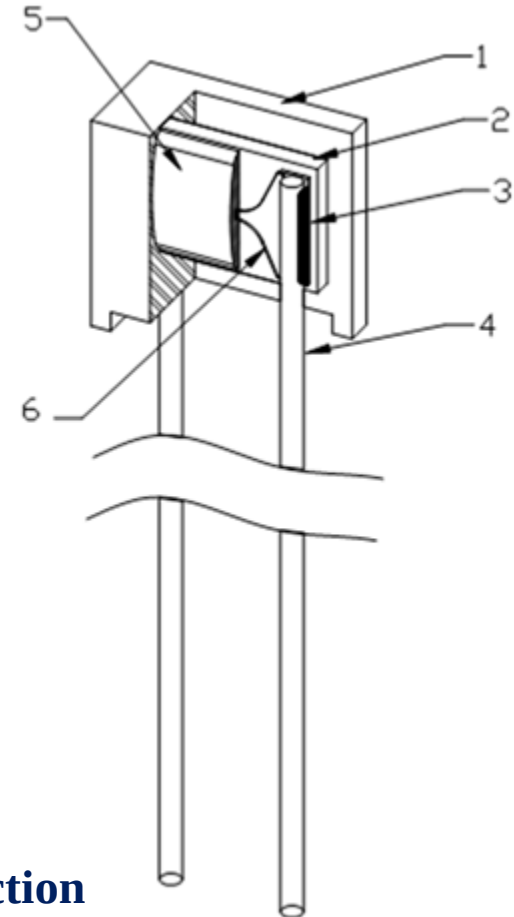
- 1 - Ceramic barrel**
- 2 - Fusible wire**
- 3 - Soldered interface**
- 4 - Copper/brass alloy end cap**
- 5 - Outer protective sleeve**
- 6 - Copper terminal with Au or Sn/Pb plating**

Solid-Body Fuse Overview

- 1 - Molded case (Engineered Thermoplastic; PPS)**
- 2 - 96% Alumina substrate with high temperature glass coating**
- 3 - Terminal attachment (Sn96 or Sn10 solder)**
- 4 - Au or Sn/Pb solder dipped copper terminal**
- 5 - Arc suppressive glass cover (lead borosilicate)**
- 6 - Au fusing element comprised of Au thick film and/or Au thick-film/Au wire portions**



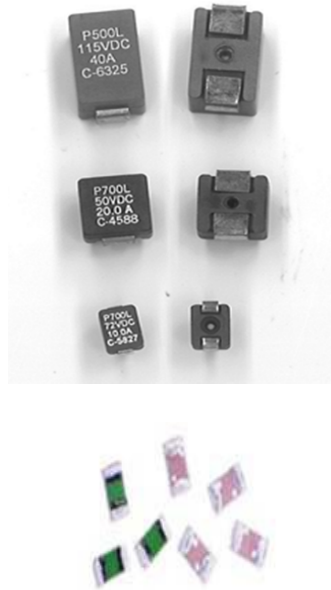
SM version utilizes same internal thick film construction



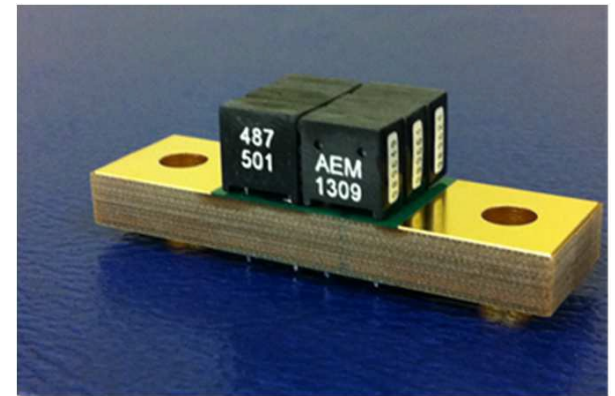
Hi-Rel Solid Body Fuse Options



Radial Leaded Packages with Solid and Flexible/Insulated Terminals



Surface Mount Molded Body Reverse-J and 1206 Chip Packages



Fuse Modules for High Current Applications

Solid Body Fuse Applications

- ***Over-current circuit protection primarily in satellites and spacecraft***
 - ***Solar Array***
 - ***Communication Panel Electronics***
 - ***Spacecraft Control***
 - ***Electronics***
 - ***Traveling Wave Tube Amplifier (TWTA)***
 - ***Batteries***
 - ***Power Supplies***
 - ***Jettison Circuitry***
 - ***Others.....***

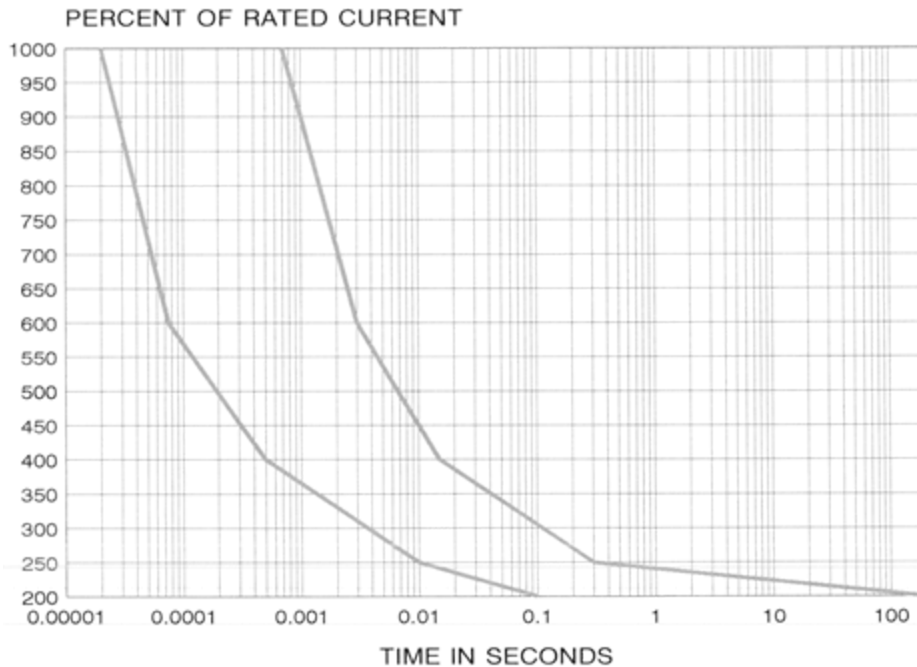


Performance Advantages of Solid-Body Fuses in Vacuum, Spacecraft, and Harsh Environments

- **Guaranteed minimum and maximum clearing (blow) times**
- **Safe Interruption of overload currents at rated voltage**
- **Steady-state current derating based on fuse case temperature that is independent of vacuum condition**
- **Greater mechanical vibration and shock resistance**



Hi-Rel Fuse Clearing Specification Comparison



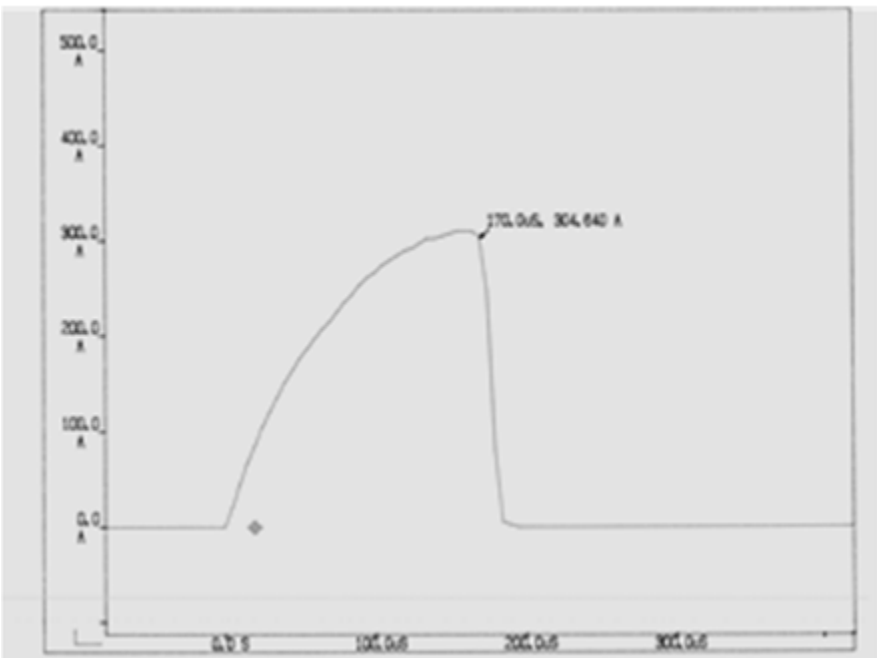
Overload Current Level (Percent)	Minimum Specified Clearing Time (Seconds)	Maximum Specified Clearing Time (Seconds)
200%	0	5.0
300%	0	0.1

**Typical Hi-Rel Solid-Body Style
Fuse Clearing Specification (FM12/P600L)**

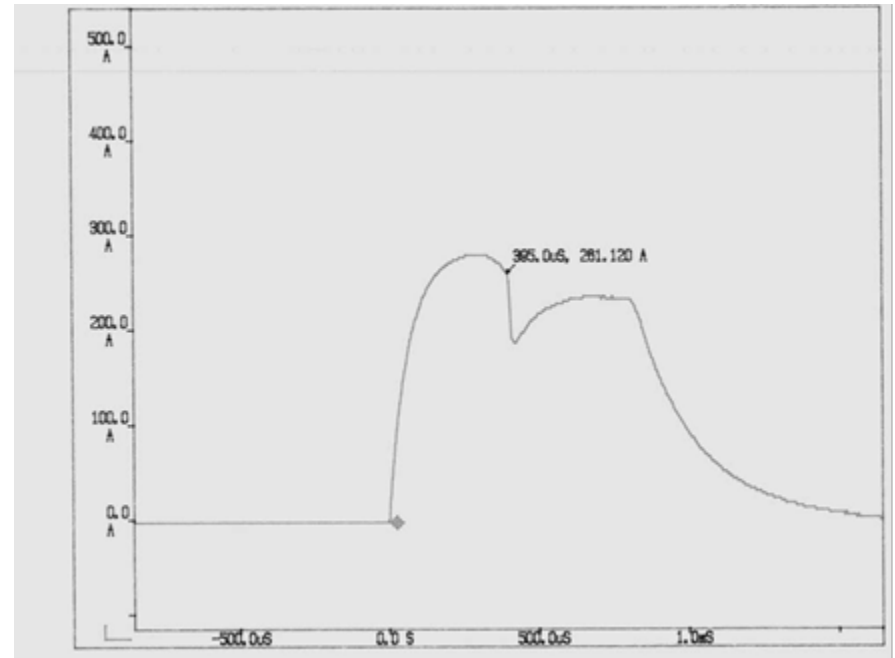
**Typical Hi-Rel Cavity Style
Fuse Clearing Specification (FM08)**



Clearing Waveform Comparison under Vacuum Conditions at Rated Voltage



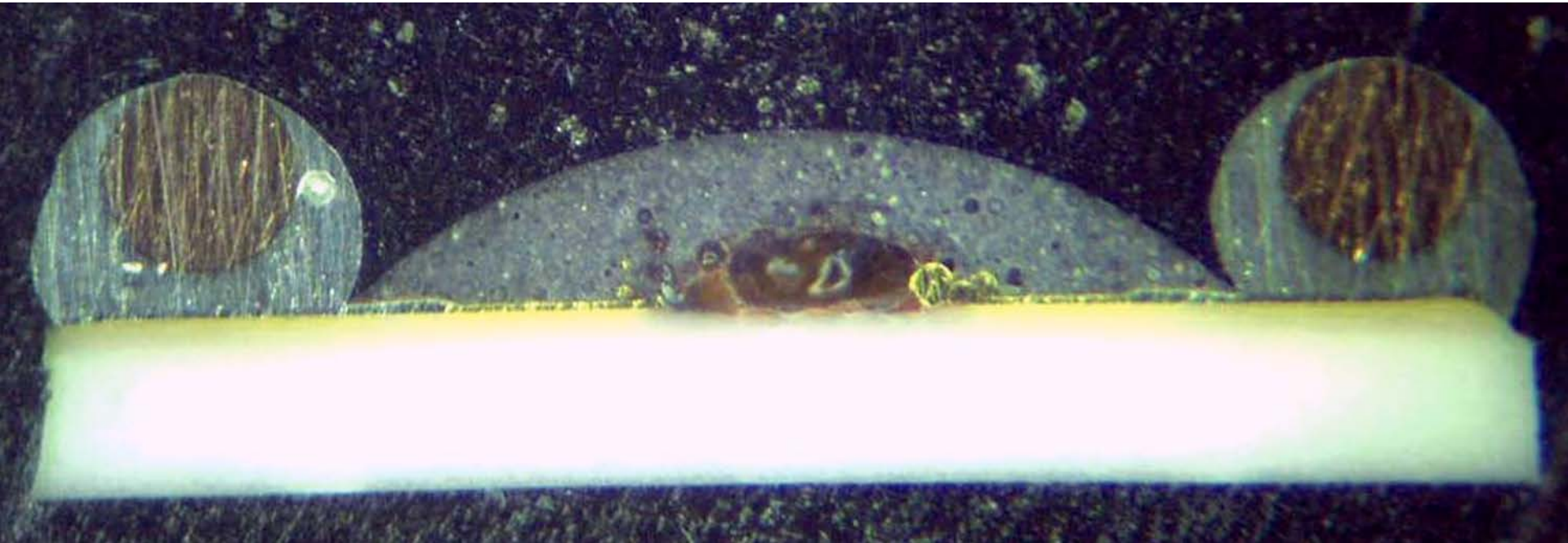
**Clearing Waveform for Solid-Body
15A, 125 VDC Fuse**



**Clearing Waveform for Cavity 10A, 125 VDC Fuse
(Second peak reveals continued arcing)**

Example of Blown Fuse under Vacuum Conditions at Rated Voltage

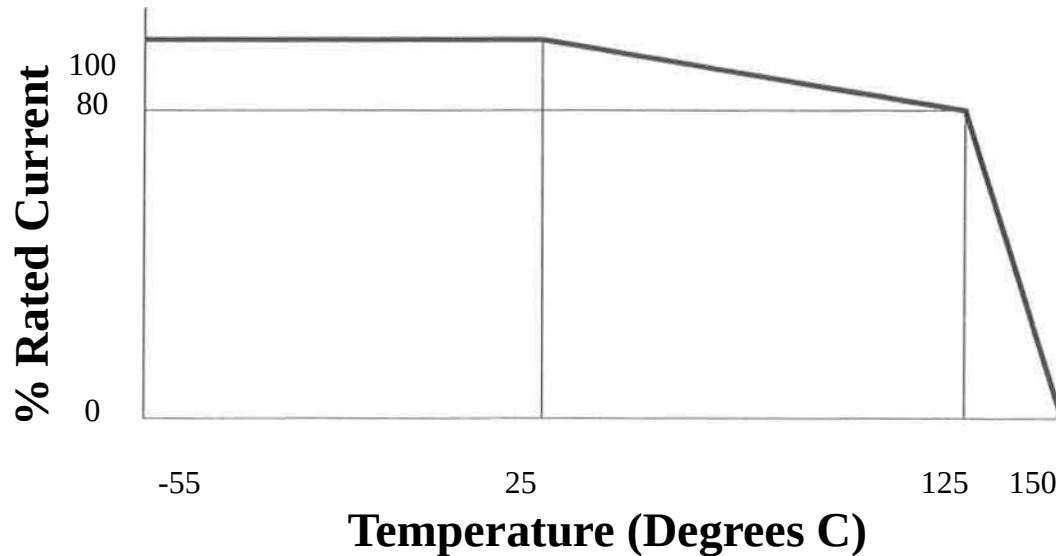
(X-section showing leads on 2 sides & gold element in the middle)



Au fusible element melts at “neck-down” region and migrates in arc suppressive cover glass. Arc and plasma fully contained within element/substrate subassembly parts of fuse.



Hi-Rel Fuse Steady State Current Derating Comparison



Typical Solid-Body Fuse Derating
Current derating is a function of fuse case temperature only.

Fuse Rating (Amperes)	Derate % of Rated Current
2.0 – 15.0 1.0 – 1.5	50%
0.750	45%
0.500	40%
0.375 0.250 0.125	35% 30% 25%

Typical Cavity Style Fuse Derating
Significant steady-state current derating required as a result of the possible loss of internal air pressure during extend vacuum operation.

Hi-Rel Fuse Mechanical Shock/Vibration Comparison

Fuse Type	Specified Vibration Level for Qualification/Group C	Specified Shock Level for Qualification/Group C
FM08 (Air Cavity)	10 G's Peak to 2000 Hz. (MIL-STD-202-204, Test Condition C)	100 G's Peak for 6 mS (MIL-STD-202-213, Test Condition I)
FM12 (Solid-Body)	30 G's Peak to 3000 Hz. (MIL-STD-202-204, MIL-PRF-23419/12)	1500 G's Peak for 0.5 mS (MIL-STD-202-213, Test Condition F)

As solid-body fuses are designed and constructed with fusible elements that are completely surrounded by an arc suppressing media (no movement permitted), they are less likely to experience a vibration induced failure. Given the relatively high levels of shock and vibration that are often associated with spacecraft launch, the increased mechanical ratings afforded by solid-body fuses are very desirable.



New Product Developments for Fuses

- **QPL for Surface Mount Models**
- **Higher Voltage Fuses (Radial Package and Surface Mount)**
- **ITAR Free**



FM13 Qualification

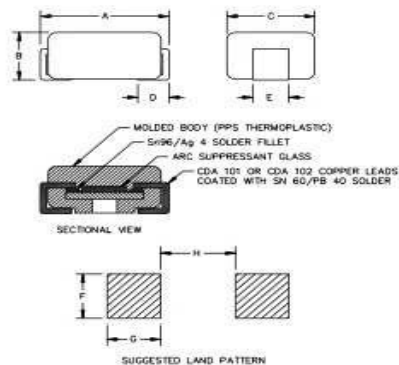
INCH-POUND
MIL-PRF-23419/13
6 February 2014

PERFORMANCE SPECIFICATION SHEET

FUSES, INSTRUMENT TYPE, STYLE FM13
(SUBMINIATURE - HIGH PERFORMANCE)

This specification is approved for use by all Departments and Agencies of the Department of Defense.

The requirements for acquiring the product described herein shall consist of this specification sheet and MIL-PRF-23419.



Ltr	Inches		mm		Ltr	Inches		mm	
	Min	Max	Min	Max		Min	Max	Min	Max
A	.320	.340	8.13	8.64	E	.090	.096	2.29	2.49
B	---	.100	---	4.06	F	.090	.110	2.29	2.79
C	.225	.245	5.72	6.22	G	.100	.120	2.54	3.05
D	.065	.085	1.65	2.16	H	.125	.175	3.81	4.32

FIGURE 1. Style FM13 fuse (72 and 125 VDC)

- FM13 Specification is based on AEM's P700L Series Fuse which has been utilized successfully in spacecraft applications for over 20 years.
- DLA approval to test (ATT) provided to AEM on 8-18-16
- Expect qualification to complete in 2017

20, 30, and 40 Amp, 115 VDC P500L Fuse Series Under Qualification



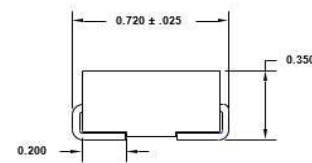
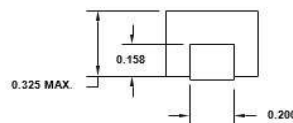
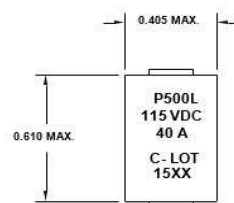
8810 Cobra Way
San Diego, California 92121
(858) 481-0210

SPECIFICATION SHEET

P500L CURRENT LIMITING FUSE

SURFACE MOUNT MODEL

Fuse Part Number / Ratings			DC Resistance (Ohms) 1/			Overload Interrupt Time (Seconds) 2/			Maximum I ² T (Ampere Seconds) 3/		
P500L Part No.	Maximum Voltage (Vdc)	Current Rating (Amps)	Min.	Max.	Figure	250% Nominal Rating	400% Nominal Rating	600% Nominal Rating	250% Nominal Rating	400% Nominal Rating	600% Nominal Rating
P500L-115-20	115	20	0.0053	0.0088	1	.050 - .50	.005 - .050	.001 - .015	12500.0	320.0	216.0
P500L-115-30	115	30	0.0041	0.0068	1	.050 - .50	.005 - .050	.001 - .015	28125.0	720.0	486.0
P500L-115-40	115	40	0.0030	0.0050	1	.050 - .50	.005 - .050	.001 - .015	50000.0	1280.0	864.0



REVISION:	A										
DATE:	10/18										
DRAWN:	Mike Van Linge										
CHECKED:	Jeff Montgomery										
APPROVED:	Jeff Montgomery										
ECN:	2185										

SHEET 1 OF 21

2.0 – 15.0 Amp, 150/180 VDC Solid-Body Fuses

- Utilizes AEM's P800L radial style package with modified multiple Au fusible element design approach
- 10/15 Amp models to be qualified by mid 2017 with lower amperage models to be available by the end of 2017
- Screening to follow FM12 flow for Qualification and Groups A, B and C



Ferrite Chips and Tin Whisker Mitigated Components have been EAR99 and with U.S. Export Control Reform, AEM, Inc.'s Solid Body Fuses have moved off ITAR control to EAR99 as of November 2014.

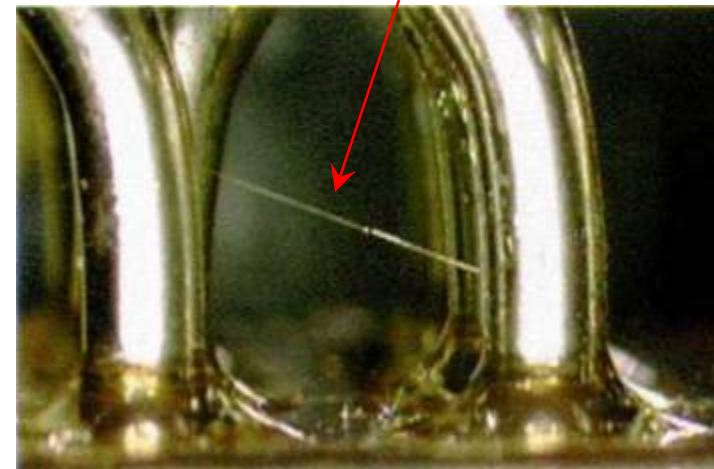
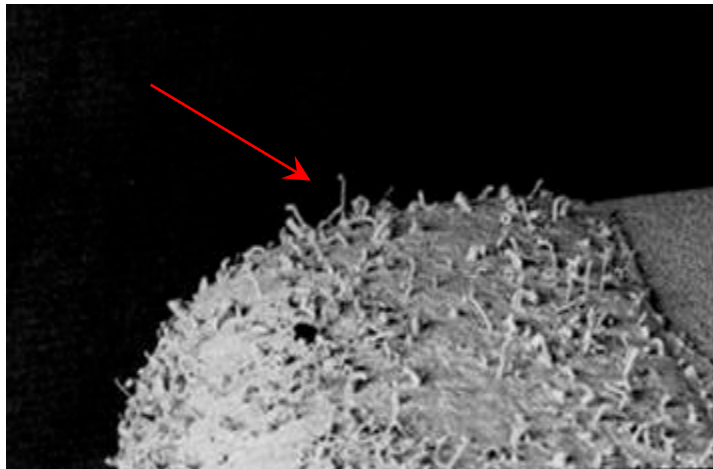
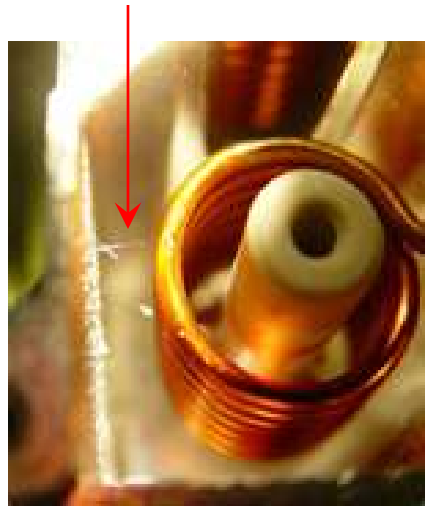


TWM / Tin Whisker Mitigation

***AEM's Tin / Lead Conversion = Plating + Fusion Processing
(Gold option available in most cases)***



Documented Tin Whisker Cases from NASA/CALCE/FDA and Others



(Images courtesy of NASA)



Whisker Growth on Hot Solder Dipped Component Where Sn/Pb Coverage is Incomplete

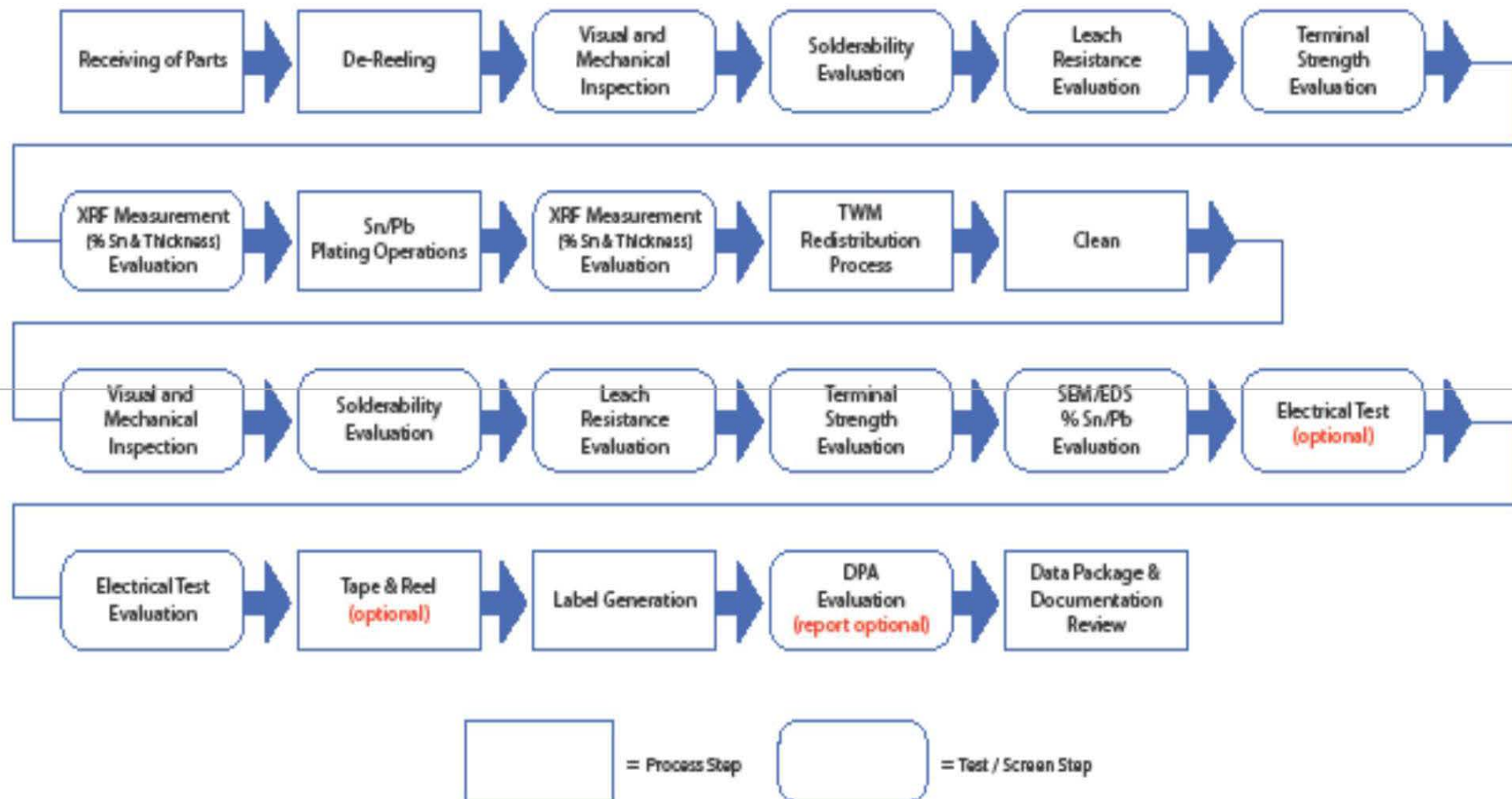


Device Failures Caused by Tin Whiskers

- **Heart Pacemaker / Defibrillator**
- **Automotive**
- **F-15 Radar System**
- **Various US Missile Programs**
- **Satellites**
- **Nuclear Utilities**
- **Rockets**
- **Increased PC Failures**
- **Watches**



Standard Operations Flow of AEM's Sn/Pb Conversion Process



Advantages of Plating + Fusing Sn/Pb Conversion Process

- The process involves Sn/Pb plating with subsequent fusion processing to ensure resultant component terminal finishes are homogenous.
- Advantages of the AEM TWM process include:
 - Component dimensional limits are maintained with no coplanarity issues.
 - Coverage of process includes lead egress and wrap around terminals.
 - Components are not subjected to thermal shock stresses.
 - Component quality monitored into and out of the Sn/Pb conversion process with built in process controls.



AEM TWM Process Includes Standardized Controls and Inspections

- The process includes lot quality assurance controls for monitoring product quality/performance going into (QA1) and out of (QA2) the Sn/Pb conversion process including:
 - Sample XRF and EDS verification of terminal finishes.
 - Sample Solderability verification of terminations.
 - Sample Leach Resistance verification of terminations.
 - Sample Terminal Strength verification of terminations.
 - Sample Destructive Physical Analysis (DPA).
 - Sample electrical / mechanical verifications.
 - Visual inspection (sample QA1 and 100% QA2).



Overview / Summary of Key AEM TWM Process Steps

1. **AEM procurement of base OEM components through approved OEM Distribution Channels.**
2. **AEM Receiving Inspection of base OEM components and QA1 sequence of evaluations.**
3. **AEM Sn/Pb conversion pre-evaluation run performed to establish optimum processing parameters specific to part type and MFG lot.**
4. **Sn/Pb conversion processing per AEM's 387070 process.**
5. **100% visual inspection per applicable manufacturer's data sheet or EIA specification (or SCD if applicable).**
6. **QA2 sequence of evaluations.**
7. **Tape and reel packaging (typical) or other method of packaging as specified by customer.**
8. **AEM preparation of Sn/Pb conversion component data package.**



TWM Visual Inspection and Electrical Test Area



**All components handled as though they are ESD devices.
AEM's ESD program compliant with JESD-625, ANSI/ESD
S20.20 and MIL-STD-1686.**



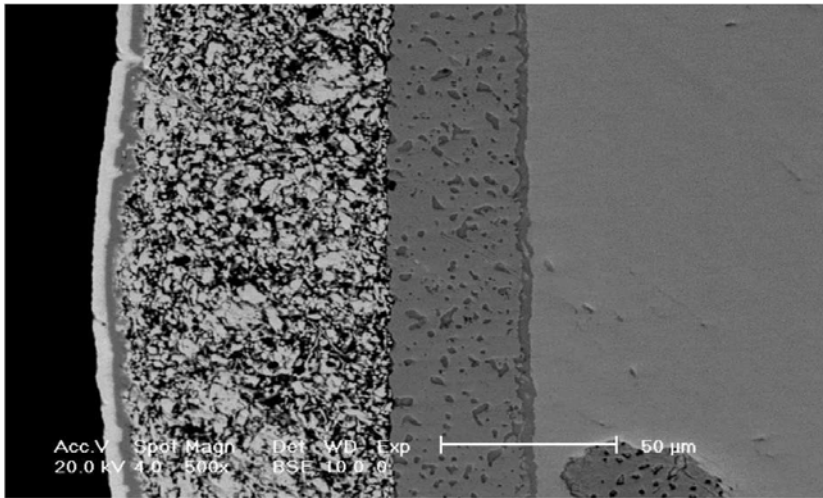
SEM / EDS Verifications of “As-Received” and “Sn/Pb Converted” Components



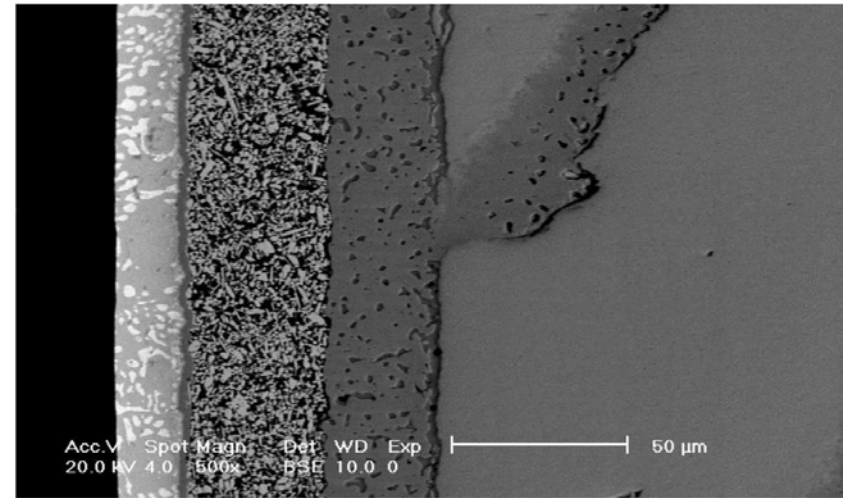
SEM / EDS inspection also performed during DPA to verify component internal construction. B.S.E. / SEM views of Sn/Pb converted terminations are required to ensure Pb content is well distributed throughout terminations. EDS inspection results provided with each component lot shipped from AEM.



SEM/BSE Images of Typical AEM Sn/Pb Converted Chip Component



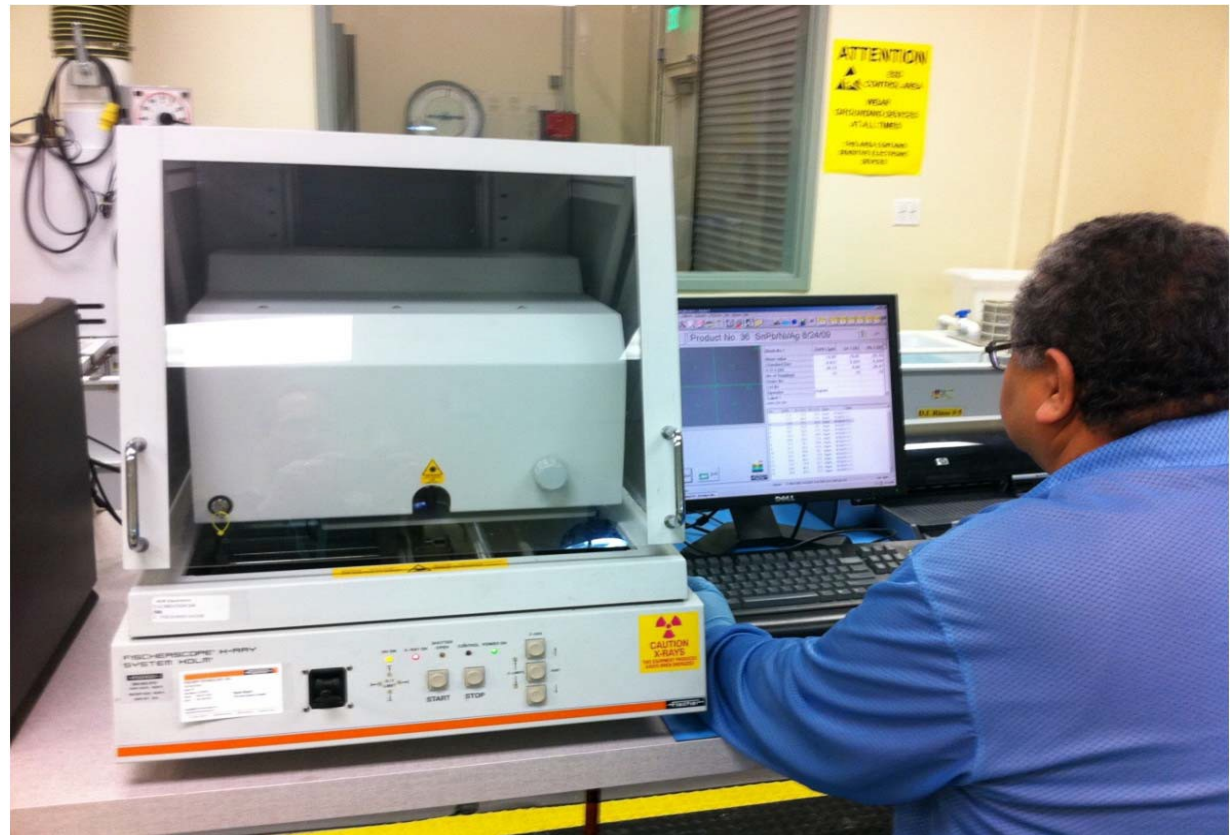
Cross-section of a typical pure tin



Cross-section of same component after fusion processing showing white lead particles

XRF Measurement Verification

- ***Pre-Conversion / “As Received”***
- ***Post-Conversion / “Sn/Pb Converted”***



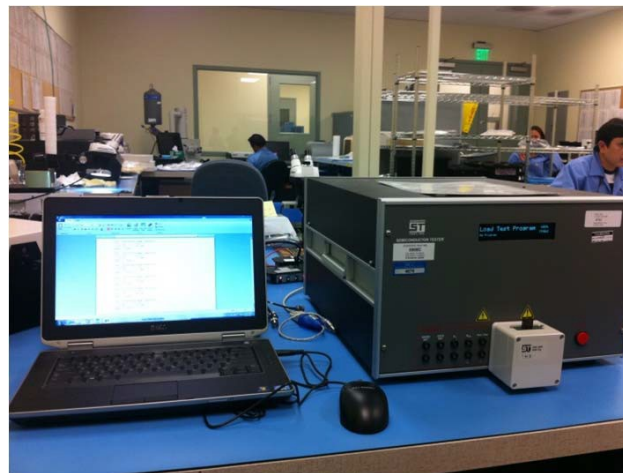
Sn / Pb Plating Processes Include Extensive Pre and Post Cleaning.



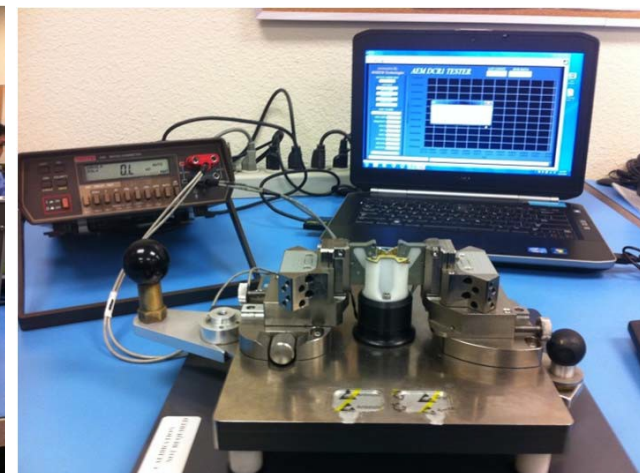
Sample Electrical Testing to Ensure Component Performance Going Into and Out of TWM Process



**Impedance/Inductance
Testing**



Diode Testing



**DCR and Capacitance
Testing**



OEM Lot Traceability Maintained for Each Sn/Pb Conversion Component Lot Processed by AEM

- **AEM will assign a unique lot number and LDC for the data package.**
- **LDC is assigned in a YYWW format and is the date of the post-conversion solderability acceptance test.**
- **Original traceability to the base component OEM lot number and LDC are always maintained.**

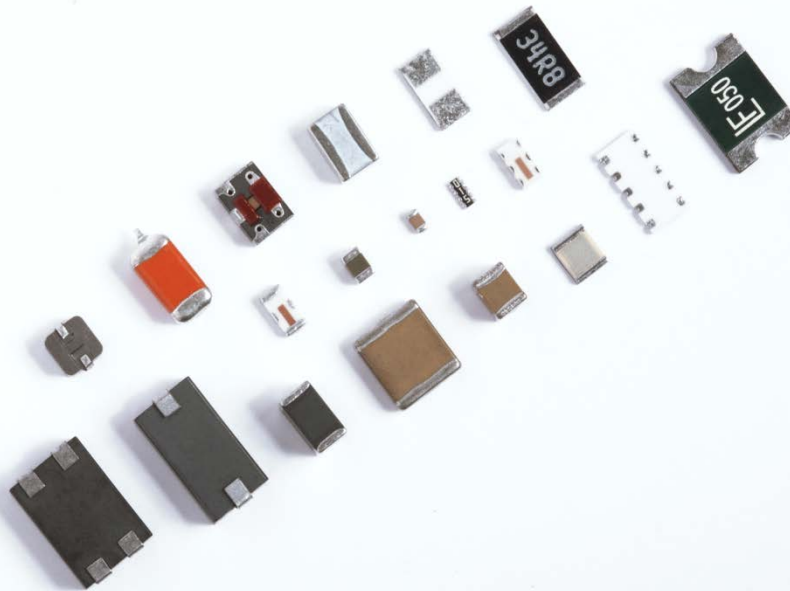


Lot Data Package Provided with Each Sn/Pb Component Lot Includes:

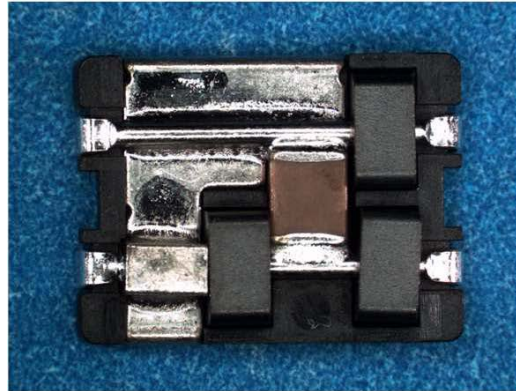
- **Certificate of Conformance certifying Pb content of 5% minimum (as verified by EDS and XRF methods)**
- **Certificate of Conformance certifying components meet MIL-STD 202 (Method 208) or ANSI J-STD-002 solderability requirement (after 8-hour steam aging exposure).**
- **Certificate of Conformance certifying Sn/Pb conversion process in accordance with AEM's standard drawing 387070 operations and screening flow.**
- **EDS data as recorded for post Sn/Pb converted components.**
- **XRF data as recorded for post Sn/Pb converted components.**
- **OEM lot traceability data for the base components.**



Sampling of Standard Parts Converted using AEM's Sn/Pb Conversion Process



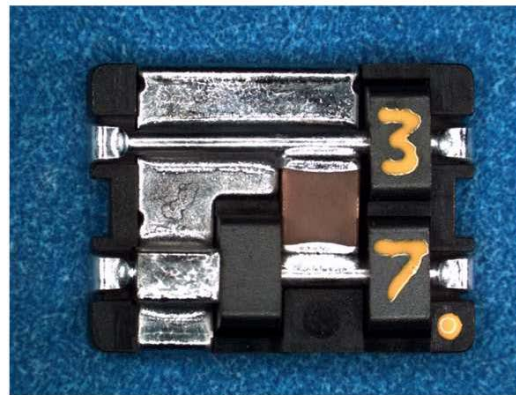
Custom Sn/Pb Conversion Example 1: Filter (Open Frame Conversion) Sn/Pb Plating and Fusion Processing + Marking and Kapton Pad after Top cover Removal



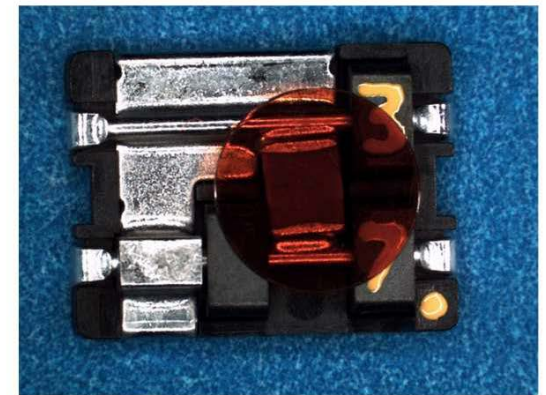
"As Received" with Top Cover Removed



Sn/Pb Plated and Fusion Processed

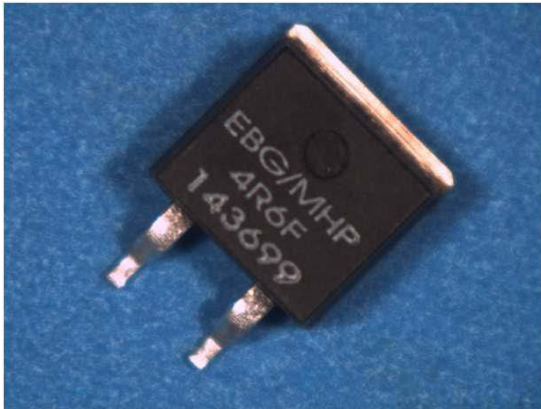


Epoxy Marking Added

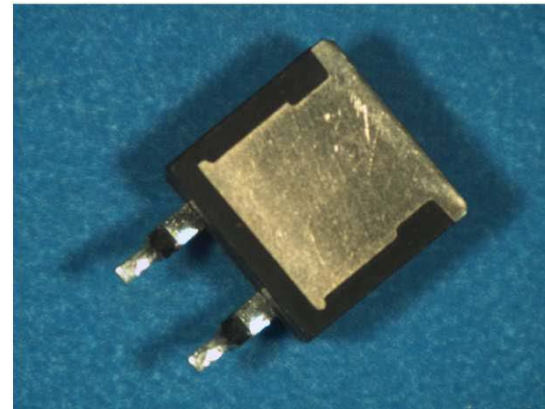


Kapton Pad Added for Raytheon Pick and Place Equipment

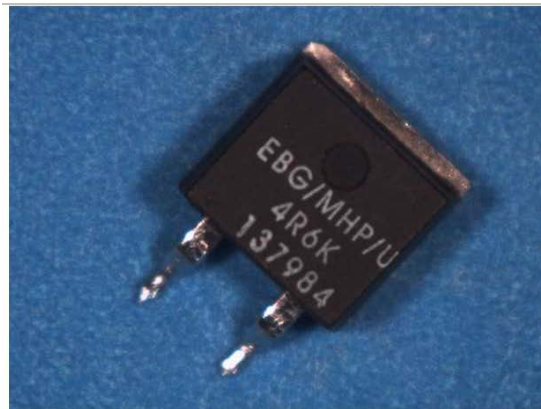
Custom Sn/Pb Conversion Example 2: Resistor Requires Sn/Pb Plating of Heat Tab and Robotic Sn/Pb Dipping of Terminals



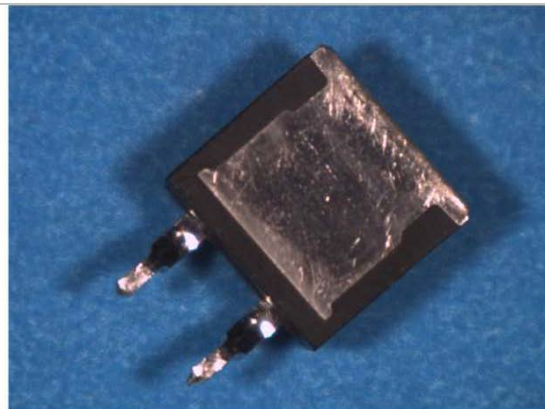
"As Received" Resistor Top View



"As Received" Resistor Bottom View (Heat Tab Exposed)

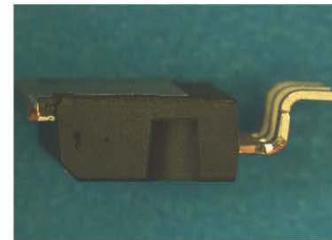
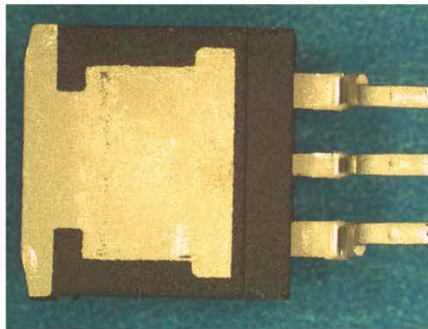
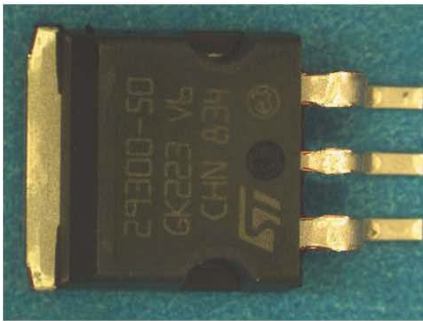


Sn/Pb Converted Resistor Top View

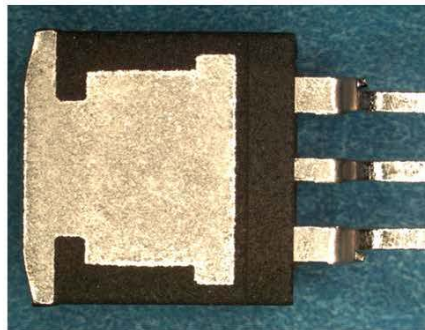
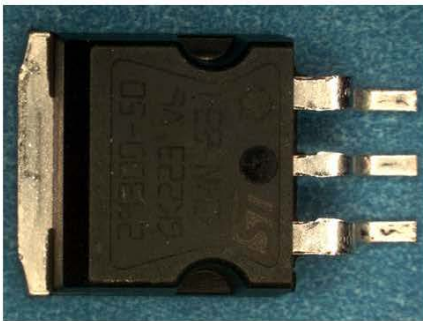


Sn/Pb Converted Resistor Bottom View

Custom Sn/Pb Conversion Example 3: Voltage Regulator Requires Sn/Pb Plating of Heat Tab and Terminals with subsequent Fusion Processing



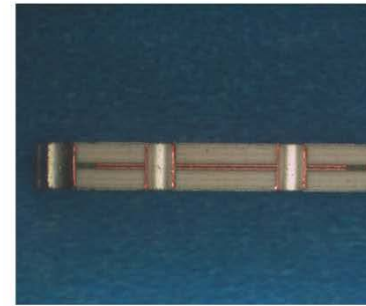
"As Received" Voltage Regulator



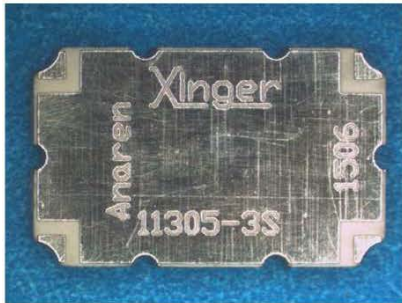
Sn/Pb Plated and Fusion Processed Voltage Regulator



Custom Sn/Pb Conversion Example 4: Voltage Regulator Requires Sn/Pb Plating of Top, Bottom, and Side Interconnections with subsequent Fusion Processing



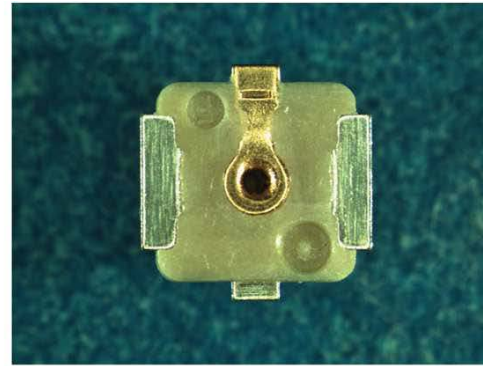
"As Received" Hybrid Coupler



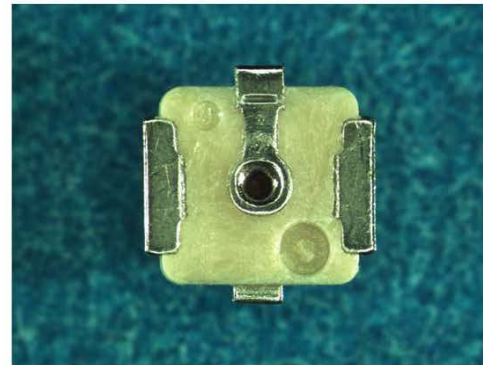
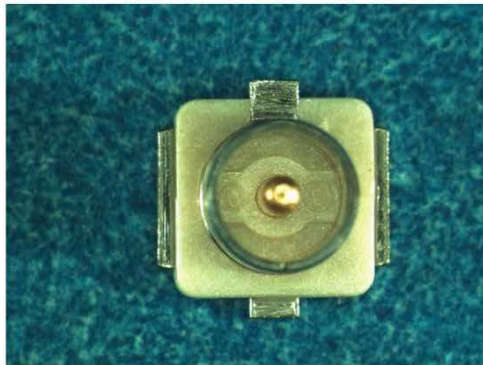
Sn/Pb Plated and Fusion Processed Hybrid Coupler



Custom Sn/Pb Conversion Example 5: Au Strip and Sn/Pb Plate of Mounting Surfaces with Masking of Au Plated Center Pin Required (Gold Embrittlement Mitigation)



"As Received" Surface Mount Connector



Sn/Pb Converted Surface Mount Connector

Partial List of Component Types Suitable for AEM Sn/Pb Conversion Processing

- **Surface Mount Chip Capacitors (01005 to 2220 package size or larger)**
- **Surface Mount Chip Resistors (0402 to 2220 package size or larger)**
- **Surface Mount Chip Inductors (0402 to 1812 package size or larger)**
- **Surface Mount Chip Beads (0402 to 1812 package size or larger)**
- **Surface Mount Fuses (0402 to 1812 package size or larger)**
- **Surface Mount Varistors (0603 to 1812 package size or larger)**
- **Resistor Arrays / Capacitor Arrays / Chip Bead Arrays**
- **Molded Body Diodes (SMA, SMB, SMC, SMD Packages with Reverse J Leads and Molded Body MOSFETS)**
- **DPAK packages**
- **SOT-23 packages**
- **SOT-223 packages**
- **DO-214AB package**
- **QFN packages**
- **Tantalum Capacitors (All Standard Sizes)**
- **Lug Connectors**
- **EMIFL packages and most chip and molded body filters**

High Reliability Ferrite Chip Beads

AEM's HRB Series / DSCC 03024 Series



High Reliability Ferrite Chip Bead Benefits

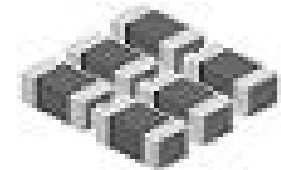
- **Product conforms to DSCC Drawing 03024 with U.S. Defense Logistics Agency (DLA) as steward**
- **Manufactured and tested in the USA**
- **For high reliability applications:**
 - **Sn / Pb terminations (5%+ Pb to prevent Sn whiskers)**
 - **Au terminations available**
 - **Group A / B data supplied with every flight model shipment; group C testing as well as SCD screening are optional**
 - **Designed and tested for extended service life applications**
 - **Complete traceability**



DSCC Ferrite Chip Bead Types

- **HRB 0603 Series**

- DSCC part # 03024-001 – 03024-009
- Impedance Range 30 – 1000 Ω
- Tolerance $\pm 5\%$, $\pm 10\%$, $\pm 20\%$, $\pm 25\%$
- Maximum amperage 0.20 - 0.50



- **HRB 0805 Series**

- DSCC part # 03024-010 – 03024-021
- Impedance Range 30 – 1000 Ω
- Tolerance $\pm 5\%$, $\pm 10\%$, $\pm 20\%$, $\pm 25\%$
- Maximum amperage 1.00 – 4.00



- **HRB 1206 Series**

- DSCC part # 03024-022 – 03024-028
- Impedance Range 30 – 600 Ω
- Tolerance $\pm 5\%$, $\pm 10\%$, $\pm 20\%$, $\pm 25\%$
- Maximum amperage 1.00 – 4.00

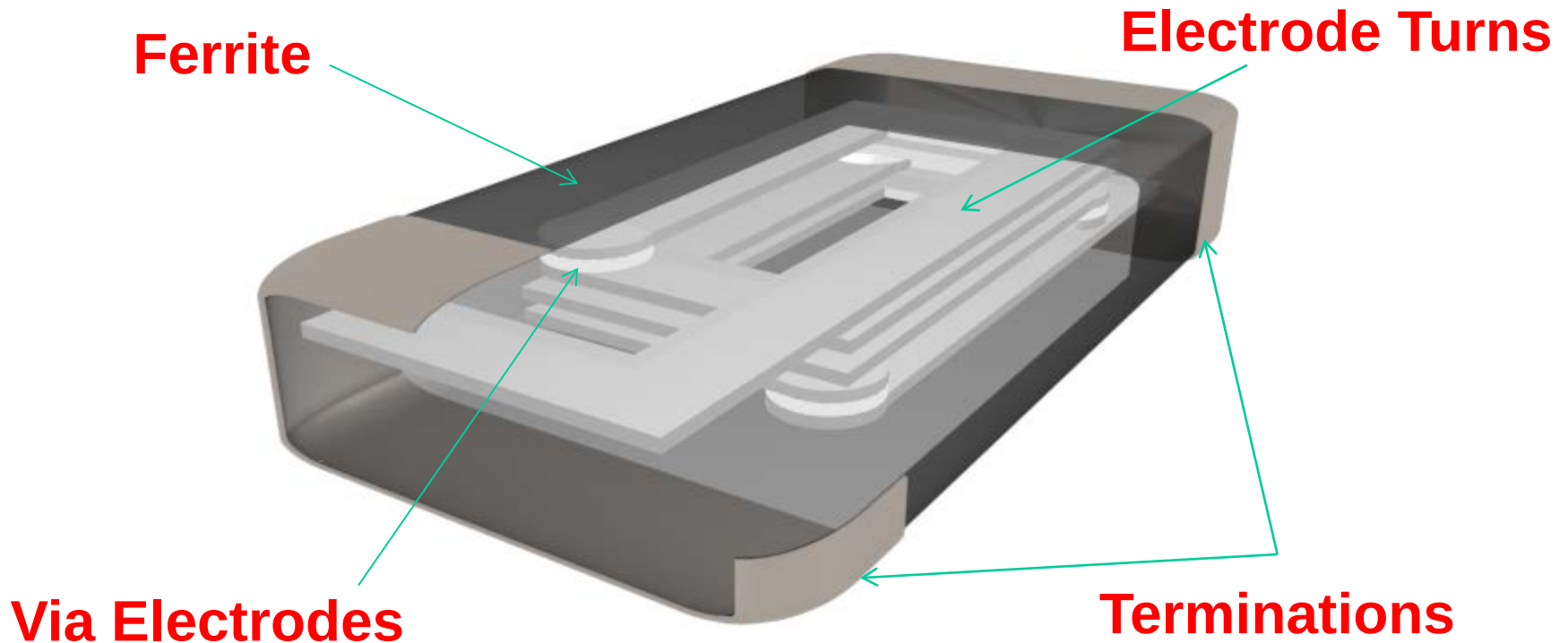


* ***All parts offered with Sn/Pb or Au termination finish***



Typical Design Construction

- *Internal Design Approach – Internal Winding of interleaved layers of ferrite and conductor*



Commercial vs. Hi-Rel Construction / Screening

- ***External Terminals***
 - ☒ ***Commercial: 100% Silver / lower frit loaded***
 - ☒ ***Hi-Rel: 100% Silver / higher frit loaded***
- ***Solder Finish***
 - ☒ ***Commercial: 100% Tin***
 - ☒ ***Hi-Rel: Tin / Lead (minimum 5% lead) or Gold***
- ***Screening***
 - ☒ ***Commercial: Screened at factory / No data with shipment, C. of C. only***
 - ☒ ***Hi-Rel: 100% screened to DSCC 03024 / Group A&B, and optional C. Data supplied with each shipment***



Commercial vs. Hi-Rel Impedance Tolerance

- ***Commercial: Typical Tolerance is $P \rightarrow \pm 25\%$***
- ***Hi-Rel: Availability***
 - ***$J \rightarrow \pm 5\%$***
 - ***$K \rightarrow \pm 10\%$***
 - ***$M \rightarrow \pm 20\%$***
 - ***$P \rightarrow \pm 25\%$***

****Offers end user a broader choice for impedance matching to EMI interference***



New Developments Related to AEM Hi-Rel Chip Beads

- **New HRB-US Series Provides Unlimited Ferrite Bead Options to End Users**
- **Brand New HRB Line Installed at AEM. Qualification of this line for 03024 Products is viewed by AEM as a pathway to a Ferrite Chip Bead QPL**
- **Mil-STD-1580 Updates to Include Ferrite Chip Beads**



HRB-US Series Ferrite Chip Beads ***(“-US” Signifies Up Screened)***

- **Commercial component ferrite chip beads procured by AEM through OEM approved distribution channels. OEM lot traceability and lot date code traceability maintained.**
- **Commercial lot subjected to DPA to verify / validate construction.**
- **Components are Sn/Pb converted per AEM's 387070 Sn/Pb Plating + Fusion Process.**
- **Components are subjected to full DSCC / DLA 03024 Group A, B, and C Screening to become HRB-US components.**
- **Components supplied with standard HRB / 03024 Data Package and are fully supported and warranted as AEM, Inc. Components.**



HRB-US Series Ferrite Chip Bead Benefits

- **Provides a wider (nearly unlimited) spectrum of Hi-Rel chip bead package options, impedance options, and DC current options**
- **Eliminates concern of Sn whisker formation as component terminations have a minimum of 5% Pb after AEM Sn/Pb conversion processing**
- **03024 style screening and resultant data package validate suitability of components for end application**
- **AEM lot traceability of –US components also includes OEM lot/LDC traceability**

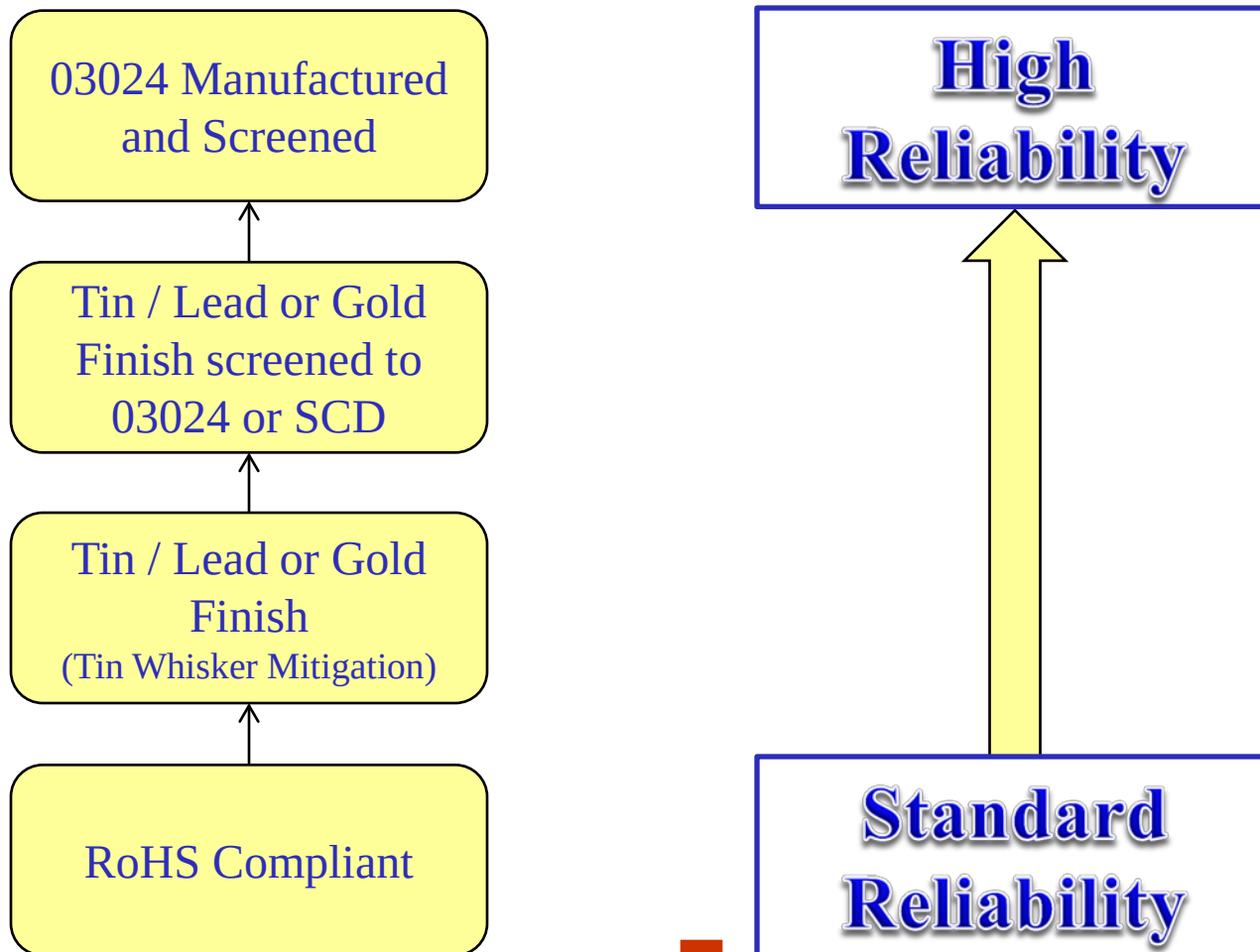


New HRB Line Installed at AEM

- New “Keko” HRB line established at AEM to provide increased capacity and increase product offerings
- Line presently in qualification mode and building products only for 03024 qualifications; expected timing for customer/DLA notifications, through PCN process, is first quarter 2017
- After 03024 qualifications are completed, AEM is planning to contact DLA and initiate QPL qualification



Ferrite Chip Bead Reliability Groups



Questions

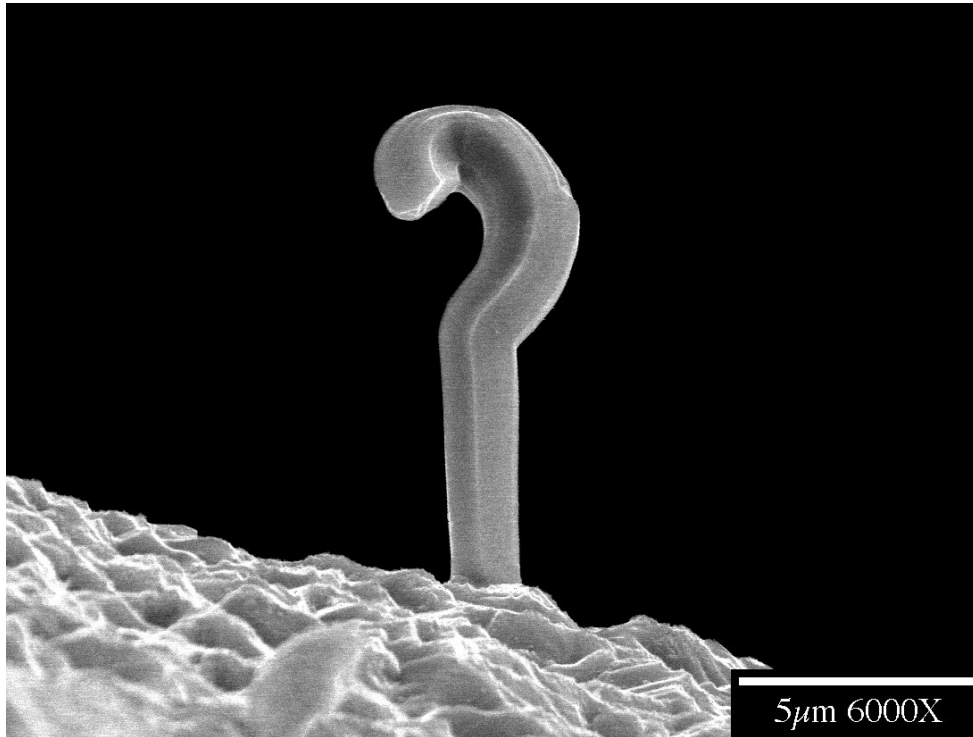


Photo courtesy of Peter Bush, SUNY at Buffalo

