Hermetic Conductive Polymer Tantalum Capacitors

CMSE 2017

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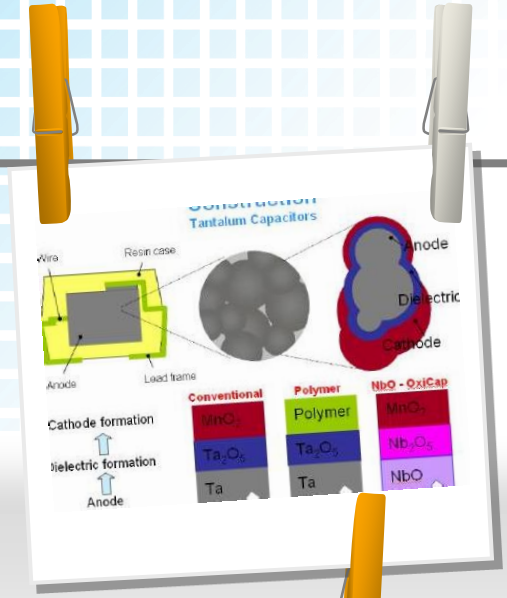
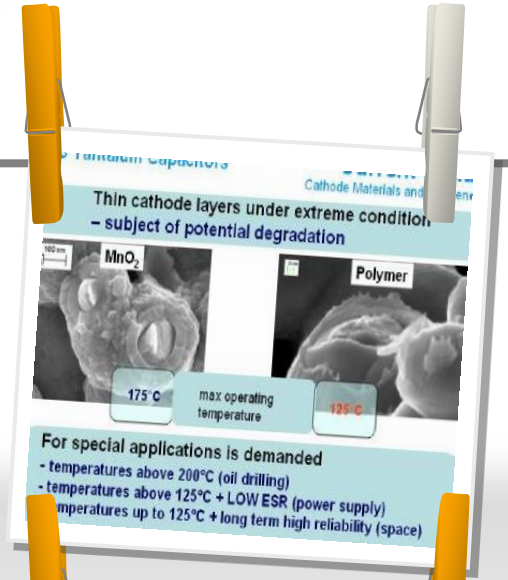
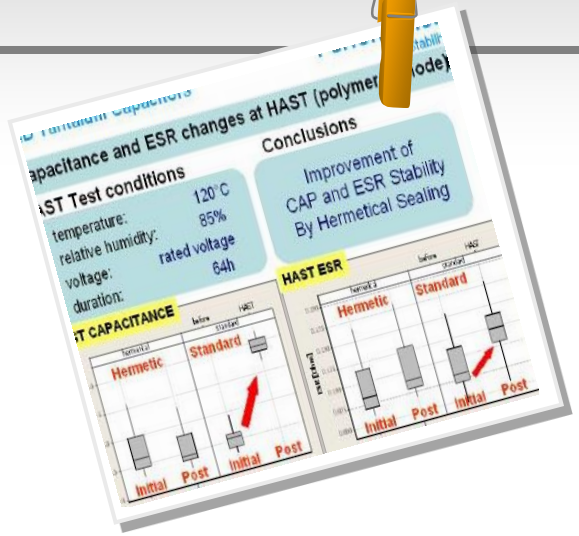
A KYOCERA GROUP COMPANY

Outline

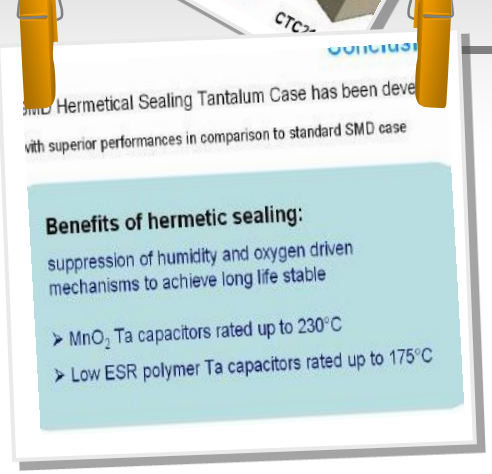

Tantalum Capacitors
Wire
Resin case
Anode
Dielectric
Cathode
Lead frame
Anode
Conventional
Polymer
NbO - OxiCap
Cathode formation
Dielectric formation
Anode
MnO_2
Ta_2O_5
Ta
Polymer
Ta_2O_5
Ta
MnO_2
Nb_2O_5
NbO


Thin cathode layers under extreme condition
– subject of potential degradation
MnO_2
Polymer
175°C
max operating temperature
125°C
For special applications is demanded
- temperatures above 200°C (oil drilling)
- temperatures above 125°C + LOW ESR (power supply)
- temperatures up to 125°C + long term high reliability (space)

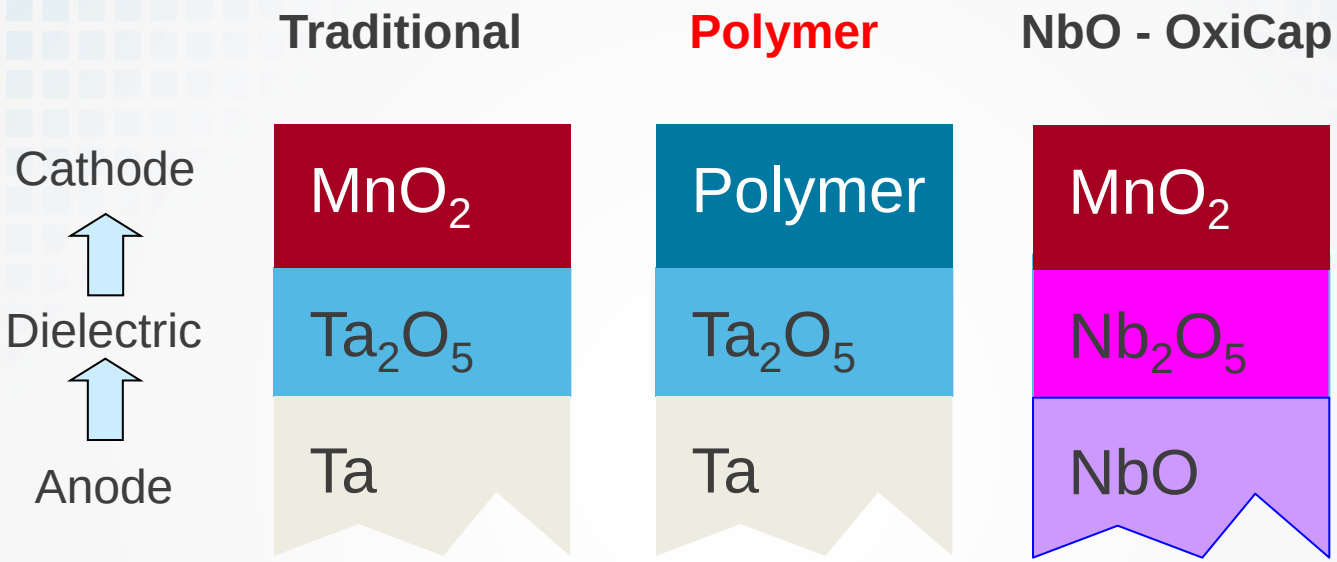

Hermetically Sealed SMD Case
- suppress oxidative degradations
- suppress of humidity degradations
Hermetic Sealing
- lid
- sealing ring
- ceramic case
- inert gas
- anode + contacts


Conclusions
Improvement of CAP and ESR Stability By Hermetical Sealing
temperature: 120°C
relative humidity: 85%
voltage: rated voltage
duration: 64h
HAST ESR
Hermetic
Standard
Initial
Post


Modular Solutions
TCH 9 case
22µF/ 100V
ESR 60 mOhm
TO3 case
100µF/ 100V
ESR 9 mOhm
Customized case
400µF/ 100V
ESR 3 mOhm
Multiple capacitors connected in parallel
Capacitace high
ESR low


with superior performances in comparison to standard SMD case
Benefits of hermetic sealing:
suppression of humidity and oxygen driven mechanisms to achieve long life stable
MnO_2 Ta capacitors rated up to 230°C
Low ESR polymer Ta capacitors rated up to 175°C

Solid Electrolytic SMD – Technology Combinations

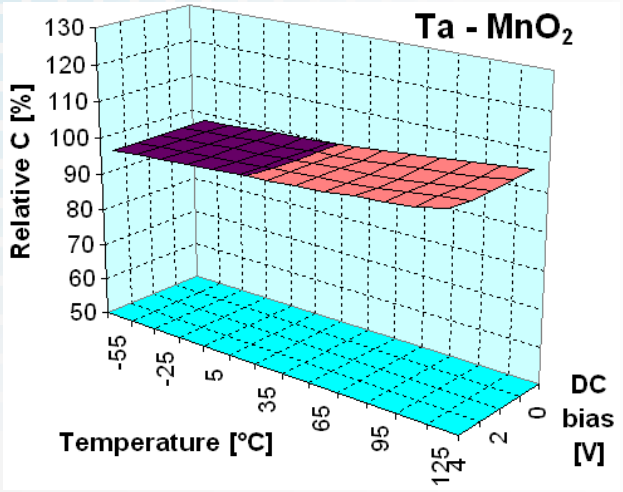


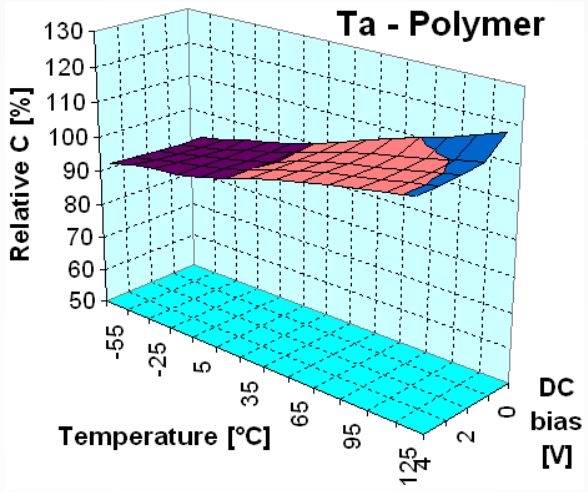
Nb – small reliability advantage over Ta; limited voltage range; adds material availability.
NbO – The only option with a non-short circuit failure mode, greater material availability.

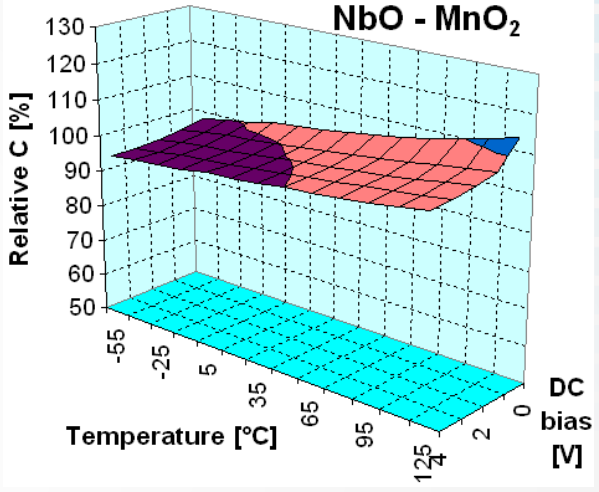
MnO_2 – Promotes self-healing; source of O_2 in failures; long-term stability.
Polymer – Low ESR capability; no O_2 contribution; higher humidity sensitivity.

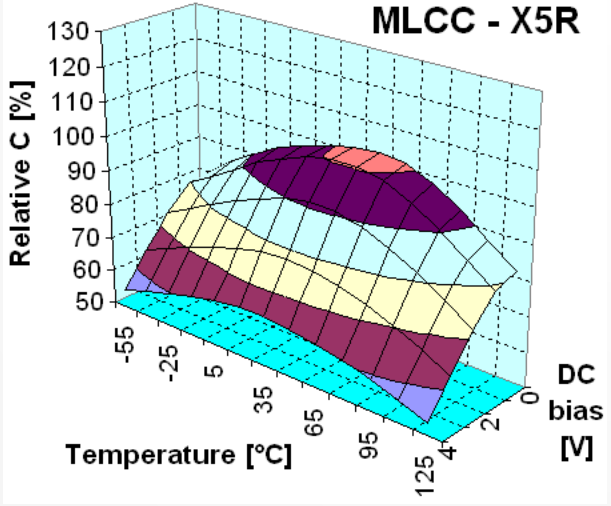
Technology Comparison – Temperature Characteristics

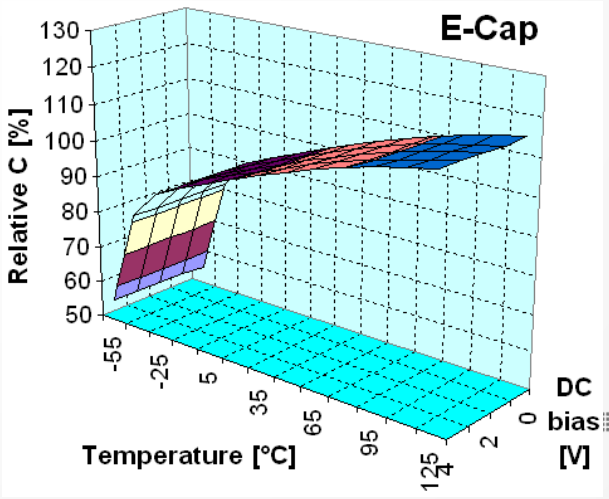
Tantalum capacitor market remains strong in applications requiring volumetric efficiency, long term reliability and stability over thermal cycling



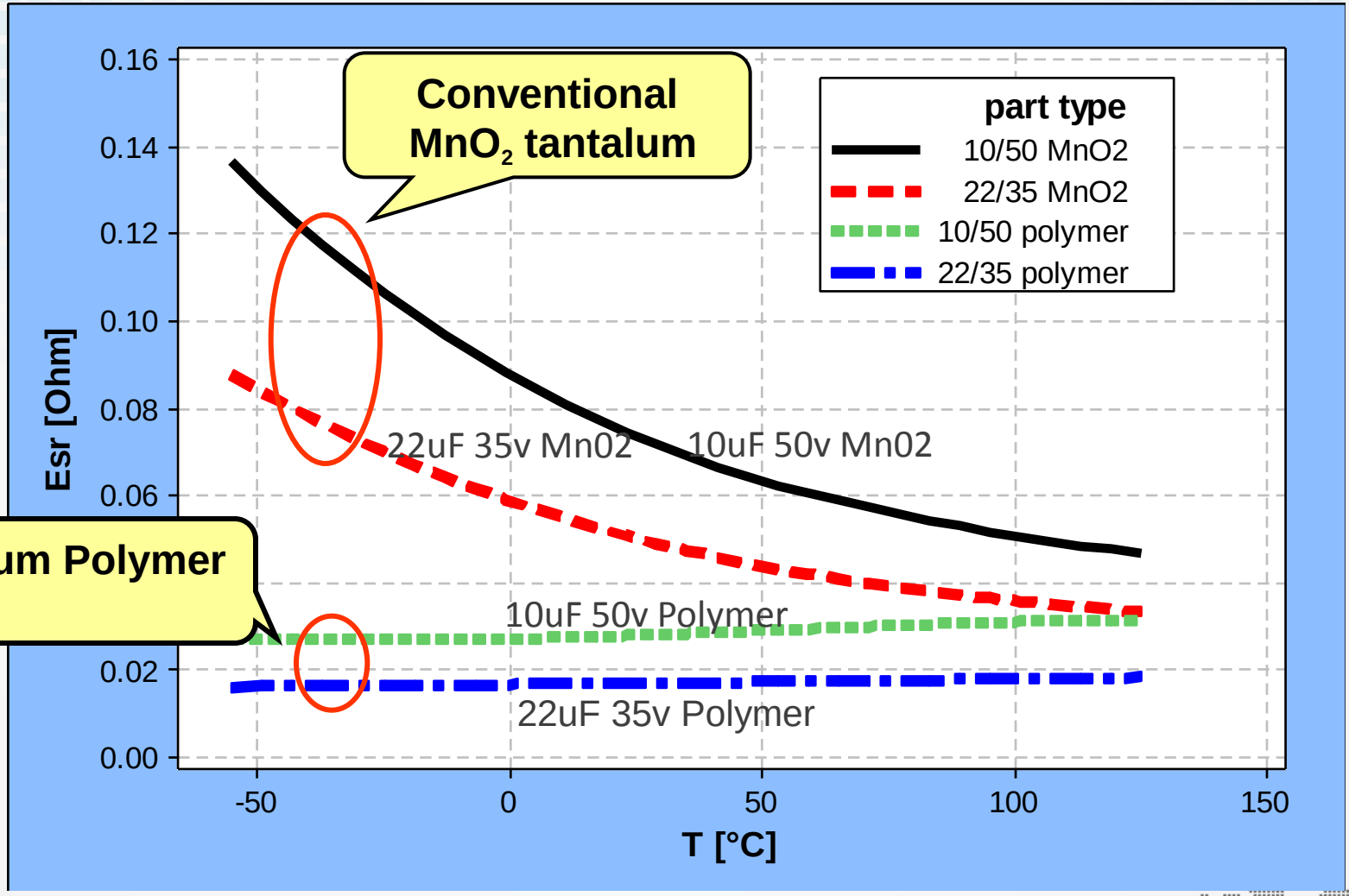








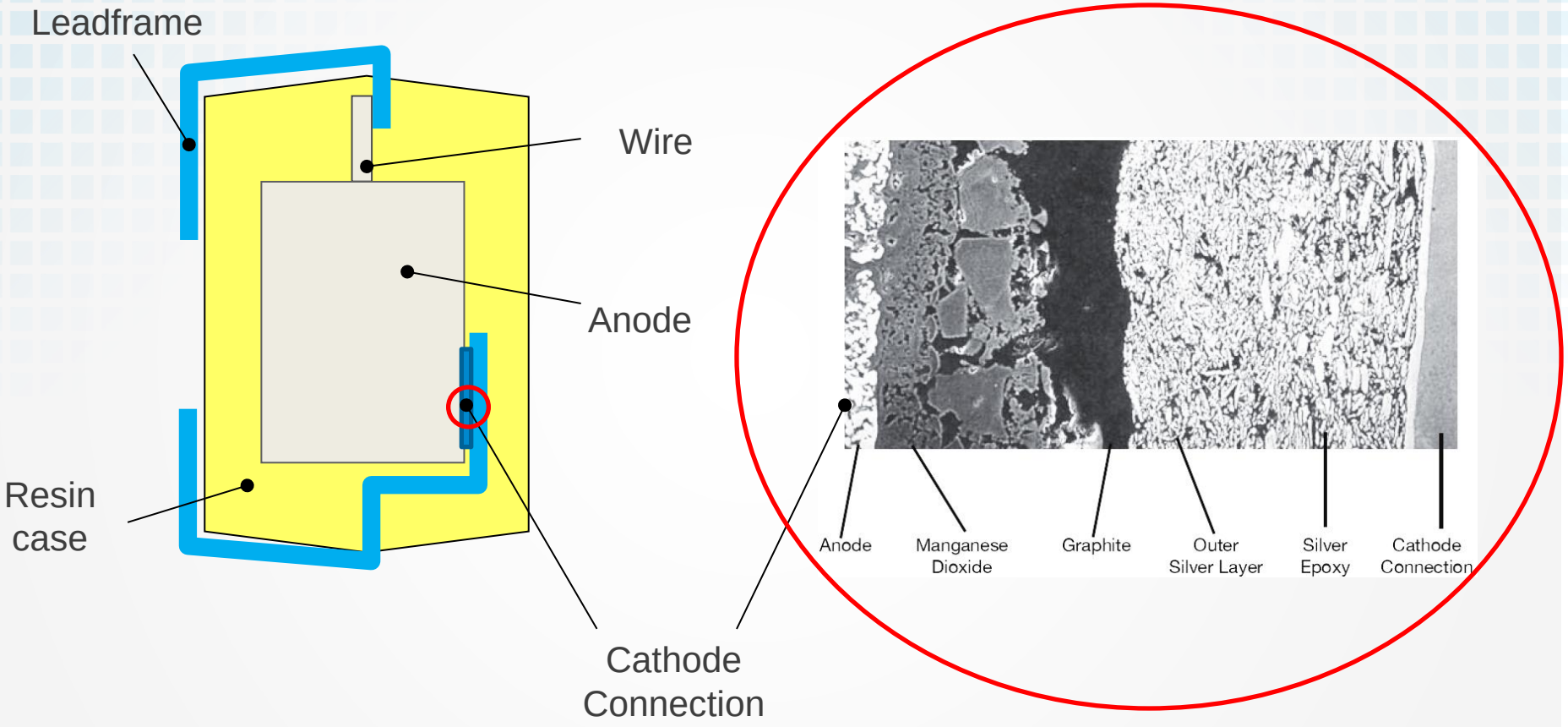
Technology Comparison – ESR Characteristics



Tantalum Polymer

ESR@100 kHz - temperature dependency

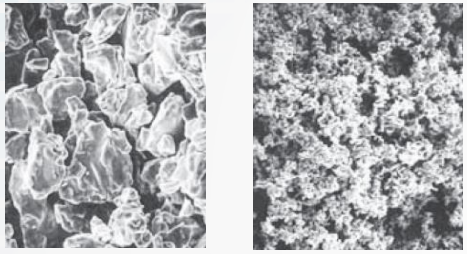
Molded Solid Electrolytic SMD – Construction Basis



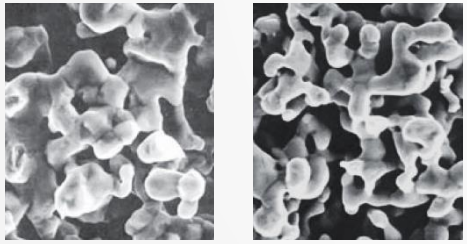
Solid Ta / Nb Electrolytic Capacitor Materials

Particle Size

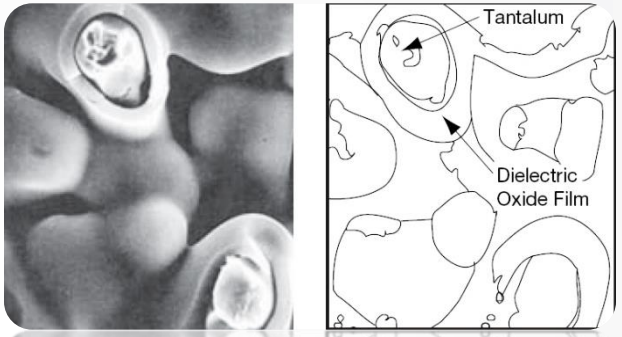
Low Surface Area High



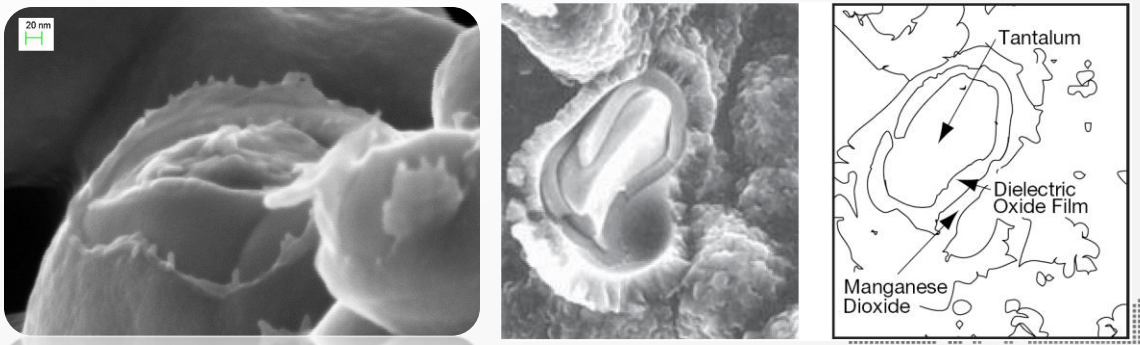
High Purity Ta / Nb or NbO powder



High Purity Ta / Nb or NbO sintered



Ta / Nb or NbO post formation
(pentoxide dielectric layer)

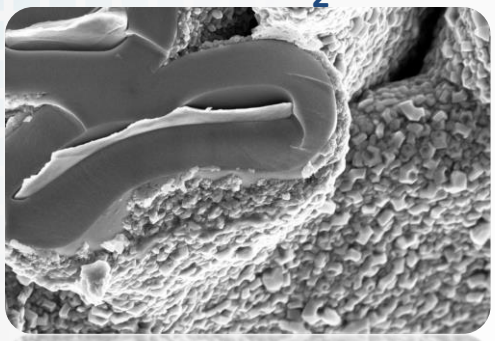


Polymer MnO_2

Application of Internal counter-electrode

Molded Solid Tantalum Capacitors – Electrolyte Options

MnO_2

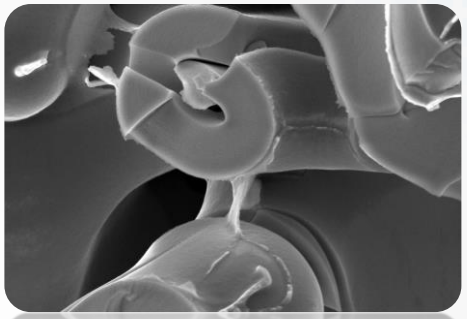


Solid - MnO_2 Semiconductor

Electronic conduction

+ Solid crystal – parametric stability vs time
  - Stable Capacitance / DF
  - Stable ESR
+ Self healing
+ High temperature
- Overheating possible
- Voltage limited
- **Standard ESR**

PEDT

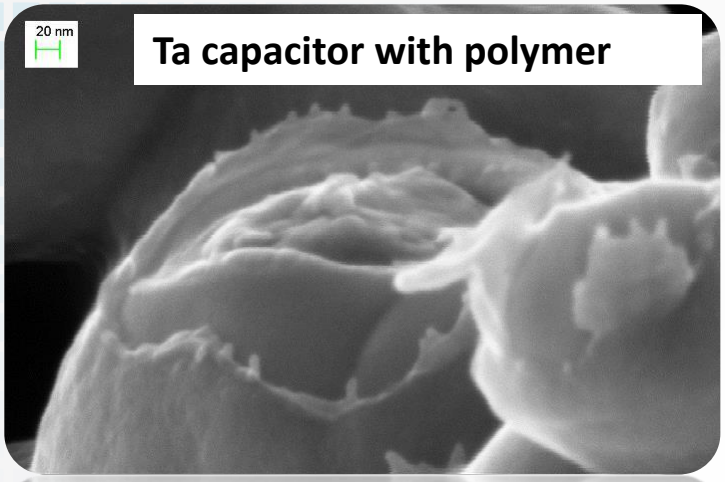


Solid – Conductive Polymer

Electronic conduction

+ Self healing
+ Low ESR
+ Safe failure mode
+ High voltage
- Lifetime – time dependent properties
  - Temperature limited
  - Humidity & oxygen sensitive

Hermetic Seal Polymer Capacitor



Why Hermetic Packaging?

In molded packages, the thin conductive polymer cathode layer is susceptible to degradation under extreme conditions of high temperature and high humidity.

- Stable, low ESR
- Parametric stability under extreme conditions
- Aerospace & Hi-Rel application compatible

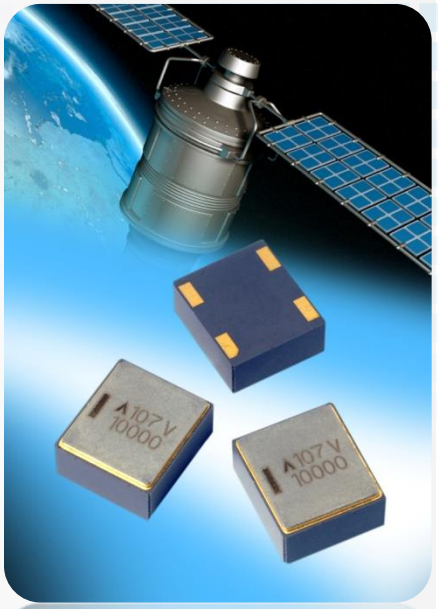
Hermetic seal:

Protects from degradation by humidity

Protects from degradation by oxidation

Hermetic Seal Polymer Capacitor

- -55/+125˚C Temperature Range
- **Low ESR** conductive polymer electrode
- High ripple current capability up to 3A
- Ceramic **hermetic** packaging suppresses environmental degradation
- Stability under humidity and ambient atmospheric conditions
- **Large CTC-21D case size enables high capacitance / voltage ratings**
- Developed with ESA for aerospace applications
- ESCC EPPL2 specification approval in process



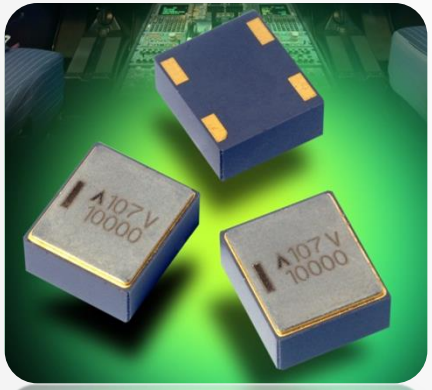
TECHNICAL SPECIFICATIONS:

Technical Data:	All technical data relate to an ambient temperature of +25ºC								
Capacitance Range:	15µF to 680µF								
Capacitance Tolerance:	±20%								
Leakage Current DCL:	0.1CV								
Rated Voltage (V_R) ≤+85ºC:	10	16	20	25	35	50	63	75	100
Category Voltage (V_C) ≤+125ºC:	7	11	13.5	17	23.5	33	42	50	66
Temperature Range:	-55ºC to +125ºC								

Hermetic Seal Polymer Capacitor

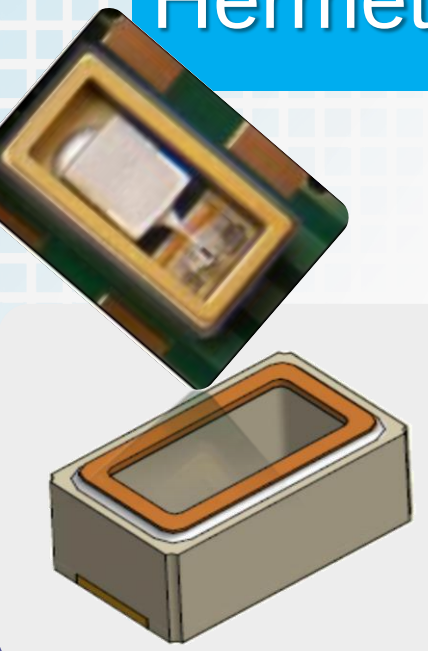
TCH SERIES

- Hermetic package design removes humidity / oxidation related limitations to conductive polymer.
  - Lifetime capability of polymer capacitor: 125°C / 0.66U_R/10.000hrs
    85°C/85% RH/1.000hrs
- Low ESR enables higher power rating, more efficient filtering and faster response in power supply applications



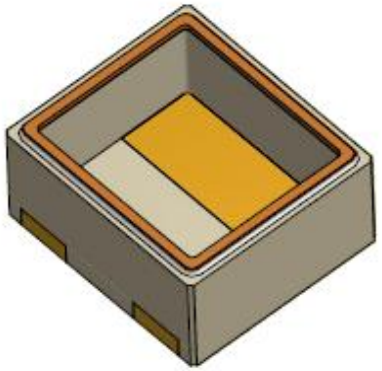
- **Reliability Testing Results**
  - ESCC 3012 — PASS
  - ESCC 5000 — PASS
  - Vibration up to 125°C — PASS
  - Vibration up to 40g — PASS

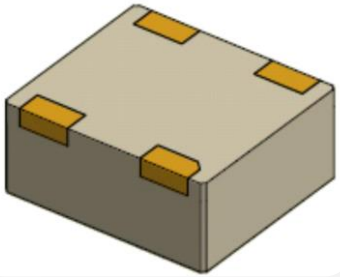
Hermetic Seal Capacitor Construction



Hermetic Sealing:

- Lid (Kovar)
- Sealing ring
- Ceramic case
- Inert gas
- Anode & contacts





Common Packaging technology for timing devices etc.

CTC21 tantalum case

Hermetic Polymer Capacitor Range

Capacitance		Rated voltage DC (VR) to 85°C								
µF	Code	10V	16V	20V	25V	35V	50V	63V	75V	100V
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)*						
330	337	9(40)	9(40)*							
470	477	9(40)*								

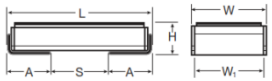
Approved

Under Development

CTC21 tantalum case styles:

Undertab Style

J-lead Style



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

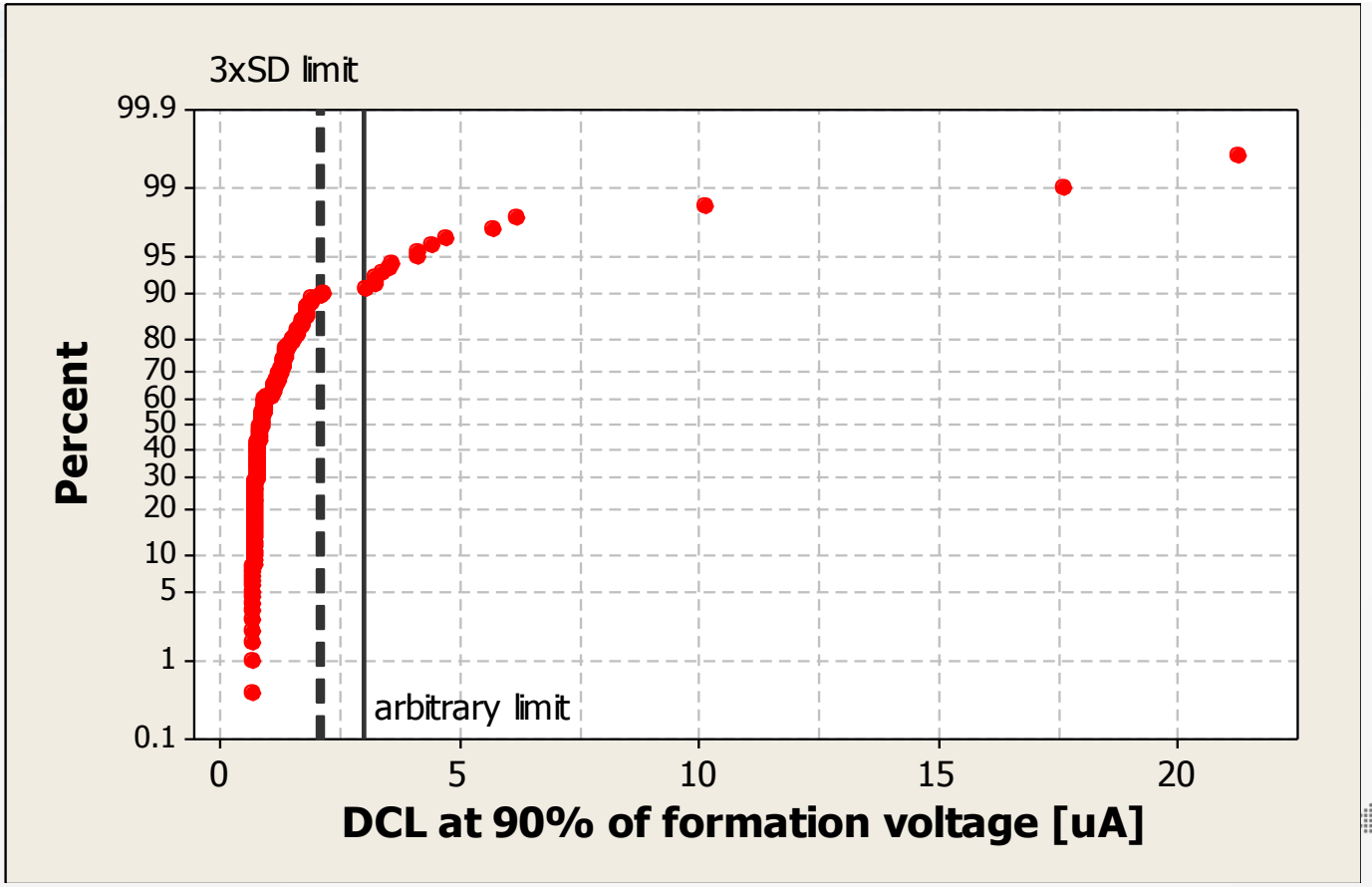
Hermetically Sealed Polymer Capacitors

Testing
&
Performance

Ageing and Screening Procedures

Every capacitor is voltage stressed.

Statistical approach applied to 3 sigma acceptance limit.



Hermetic Capacitor Performance - HAST

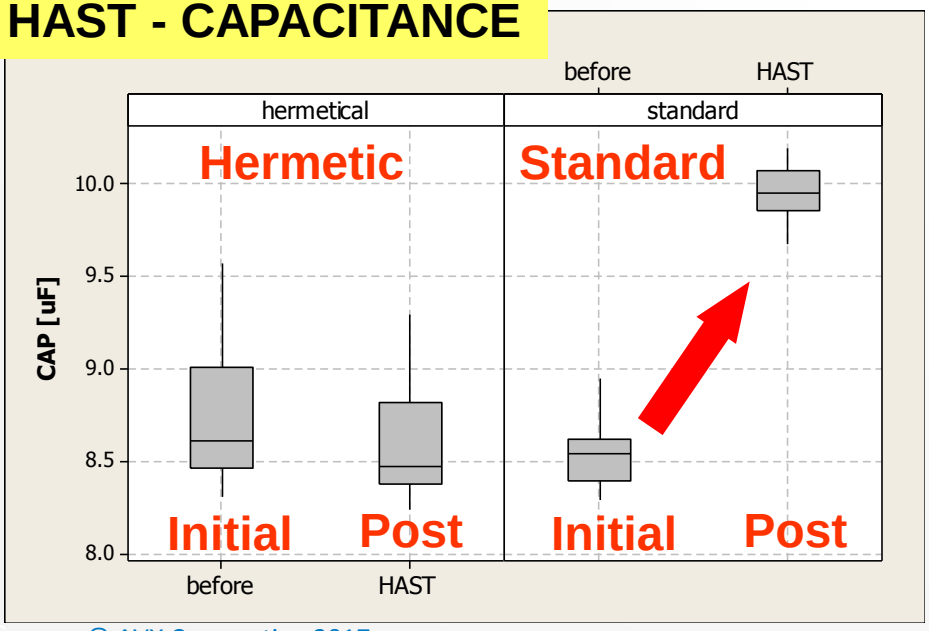
HAST Test Conditions:

Temperature:	120°C
Relative Humidity:	85%
Voltage:	Rated Voltage
Duration:	64h

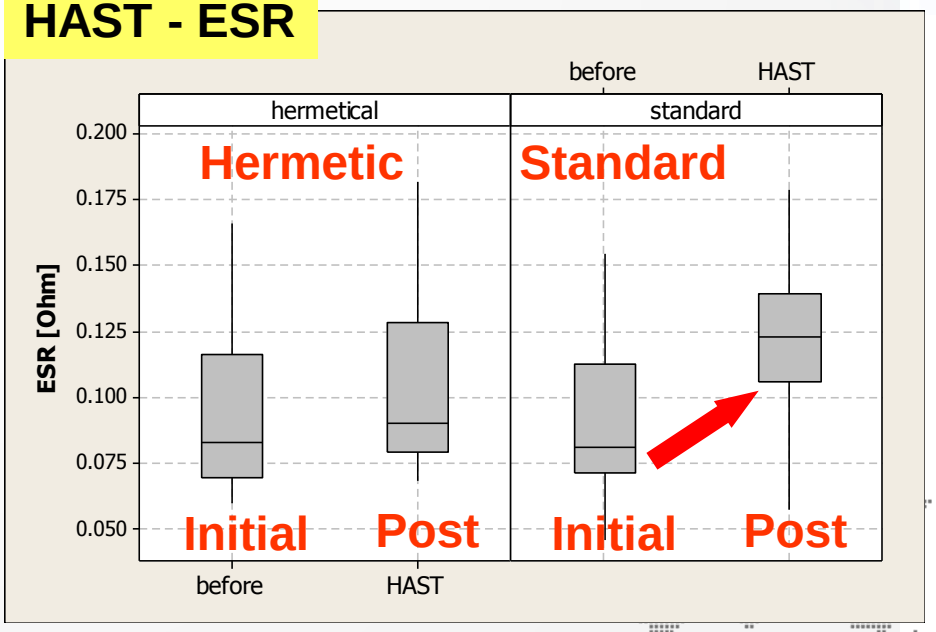
Results:

Demonstration of improved CAP and ESR Stability by Hermetic Sealing

HAST - CAPACITANCE



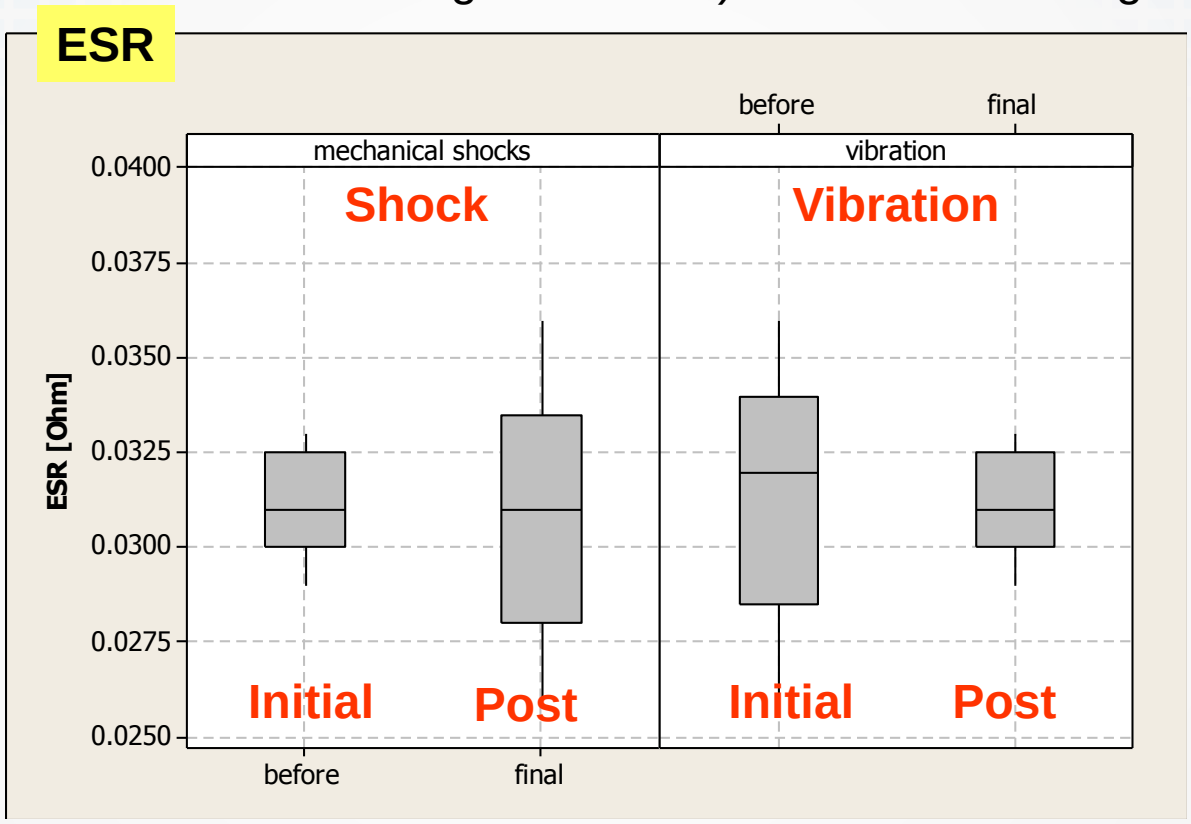
HAST - ESR



Hermetic Capacitor Performance – Shock / Vibration

1) Mechanical Shock Test: 5x 1500g

2) Vibration Test: 20g at 125C



Results:

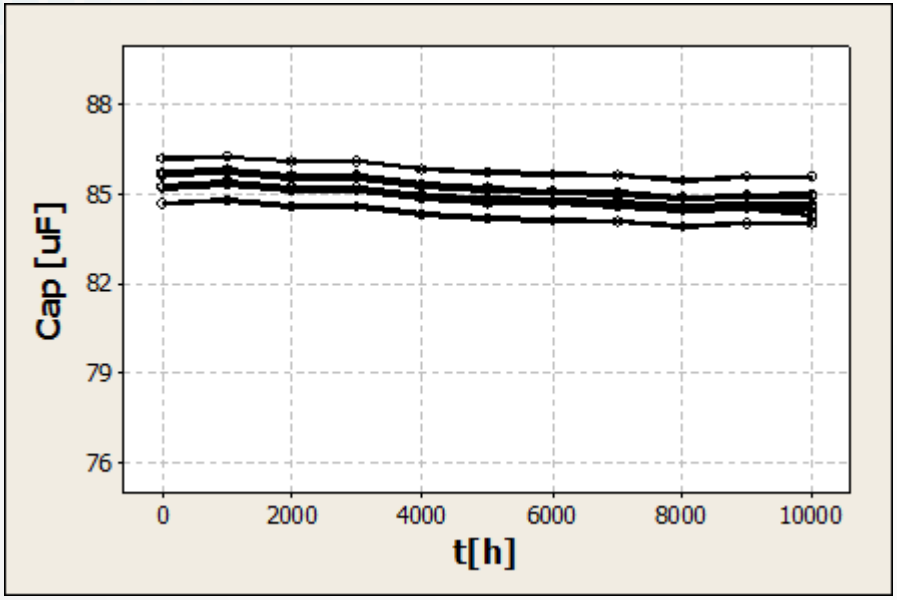
- Stable Electrical Performance CAP, DF, ESR, DCL
- Post Test Hermeticity: Pass

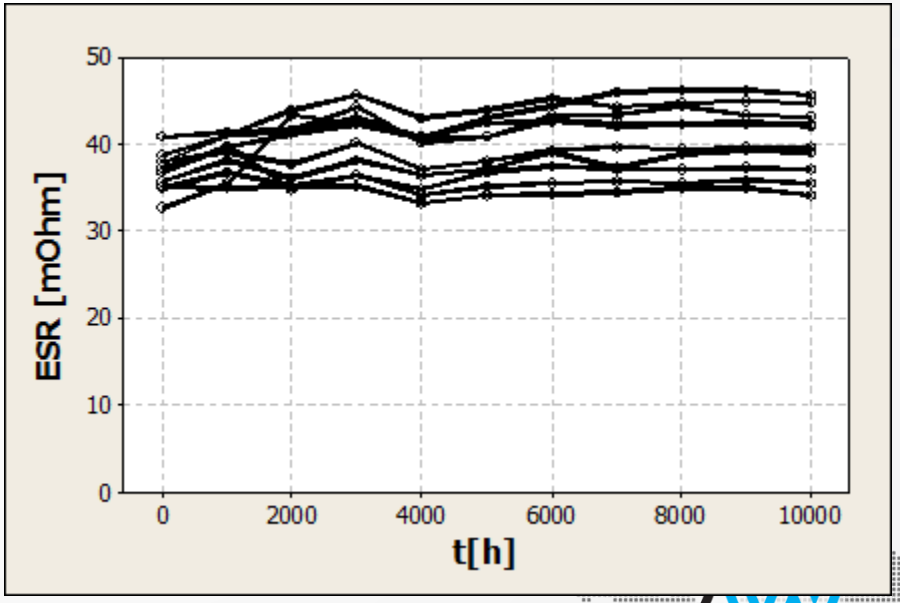
Lifetime Stability of Hermetic Seal Capacitors

Stability of capacitance and ESR

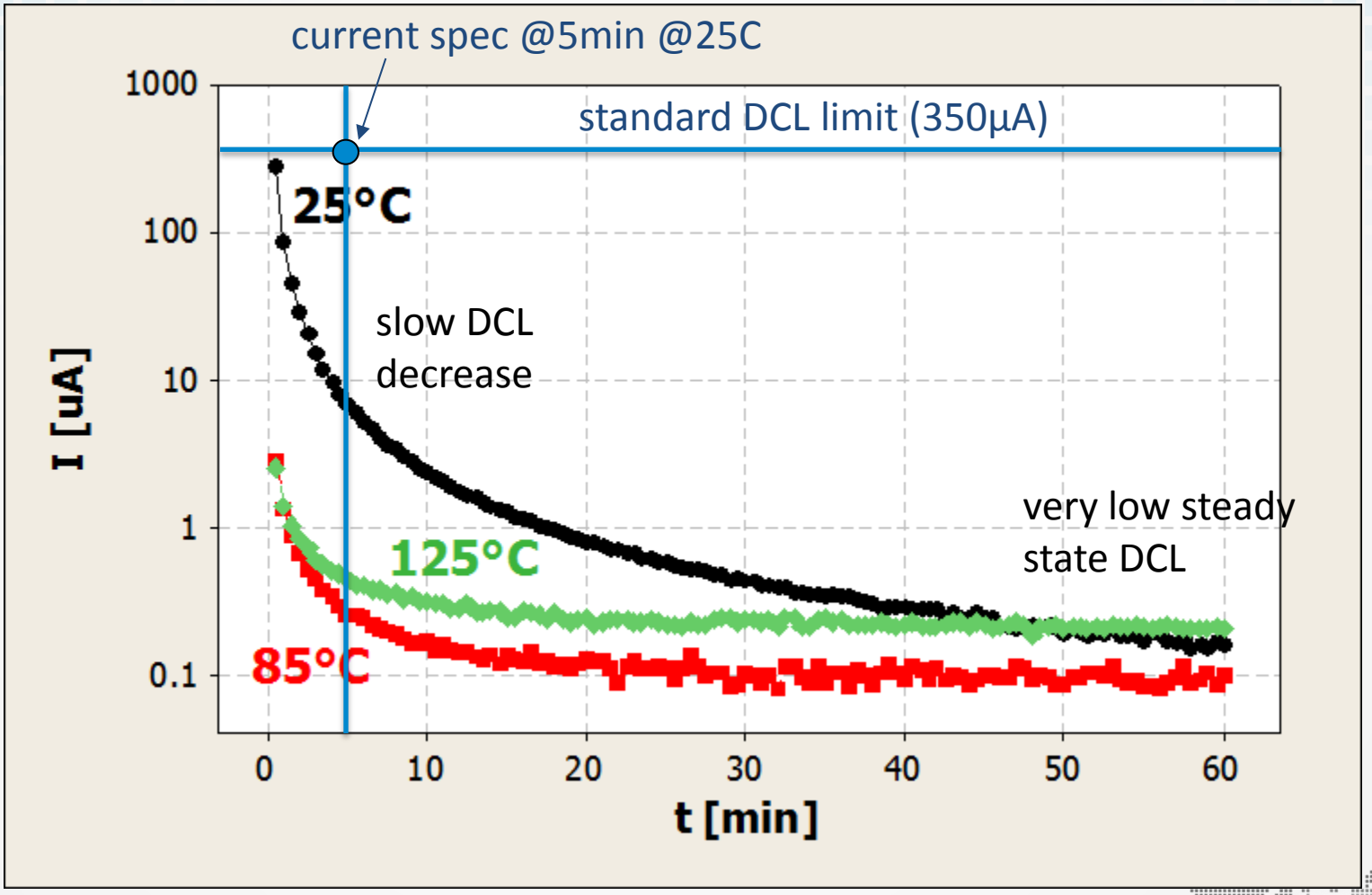
- 35V rated voltage capacitor at 125°C and UR
- Stable Performance

10,000 hrs





DCL Stability of Hermetic Seal Capacitors



DCL measurement after 10,000h at 125°C and rated voltage

Hermetic Seal Polymer Capacitor ESCC

ESCC 5000 TESTS

SMD Hermetically sealed
low ESR tantalum polymer capacitor

subgroup I	subgroup II	subgroup III	subgroup IV
initial measurement - loose units	initial measurement - loose units	initial measurement - loose units	
mechanical shock MIL-STD-750, test method 2016 1500g, 0,5ms duration, 5 shock, planes X, Y, Z	**temperature cycling** MIL-STD-750, test method 1051 test condition C, 100cycles	**operating life** 125°C, without voltage, 2000hrs	**bond strength** anode - ceramic package leadframe - carammic package
M1	M1		
vibration MIL-STD-750, test method 2056 20g, 10-2000Hz, cross over at 50Hz	**moisture resistance** MIL-STD-750, test method 1021		
M2	M2	M1	
seal MIL-STD-750, test method 1071 seal (fine leak) condition H1, H2 seal (gross leak) condition C, K	**seal** MIL-STD-750, test method 1071 seal (fine leak) condition H1, H2 seal (gross leak) condition C, K	**seal** MIL-STD-750, test method 1071 seal (fine leak) condition H1, H2 seal (gross leak) condition C, K	
M(final)	M(final)	M(final)	
visual control	visual control	visual control	

TEST RESULTS ESCC 5000 size 9	100/35
1. Mechanical shock (1500g) - vibration – seal test	PASS
2. Rapid change temperature – moisture resistance – seal test	PASS
3. Life test - seal test	PASS
4. Bond strength	PASS

Hermetic Seal Polymer Capacitor ESCC

ESCC 3012 TESTS

SMD Hermetically sealed low ESR tantalum polymer capacitor

subgroup I	subgroup II	subgroup III	subgroup IV	subgroup V
PCB mounting	PCB mounting	PCB mounting	PCB mounting	visual control
M0	M0	M0	M0	solderability (235°C,4sec)
adhesion 5N, 10sec	rapid change of temperature IEC 68-2-14 Na (-55/125°C,30min,5cycles)	high and low temp. stability (22/-55/22/rated/category/22°C)	operating life (125°C, UR, 2000hrs,intermediate meas.)	visual control
M1	M1	M1	M(final)	
Damp heat tests IEC 68-2-2 Ba (125°C,2hrs) IEC 68-2-30 Db (1.cycle) IEC 68-2-1 Aa (-55°C,2hrs) IEC 68-2-13 M (1-2min 85mbar, 15-35°C, Ur) IEC 68-2-30 Db (5cycles)	vibration IEC 68-2-6 Fe (10-2000-10Hz, 20min,12x3dir)	surge test (rated temp,1000cycles,30ces,33Ohm)		
M(final)	shock IEC 68-2-27 Ea	M2		
	M2	DHSS IEC 68-2-3 Ca (40°C,93%rh,0V,56days)		
	Damp heat tests IEC 68-2-2 Ba (125°C,2hrs) IEC 68-2-30 Db (1.cycle) IEC 68-2-1 Aa (-55°C,2hrs) IEC 68-2-13 M (1-2min 85mbar, 15-35°C, Ur) IEC 68-2-30 Db (5cycles)	M(final)		
	M(final)			

TEST RESULTS ESCC 3012 size 9	330/10	100/35
1. mounting - adhesion – damp heat test	PASS	PASS
2. mounting - rapid change temperature – vibration, shock – damp heat test	PASS	PASS
3. mounting - high and low temp. stability – surge test – DHSS	PASS	PASS
4. mounting - operating life 125°C, UC, 2000hrs	PASS	PASS
5. solderability	PASS	PASS

Stability of Hermetically Sealed Capacitors

- **Additional Tests:**

1.	Life Test at 125°C/100V, 5000h	pass
2.	Extended Temperature Cycling -55/125°C, 30 min, 1000 cycles	pass
3.	Biased Humidity (85°C/85RH/1000h, Ur)	pass
4.	Vibration 40g 6h, 10-2000-10Hz at room temperature	pass

Hermetic Seal Polymer Capacitors

MODULAR SOLUTIONS

Hermetic Seal Modular Solutions

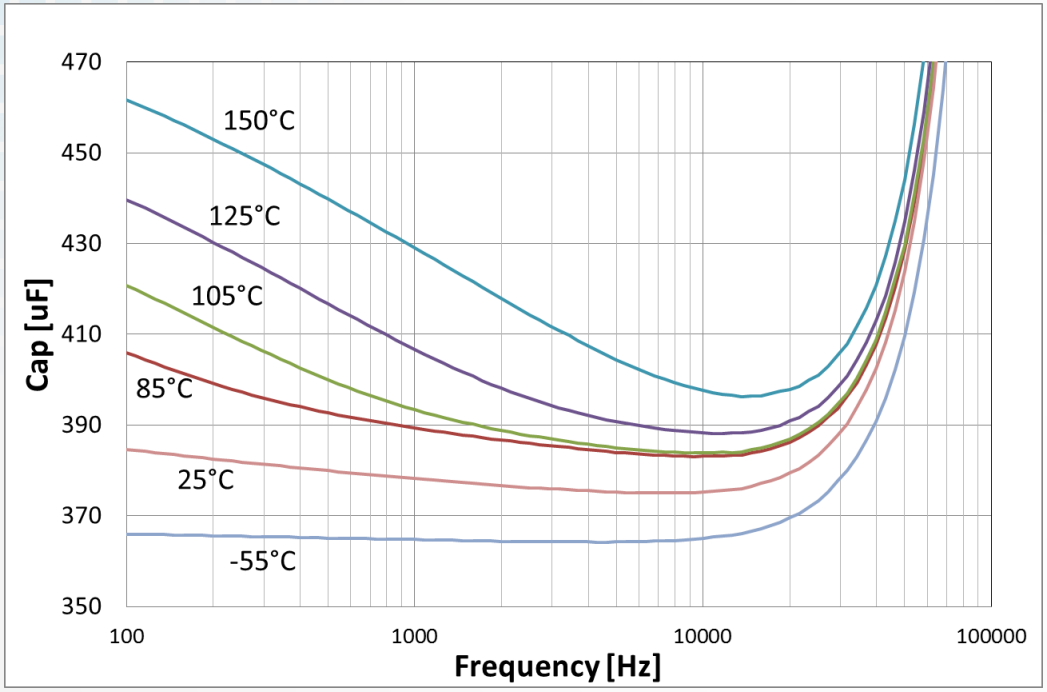
- **TCH 9 case**
- 22µF/ 100V
- ESR 60 mOhm

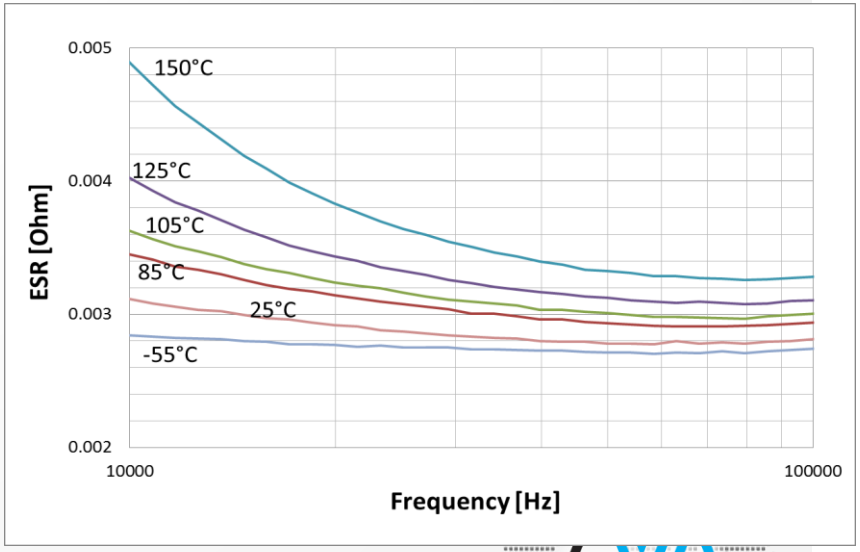
- **Customized case**
- 400µF/ 100V
- ESR 3 - 15 mOhm

- Multiple capacitors connected in parallel
- High Capacitance
- Ultra-Low ESR (< 5mOhms)

Modular Solution - Capacitance and ESR

- **400µF/ 100V – low ESR model**





- Capacitance stable with temperature and frequency

Summary & Conclusion

Hermetically Sealed Conductive Polymer Tantalum Capacitors

- Stable performance and reliability exceeding:
  - 10,000 hours, 85°C at Ur,
  - 10,000 hours, 125°C at 0.66x Ur
- Super-low DCL and low ESR performance achieved
  - Sub 0.0001 CV
  - Lowest DCL ever for any tantalum based capacitor technology!

A New Class of SMD Tantalum Polymer Capacitors:

- Lowest Tantalum DCL specifications (Lower Than Conventional MnO_2)
- Improved Humidity Stability

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