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Low ESR SMD Tantalum Capacitors for Aerospace Applications

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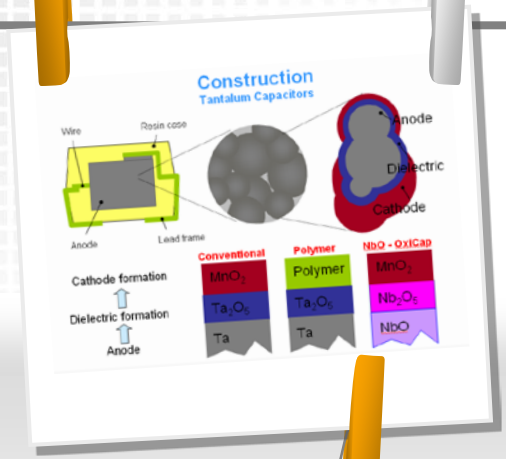
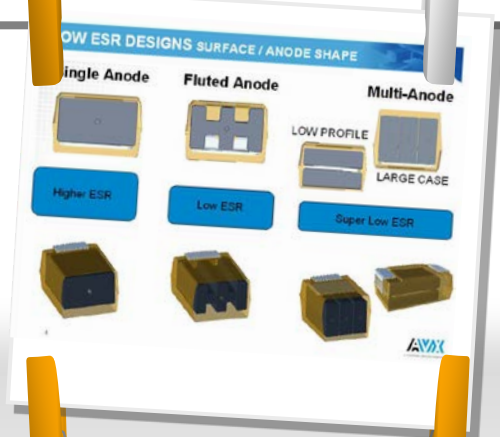
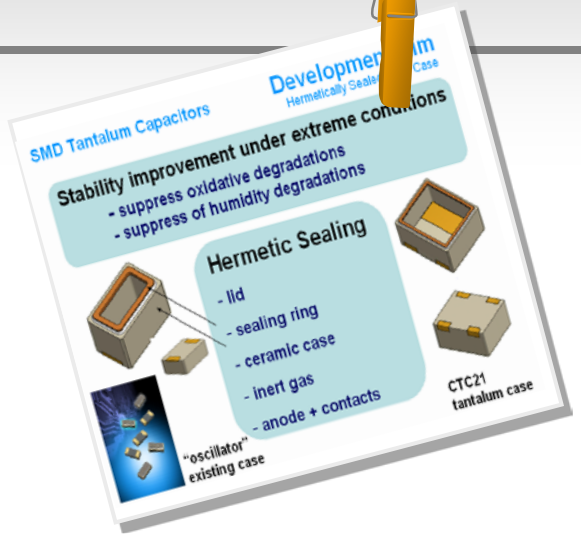
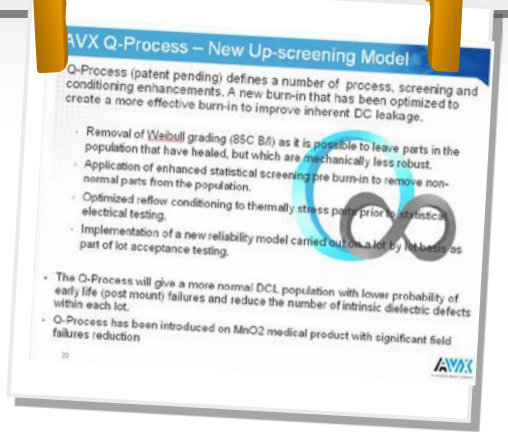
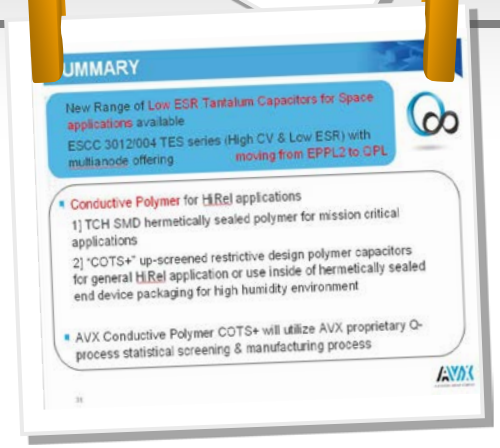
OUTLINE











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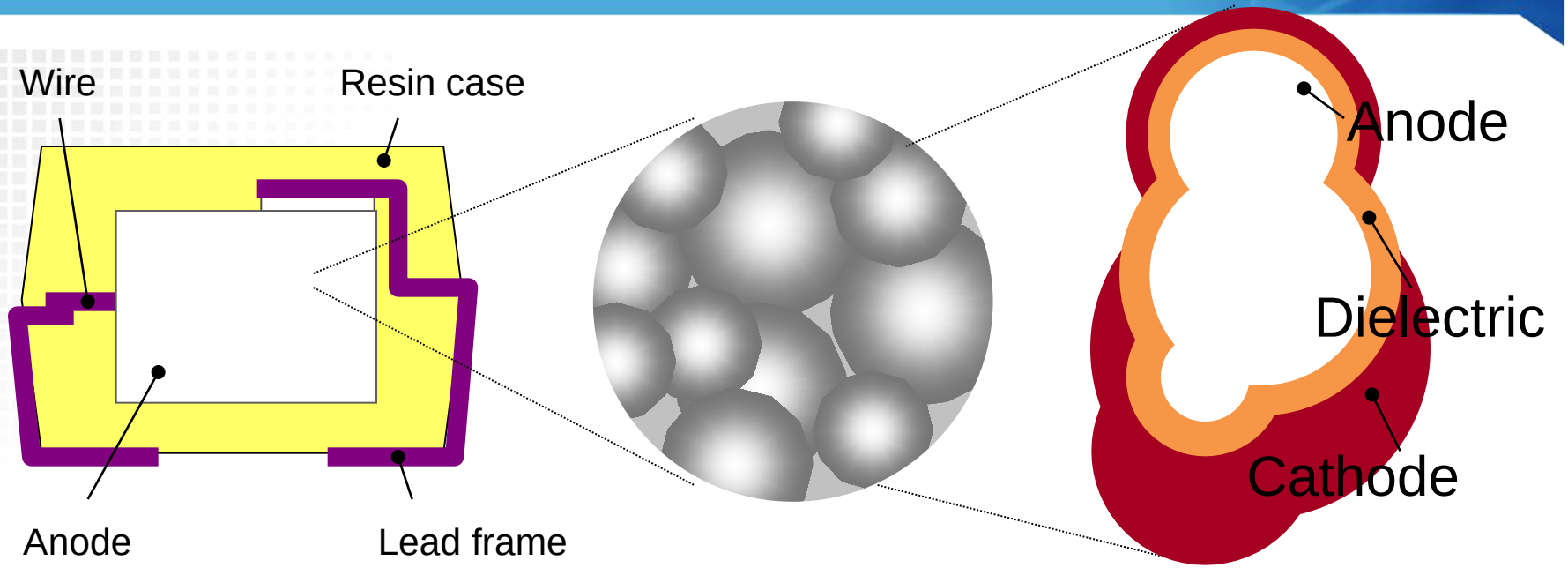
CONSTRUCTION Tantalum Capacitors



Cathode formation

Dielectric formation

Anode

Conventional	Polymer
MnO_2	Polymer
Ta_2O_5	Ta_2O_5
Ta	Ta

LOW ESR

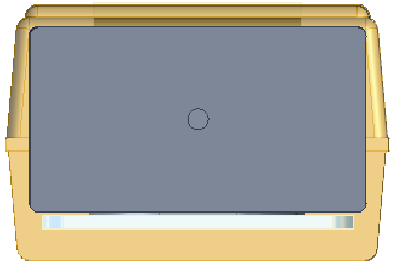
MAIN CONTRIBUTORS

1] SURFACE AREA

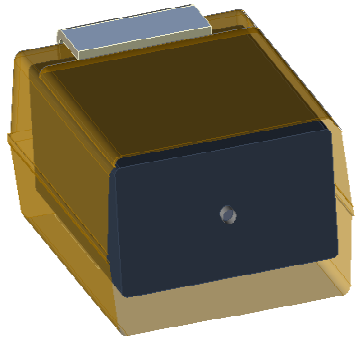
2] MATERIALS CONDUCTIVITY

LOW ESR DESIGNS SURFACE / ANODE SHAPE

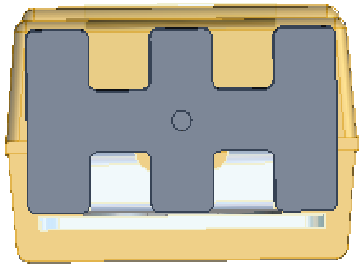
Single Anode



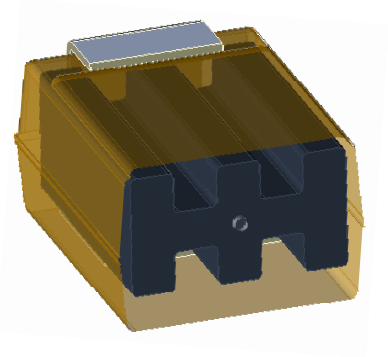
Higher ESR



Fluted Anode

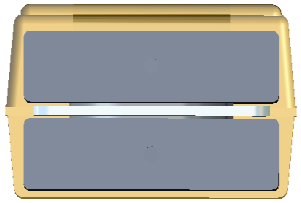


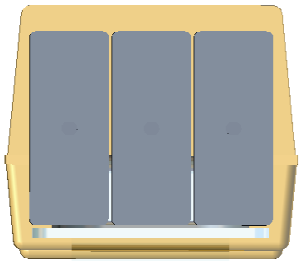
Low ESR



Multi-Anode

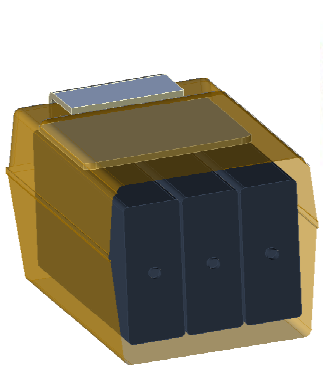
LOW PROFILE

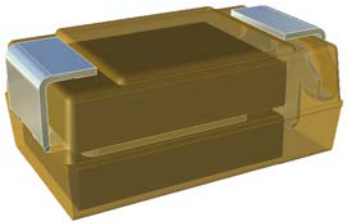




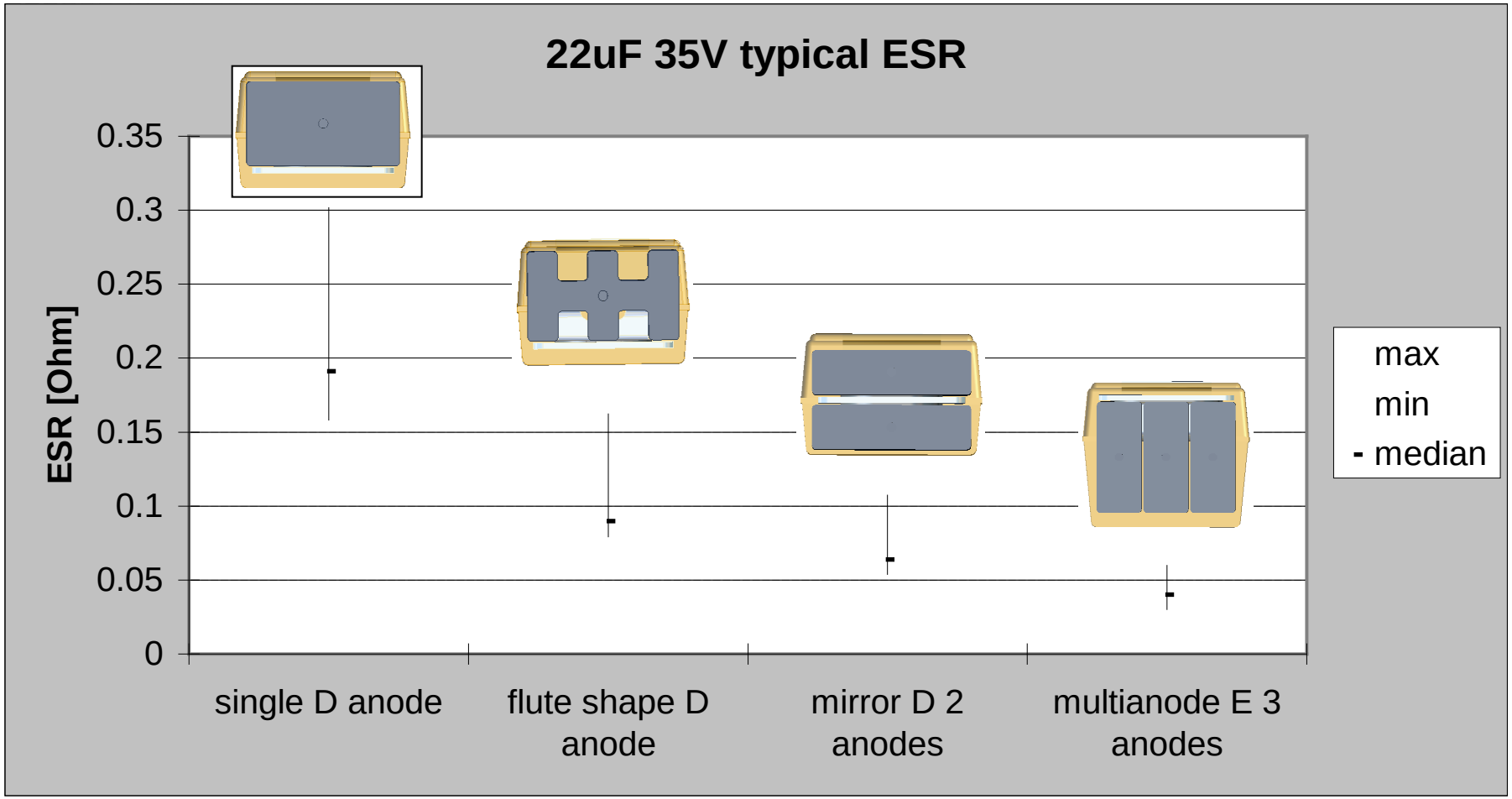
LARGE CASE

Super Low ESR





LOW ESR DESIGNS SURFACE / ANODE SHAPE

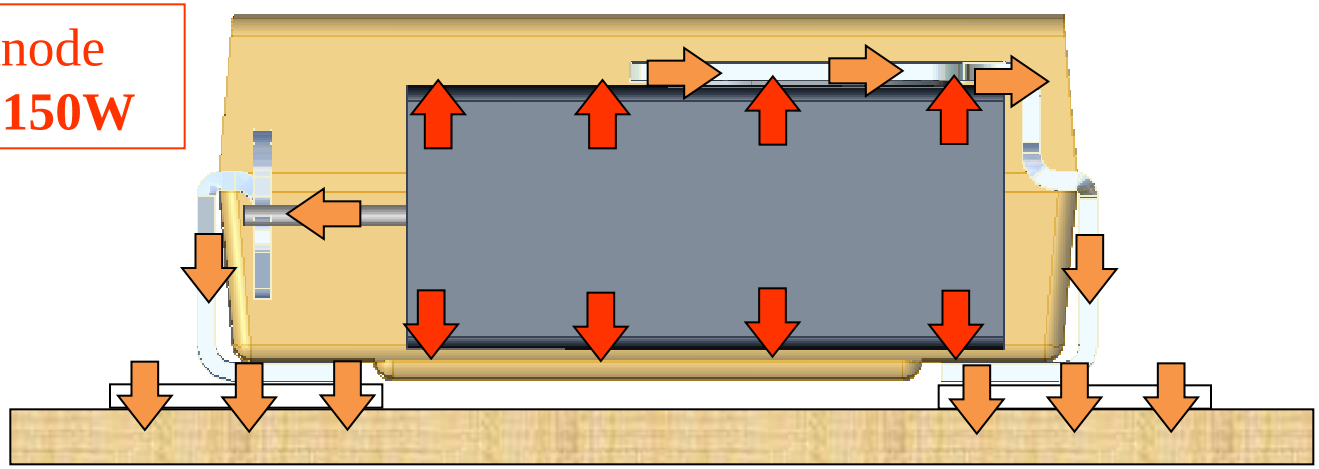


LOW ESR DESIGNS SURFACE / ANODE SHAPE

Higher Power Dissipation = Higher Continuous Current + Surge Robustness

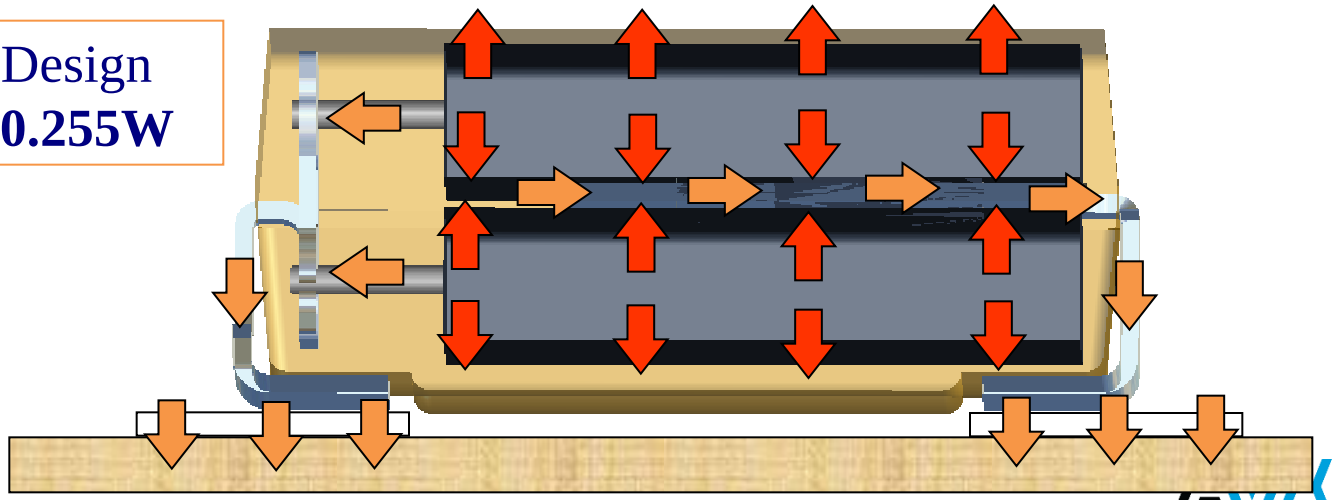
Single Anode
PWD = **0.150W**

Irms (D330µF10V,150mΩ):
1.00A @25C



Mirror Design
PWD = **0.255W**

Irms (D330µF10V,35mΩ):
2.70A @25C



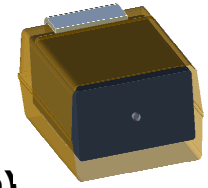
ESA ESCC Space Level Tantalum Capacitors

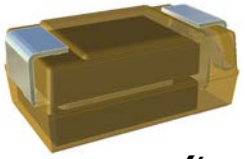
ESCC 3012/004 EPPL 2 uses multi-anode and ‘mirror’ design internal construction to achieve low ESR

Capacitance		Rated Voltage DC (V_R) at 85°C							
µF	Code	6.3V (J)	10V (A)	12V (B)	16V (C)	20V (D)	25V (E)	35V (V)	50V (T)
1.0	105						A(3000)		B(2000)
1.5	155								
2.2	225								
3.3	335					A(2500)		B(1000)	C(1000)
4.7	475				A(2000)		B(1000)	C(600)	D(200)*
6.8	685								
10	106		A(1800)			B(1000)	C(600)	D(120)	E(150)*
15	156								
22	226	A(900)			B(600)	C(400)		D(100)	
33	336		B(650)			C(300)	D(65)	E(65)	
47	476	B(500)			C(350)	D(55)	E(65)		
68	686								
100	107		C(200)		D(55)	E(45)			
150	157	C(300)	D(45)		E(40)				
220	227		D(35)	E(35)					
330	337	D(35)	E(35)						
470	477	E(30)							
680	687								

ESR down to 30mOhm

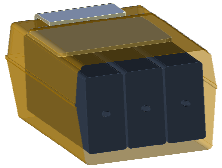
A, B case single anode (standard design)





D case multi anode (‘mirror’ design)

E case multi anode (3 anode design)



TES ESA ESCC 3012/004 – Low ESR, HiCV Space Level

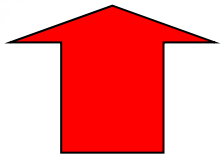
ESA ESCC Space Level Tantalum Capacitors

ESA QPL Qualified SMD Tantalum Capacitors

ESCC 3012 / 001 TAJ-ESA

ESCC 3012 / 004 TES

→ Currently Low CV & High ESR



NEW HiCV & Low ESR QPL from October 2013)

Evaluation & Qualification Completed
- Evaluation ESCC 2263000
- Qualification ESCC 3012 / 004
- Final Review Sep 2013

ESCC 3012 004 (low ESR) EPPL 2

ESA EPPL2 SMD Tantalum Capacitors

ESA ESCC Space Level Tantalum Capacitors

1. ESCC 3012/001 QPL (TAJ ESA series)
2. ESCC 3012/004 Low ESR, EPPL2 (TES series)

ESCC 3012 / 004 vs 3012/001
CV range comparison

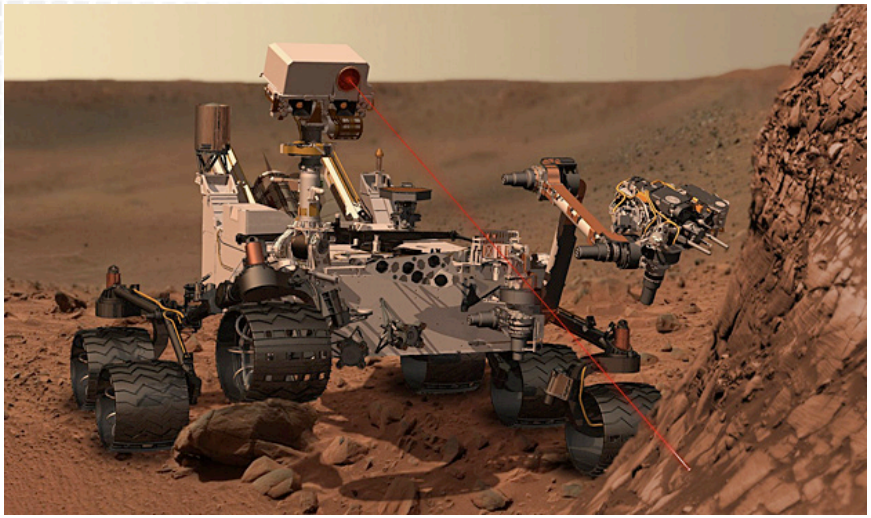
Capacitance		Rated voltage							
µF	Code	4V	6.3V (J)	10V (A)	16V (C)	20V (D)	25V (E)	35V (V)	50V (T)
0.10	104							A	A
0.15	154							A	B
0.22	224							A	B
0.33	334							A	B
0.47	474						A	A/B	C
0.68	684					A	A	A/B	C
1.0	105				A	A	A	B/T	B/C
1.5	155			A	A	A	B	B/C	D
2.2	225		A	A	A/B	B	B	B/C	D
3.3	335	A	A	A	A/B	A/B	B/C	B/C	C/D
4.7	475	A	A	A/B	A/B	B/C	B/C	C/D	D
6.8	685	A	A/B	B	B/C	C	C/D	D	
10	106	A/B	B	A/B/C	C	B/C	C/D	D	E
15	156	B	B/C	C	C	C/D	D	D	
22	226	B/C	C	C	B/C/D	C/D	D	D/E	
33	336	C	C	B/C/D	D	C/D	D/E	E	
47	476	C/D	C/D	D	C/D	D/E	E		
68	686	C/D	D	D	D	E			
100	107	D	D	C/D	D/E	E			
150	157	D	D	D/E	E				
220	227	E	E	D/E					
330	337		D	E					
470	477		E						

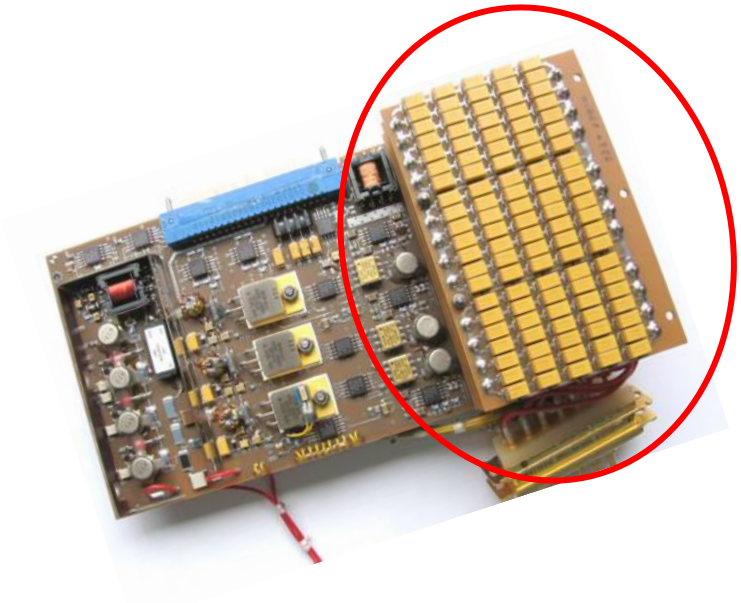
ESCC 3012/004

- Low ESR
- downsizing option
- High CV parts

AVX Tan Power Curiosity's ChemCam Laser on Mars

630 tantalum multi anode capacitors





AVX Corporation developed and supplied the 630 tantalum multi-anode capacitors to power the ChemCam laser module on-board of Curiosity

ChemCam laser module, a combination of chemistry and camera equipment, is designed to analyze the chemical composition of rocks on Mars.

SUCCESS STORY

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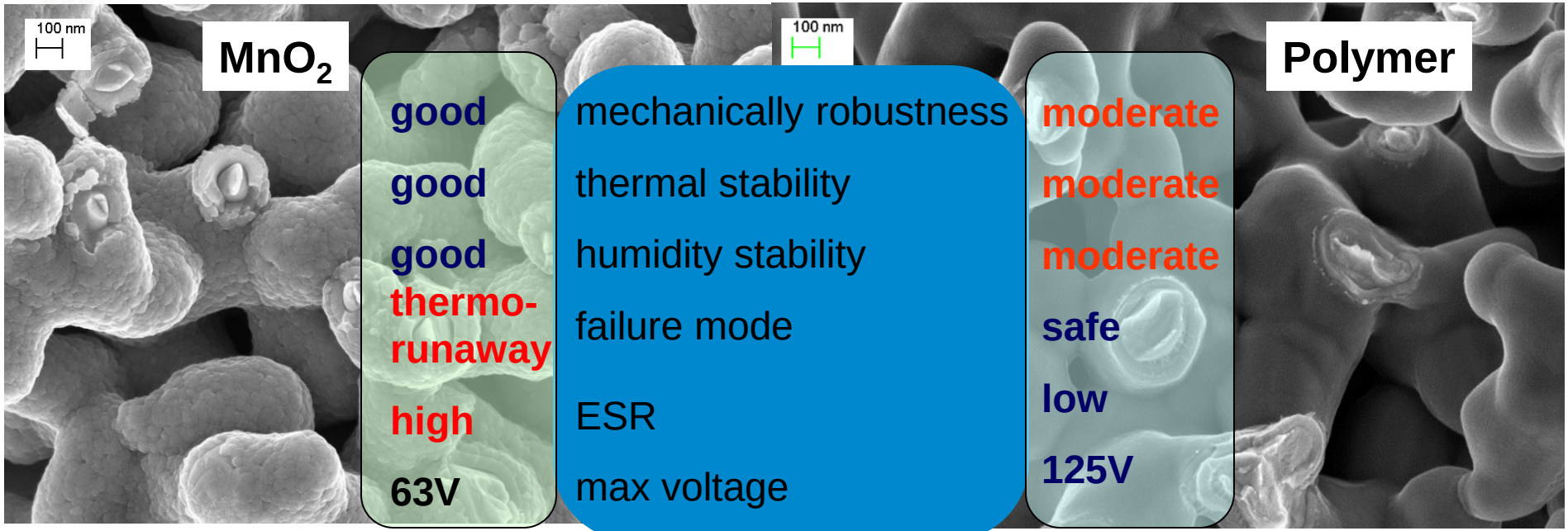
LOW ESR DESIGNS CATHODE MATERIALS

Anode and dielectric (Ta – Ta_2O_5) make Ta capacitors in general - highly stable, reliable and volumetrically efficient

Cathode materials - MnO_2 or Conductive Polymers



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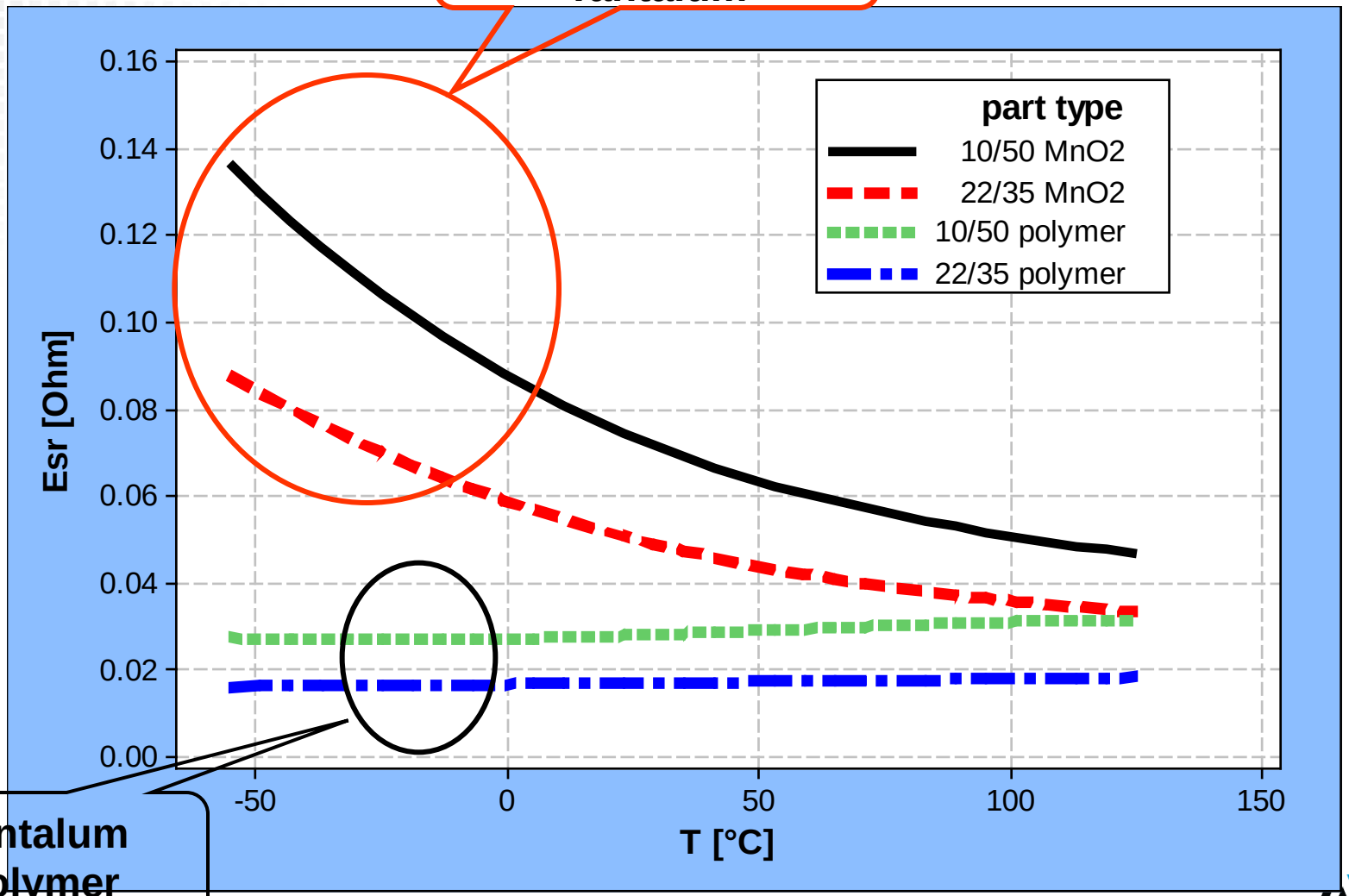
ESR@100 kHz Temperature Dependency



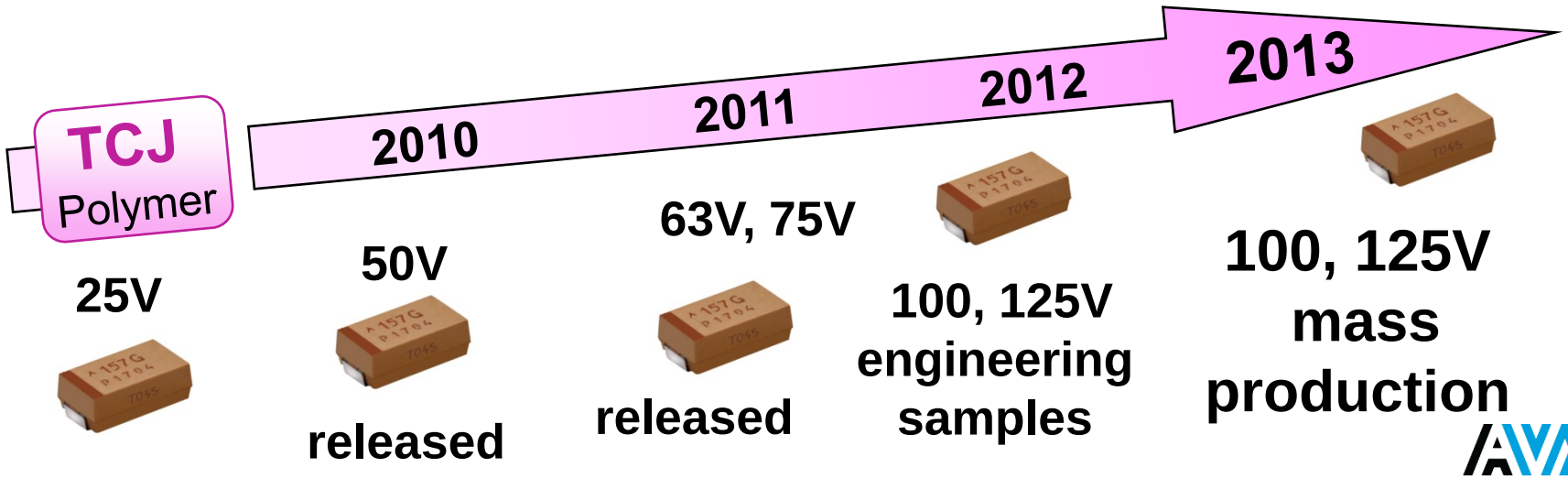
High voltage polymer development roadmap

Capability to manufacture 125V rated tantalum polymer capacitors, almost more than twice the rated voltage of similar products on the market today.
Eng. Samples of TCJ V 6.8uF/100V and TCJ D 3.3uF/125V available

Opening new opportunities for apps required 48 rail voltage – telecom / network

Important move

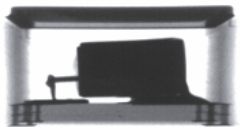
2011 Released 63V and 75V TCJ Series

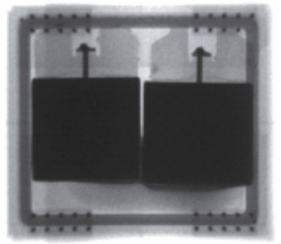


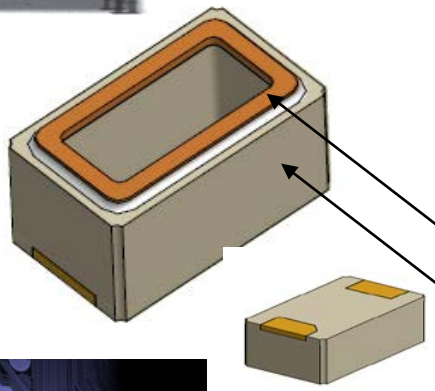
Hermetically Sealed Tantalum Polymer Capacitors

Stability improvement under extreme conditions

- suppress oxidative degradations
- suppress of humidity degradations

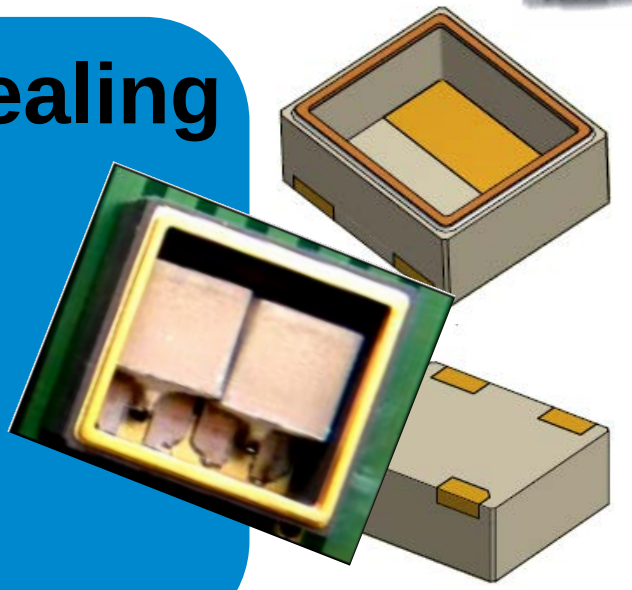






Hermetic Sealing

- lid
- sealing ring
- ceramic case
- inert gas
- anode + contacts



"oscillator" existing case

CTC21 tantalum case

HAST Test Stability

Capacitance and ESR changes at HAST

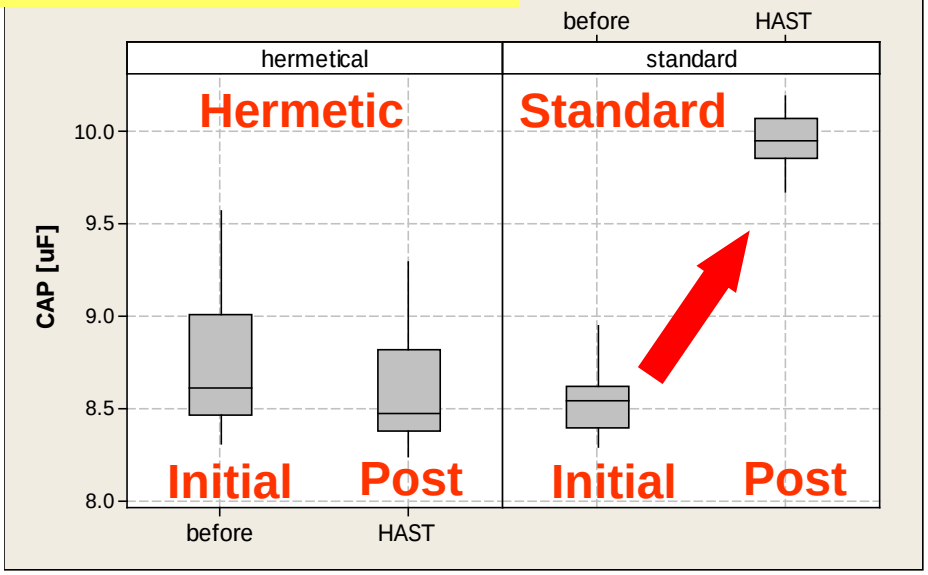
HAST Test conditions

temperature:	120°C
relative humidity:	85%
voltage:	rated voltage
duration:	64h

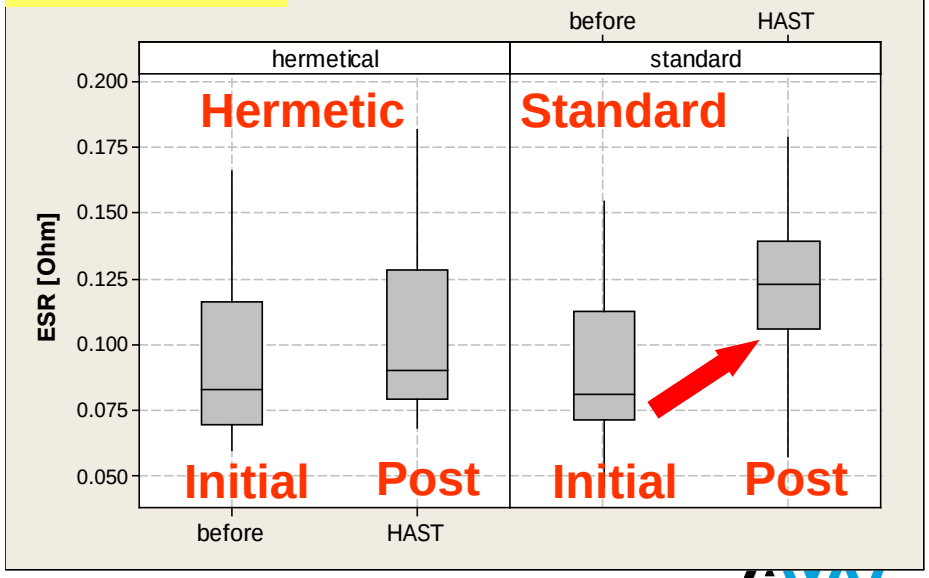
Conclusions

Improvement of
CAP and ESR Stability
By Hermetical Sealing

HAST CAPACITANCE

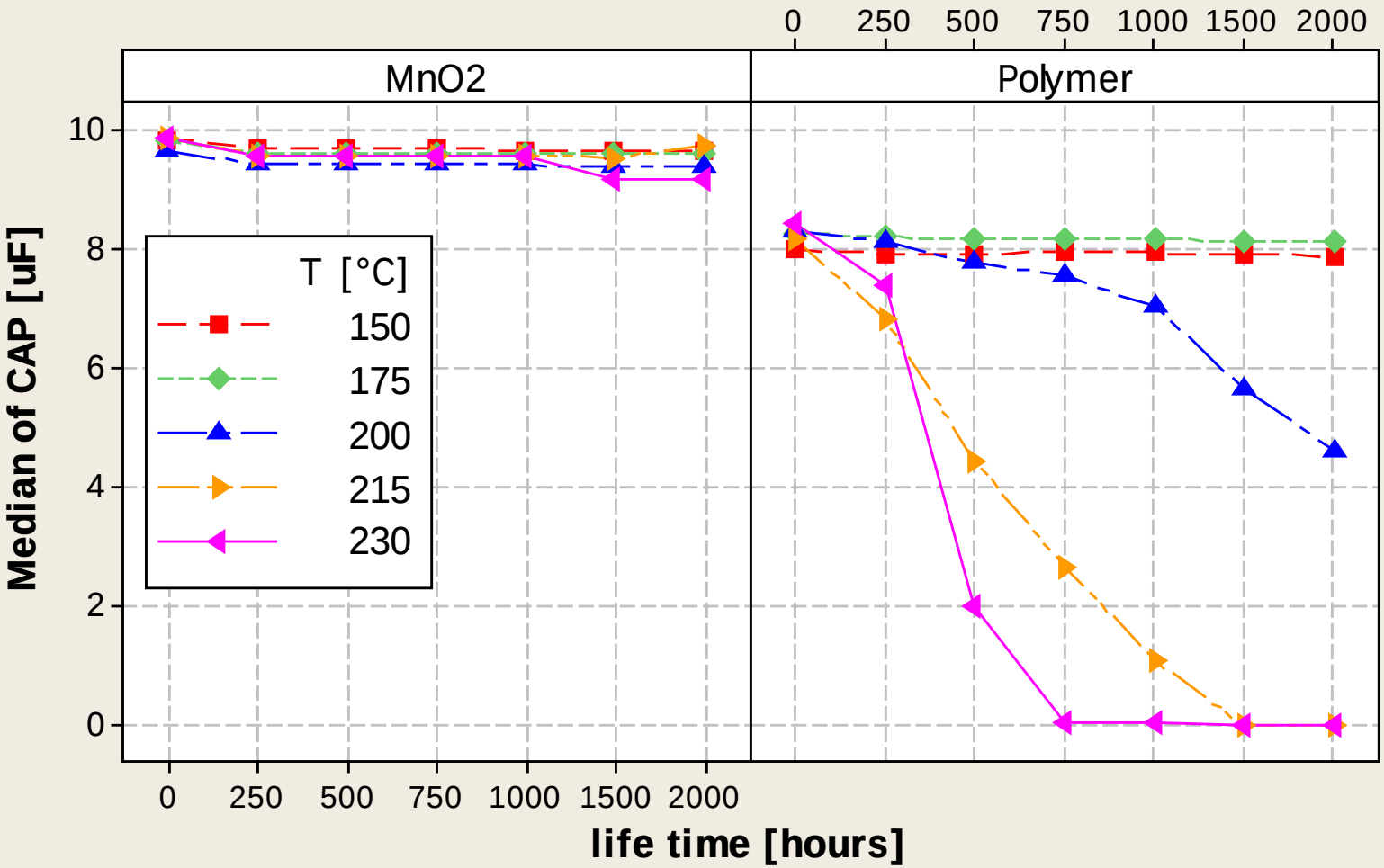


HAST ESR



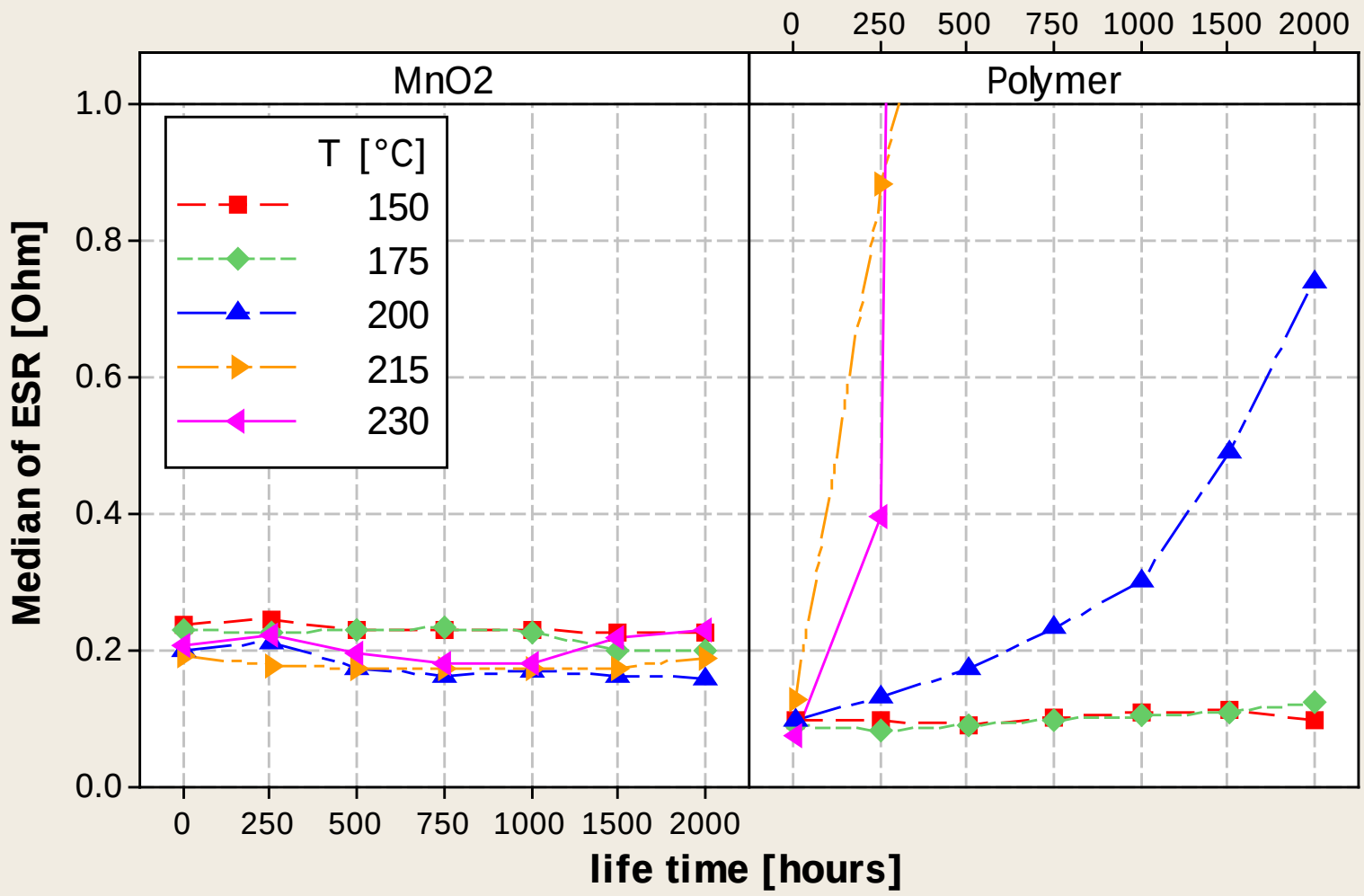
Hermetically Sealed Tantalum Temperature Stability

Capacitance stability 10uF 35V over time, no BIAS



Hermetically Sealed Tantalum Temperature Stability

ESR stability over time, no BIAS



Hermetically Sealed Tantalum Temperature Stability

MnO_2 capable up to 230°C

Conductive polymer capable up to 175 °C

Causes of CAP & ESR instability above 175°C for polymer

- instability is due to cathode degradation

Possible degradation mechanism:

- chemical or morphological changes of polymer

Possible sources of polymer changes:

- material impurities
- technological processing
- leakage current

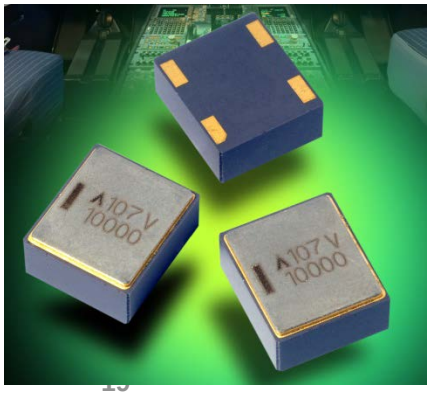
Preliminary data show possibility of overcoming 175°C temperature limitation

Hermetically Sealed Tantalum Temperature Stability

HERMETIC PACKAGES OUTLOOK

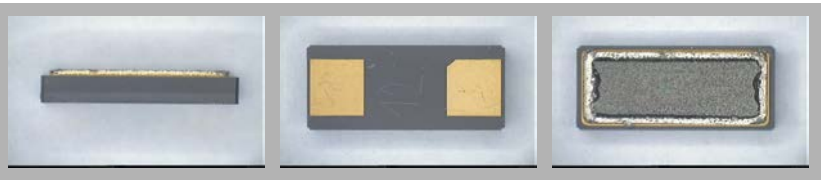
TCH SERIES

- hermetic package design removes humidity / oxudisation related limitations
  - long term reliability of polymer capacitor up to
    : 125°C/0.66U_R/10.000hrs
    : 85°C/85% RH/1.000hrs
- the low ESR feature allows higher power rating capability of the capacitor, more efficient filtering and faster response in power supplies applications
  - Reliability Tests
    - ESCC 3012 PASS
    - ESCC 5000 PASS
    - vibration up to 125°C PASS
    - vibration up to 40g; PASS



ESCC 3012/005 – TCH Hermetical SMD low ESR Tantalum Polymer

released in July 2013

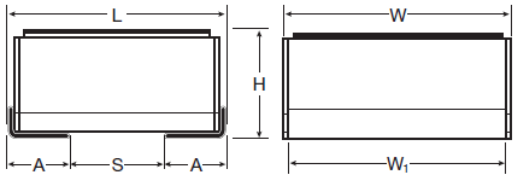


- Ongoing development of ESA qualified tantalum polymer hermetic caps
- Mission Critical Applications

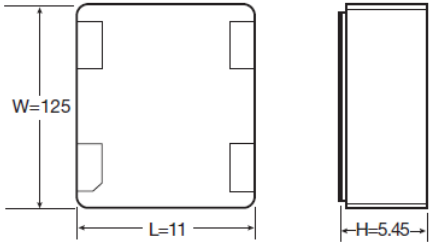
-Designed for Aerospace and Hi-rel applications
- Hermetically sealed
- Low ESR
- Rated voltage up to **100V**
- High ripple current capability
- Stability under humidity
- SMD Case size including CTC-21D

-

'J' Lead Temination



Undertab Termination



Capacitance		Rated Voltage DC (V_R) at 85°C								
µF	Code	10V	16V	20V	25V	35V	50V	63V	75V	100V
15	156									9*
22	226								9*	
33	336							9*	9*	
47	476						9*	9*		
68	686						9*			
100	107				9*	9*				
150	157			9*	9*	9*				
220	227	9*	9*	9*	9*					
330	337	9*	9*	9*						
470	477	9*	9*							
680	687	9*	9*							

Code	L	W	H
9 (CTC-21D)	12.5	11	5.45
I	11	6	2.4

TCH Hermetically Sealed Tantalum Polymer

Roadmap (product launch schedule) for 2013 (key selling parts in bold)

CAPACITANCE AND VOLTAGE RANGE (LETTER DENOTES CASE SIZE)

Capacitance		Rated voltage DC (VR) to 85°C								
µF	Code	10V	16V	20V	25V	35V	50V	63V	75V	100V
1,5	155									
2,2	225									
3,3	335									
4,7	475									
6,8	685									
10	106									
15	156									9 (150)
22	226								9 (120)	9 (150)
33	336							9 (100)	9 (120)	
47	476						9 (70)	9 (100)		
68	686						9 (70)			
100	107				9 (50)	9 (55)				
150	157			9 (45)	9 (50)	9 (55)				
220	227	9 (40)	9 (40)	9 (45)	9 (50)					
330	337	9 (40)	9 (40)	9 (45)						
470	477	9 (40)	9 (40)							
680	687	9 (40)	9 (40)							

August 13

100/35

December 13

330/10, **220/16**, **680/16**, 150/25, 47/50, (***22/100***)

CASE DIMENSIONS: millimeters

Code	Type	L	W	H	W_1	A	S
9 (CTC-21D)	J-lead	11.8	12.5	5.8	10.5	1.9	8
9 (CTC-21D)	Undertab	11	12.5	5.45	10.5	1.5	8

AVX
A KYOCERA GROUP COMPANY

“COTS+” Tantalum Polymer Proposal

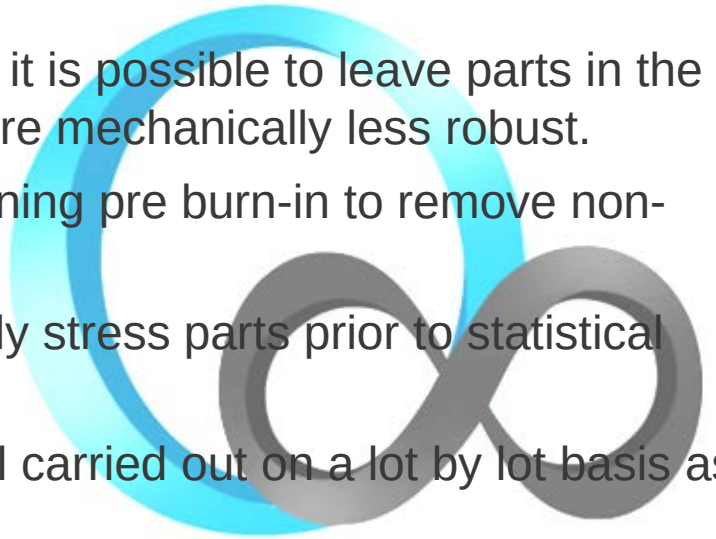
- Commercial Polymer with Restrictive Design
- **Statistical Screening & Process Management “Q-Process”**

Project Milestones (status Sep 13)

- commercial CECC reliability testing data	available	
- HiRel conservative design	defined	
- matrix	defined	
- manufacturing process route (excl.Qprocess)	defined	
- Q-process	optimization	1H14
- engineering samples	TBC	~ 1H14
- release of first codes / 2000hrs life data	TBC	~ 2H14

AVX Q-Process – New Up-screening Model

- Q-Process (patent pending) defines a number of process, screening and conditioning enhancements. A new burn-in that has been optimized to create a more effective burn-in to improve inherent DC leakage.
  - Removal of Weibull grading (85C B/I) as it is possible to leave parts in the population that have healed, but which are mechanically less robust.
  - Application of enhanced statistical screening pre burn-in to remove non-normal parts from the population.
  - Optimized reflow conditioning to thermally stress parts prior to statistical electrical testing.
  - Implementation of a new reliability model carried out on a lot by lot basis as part of lot acceptance testing.



- The Q-Process will give a more normal DCL population with lower probability of early life (post mount) failures and reduce the number of intrinsic dielectric defects within each lot.
- Q-Process has been introduced on MnO2 medical product with significant field failures reduction

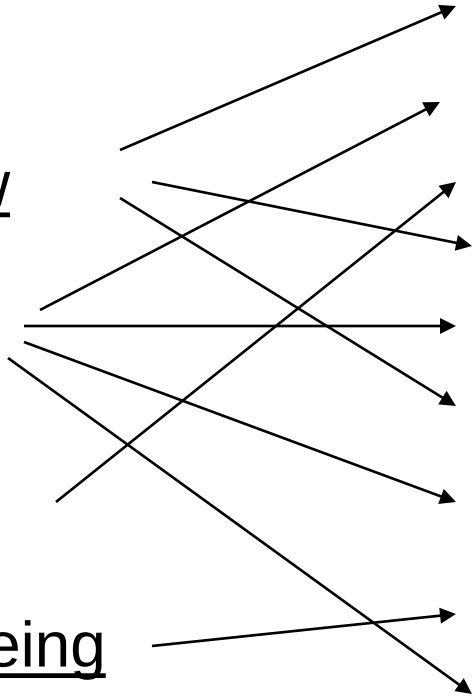
AVX Q-Process – New Up-screening Model

100% multiple reflow

3 sigma screening

100% hot burn in

100% 24hrs 85C ageing



Q Process

100% Reflow #1

Pretester – hot DCL
3 sigma

100% Ageing 125°C

100% Reflow #2

100% TST **3sigma**

100% Reflow #3

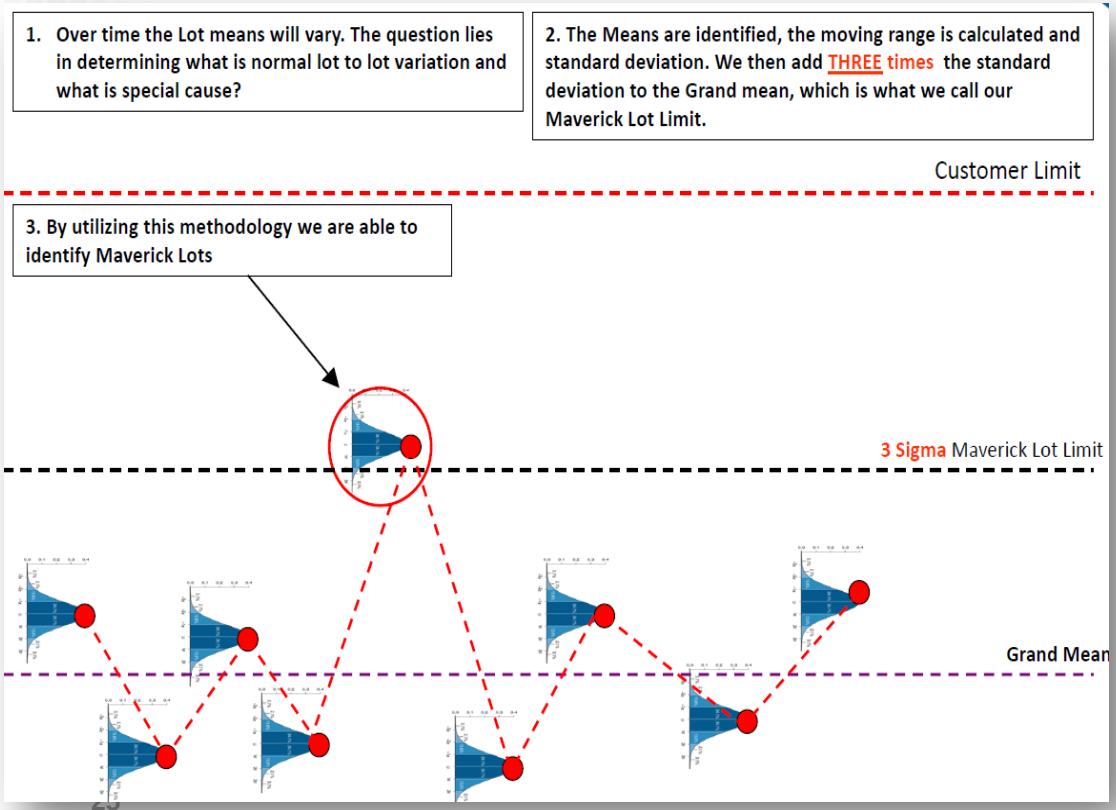
100% TST (hot DCL)
3 sigma

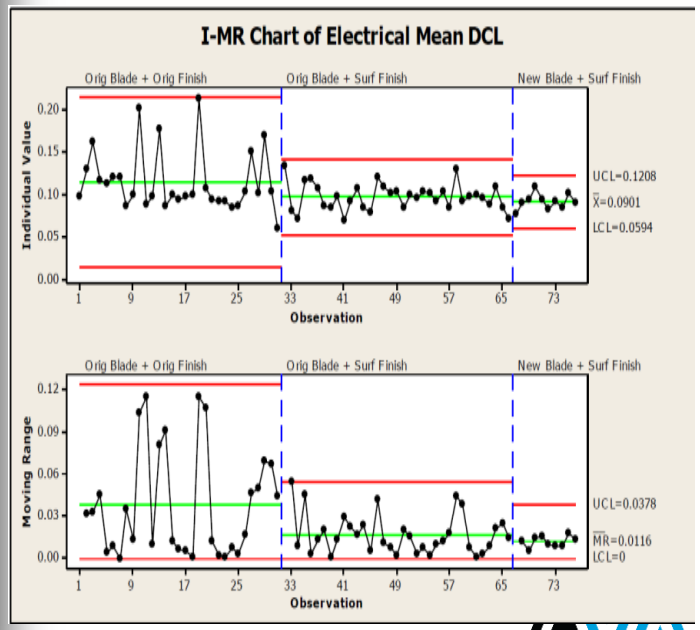
24 h Ageing 85°C

100% TST **3 sigma**

Q-Process: Maverick Lot Detection

- AVX's maverick lot program is designed to identify any lot that is statistically different than previously supplied lots
- This program insures that the lots produced are statistically the same as the originally qualified design
- The maverick lot program is a key driver of continuous improvement projects at AVX





POLYMER COTS+ Matrix Proposal (2-3 years)

Design rules:

- A, B, C, D cases
- FR ≥ 3 (conservative design)
- 100% hard surge current testing
- lower CV powder (conservative approach)
- Assembly Q-process
- 6.3 to 63V
- MSL level 3 dry pack mandatory
- 100% ageing (no extra ageing need

Preliminary COTS+ matrix

µF/V	6.3	10	16	20	25	35	50	63
0.47								B(400)
0.68							B(400)	B(300)
1							B(300)	
1.5						B(250)		
2.2						B(250)		C(200)
3.3						B(250)	C(200)	C(200)
4.7							C(200)	D(150)
6.8			A(200)			C(200)	D(150)	D(150)
10		A(300)	A(200)		B(150)	C(200)	D(150)	
15	A(300)	A(200)	B(150)		B(150)	D(100)		
22	A(300)				D(100)	D(100)		
33	B(70)	B(70)			D(100)			
47	B(70)	B(70)	D/Y(70)	D(70)				
68			D(70)	D(70)				
100		D(70)	D(70)					
150	D(70)	D(70)						
220	D(70)							

(ESR in mO in brackets)

POLYMER COTS+ Project Milestones

Project Milestones (status Aug 13)

- commercial reliability testing data	available	
- HiRel conservative design	defined	
- matrix	defined	
- manufacturing process route (excl.Qprocess)	defined	
- Q-process	optimization	1H14
- engineering samples of the first “true” codes	TBC	~ 1H14
- release of first codes / 2k life data	TBC	~ 2H14

Hi-Rel Polymer statement on TH with Bias

- Sensitivity to humidity and higher sensitivity to thermo-mechanical load (such as aggressive reflow) is a disadvantage of polymer materials (applies to all manufacturers)
- Tantalum polymer capacitors can be qualified to tests at 60C/95% r.h. but not combination of high temp, high humidity and voltage such as 85/85 2000hrs, Vr (that is why polymers are not automotive qualified parts per AEC-Q200 requirements)
- If parts are tested on TH WITH BIAS - than the parts might have issues to pass failing with both ESR and DCL

for mission critical applications TCH hermetically sealed polymer is strongly recommended

alternative hermetically sealed packaging of the end device may need to be used with the Polymer COTS+ designs

Q-PROCESS– Achieving highest reliability for Tantalum capacitors

Q-Process is not a theory. AVX is actively motivating and exercising the known failure mechanisms, then recognizing non-normal parts and removing them from the population

AVX has real life evidence that the Q-Process works:

- With implementation of only a portion of the methodology, customers have reported 99.99%+ elimination of failures
- Little to no failures in the hybrid post mount stage, post burn in, and finally in the field
- This was achieved through implementation of effective statistical screening and conditioning of the parts to remove maverick pieces from the population. This early phase of the Q-Process did not utilize the benefits associated with moving to an optimized 125C burn-in.

No other Hi-Rel tantalum supplier can demonstrate such an impact over such a long time frame

Hi-Rel and Aerospace Low ESR Tantalum Capacitors

European Standardization Based

ESA QPL qualified products

ESCC 3012 / 001 TAJ-ESA
ESCC 3012 / 004 TES
(HiCV&Low ESR SMD Oct.2013)

ESCC 3012 / 004 (low ESR) EPPL 2
ESCC 3012 / 005 TCH
hermetical SMD proposal

CECC Avionics & Industrial IQC

CECC 30801 005 / 011 (CTC4)
CECC 30201-032 (leaded Ta)

US Standardization Based

CWR09 MIL QPL group family
CWR 11 (EIA case sizes)
CWR 15 (Microchip)
CWR 19 (Ext. range)
CWR 29 (Low ESR)
CLR79 / 81/ 90 /91 (Wet)

DSCC 95158
DSCC 07016 (Hi-Rel, low ESR, ext. range)
DSCC 93026 (Wet)

COTS+
COTS+ Aerospace - SRC9000

Polymer Q-Process “COTS+”
Under development for 2014

SUMMARY

New Range of Low ESR Tantalum Capacitors for Space applications available

ESCC 3012/004 TES series (High CV & Low ESR) with multianode offering moving from EPPL2 to QPL

- Conductive Polymer for HiRel applications

  1] TCH SMD hermetically sealed polymer for mission critical applications

  2] “COTS+” up-screened restrictive design polymer capacitors for general HiRel application or use inside of hermetically sealed end device packaging for high humidity environment

- AVX Conductive Polymer COTS+ will utilize AVX proprietary Q-process statistical screening & manufacturing process

Thank You