Electronic Components

KEMET

CHARGED.®

Ta SMD capacitors with MnO_2 and Polymer Counter Electrode for Space Applications

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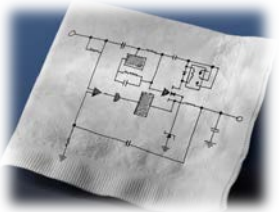
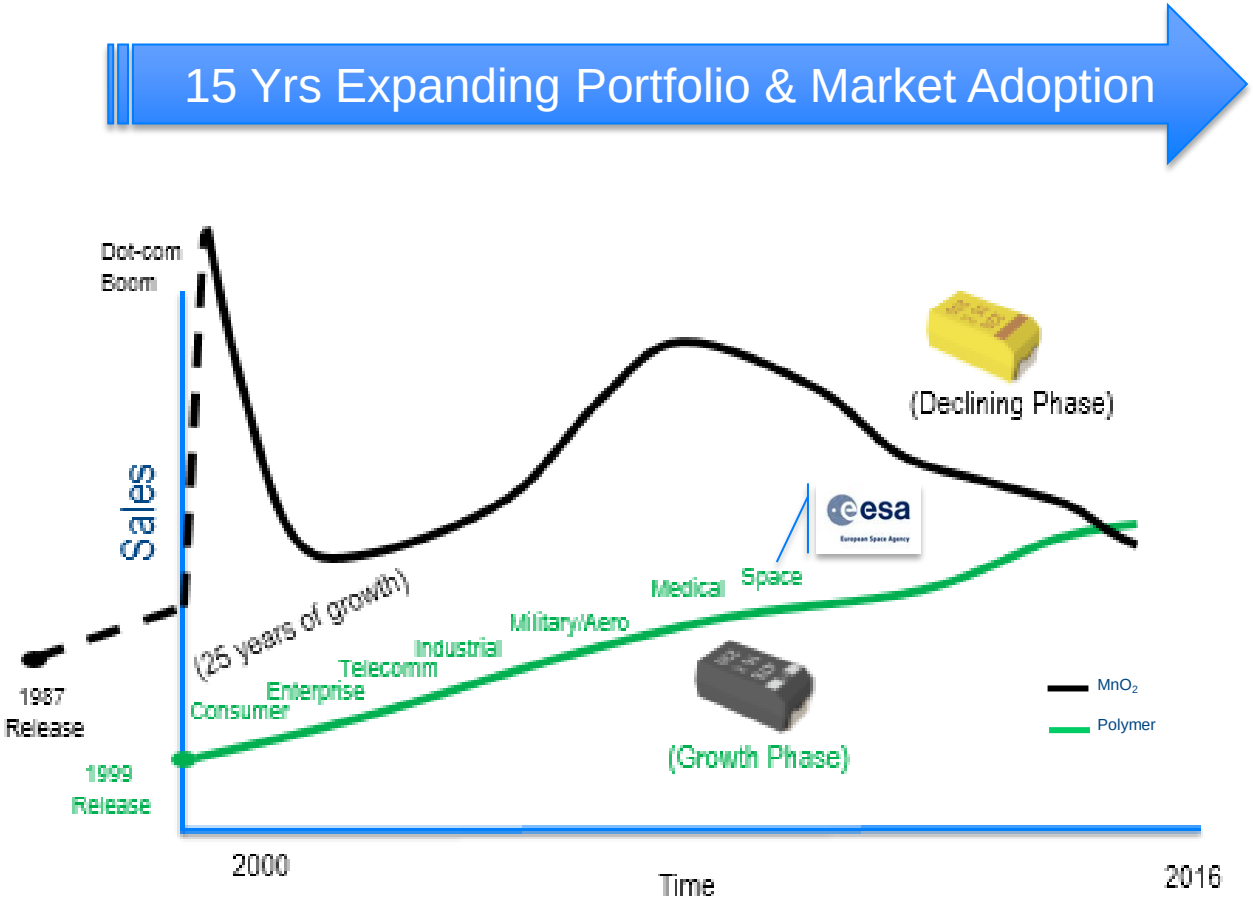
2nd SPCD 2016, International Symposium

Ta SMD cap MnO_2 & KO for Space Apps
Outline

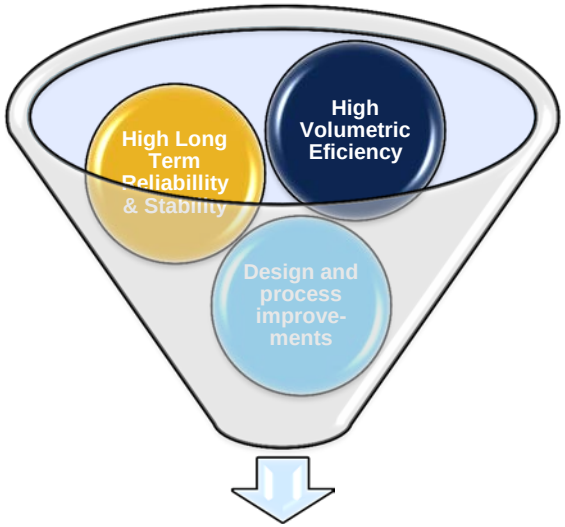


- Historical Bakckground
- Basic Construction
- KEMET Évora Capabilities
- Pros & Cons of both technologies
- Polymer project evolution
  - Low Voltage applications
  - High Voltage applications
- MnO_2 project evolution
- Path Forward

Ta SMD cap MnO_2 & KO for Space Apps
Historical Background



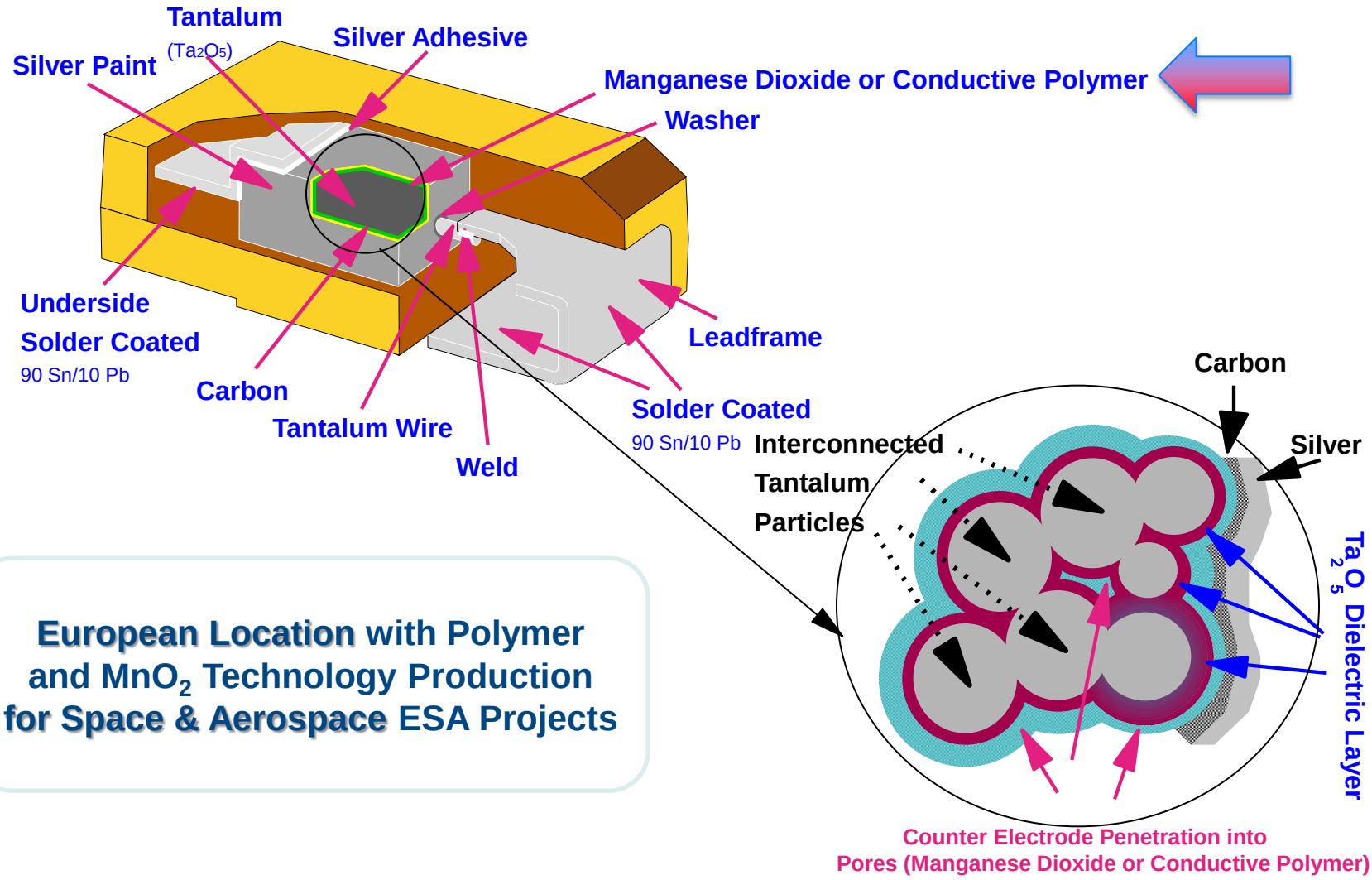
Historical Segment Adoption and Sales Evolution – Ta SMD Capacitors MnO_2 and Polymer.



Increased Flexibility in Electronics Design

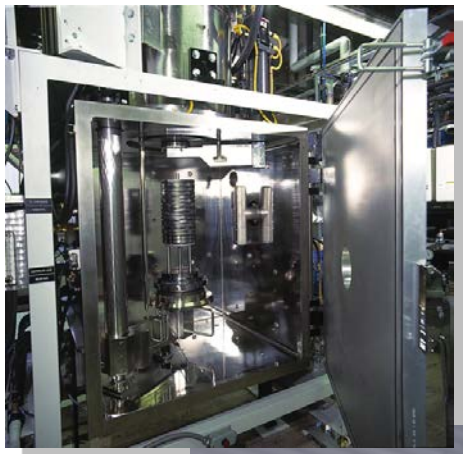
Evolution form terrestrial to Space Applications

Ta SMD cap MnO_2 & KO for Space Apps
Basic Construction



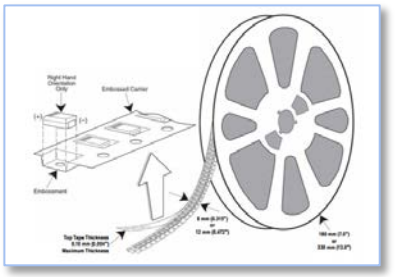
European Location with Polymer and MnO_2 Technology Production for Space & Aerospace ESA Projects

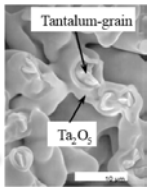
Ta SMD cap MnO_2 & KO for Space Apps
Basic Construction

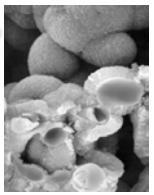


Sintering

Molding

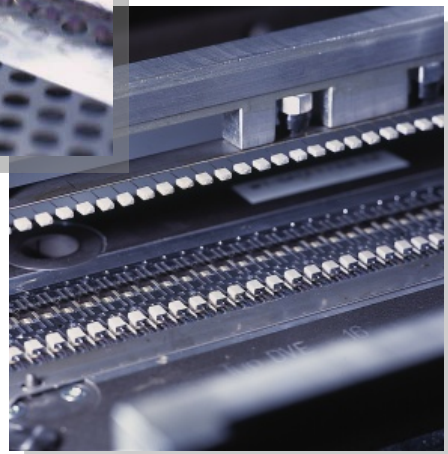




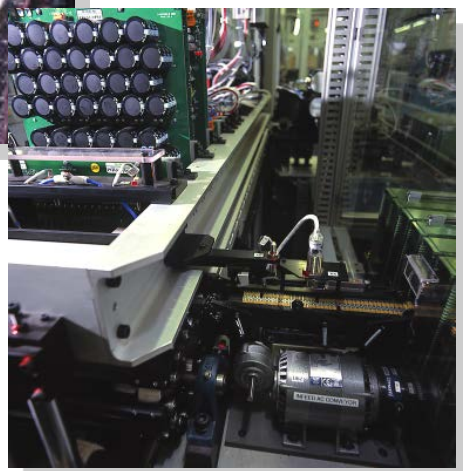


Electro-Chemical Processes

Aging



Assembly



100% Testing

Ta SMD cap MnO_2 & KO for Space Apps
KEMET Évora Capabilities

'***Laboratory Capabilities***'
Significant Investment from KEMET to implement an European Specialty Footprint and needed capability for in-line and Laboratory processes:

- ✓ **RCT;**
- ✓ **Radiographic Inspection**
- ✓ **Surge Current Testing**
- ✓ **Weibull**
- ✓ **Burn-in**
- ✓ **Marking/Serialization**

Life Testing capability
(Endurance, Humidity Chambers, Characterization in temperature and frequency);

Failure analysis Laboratory

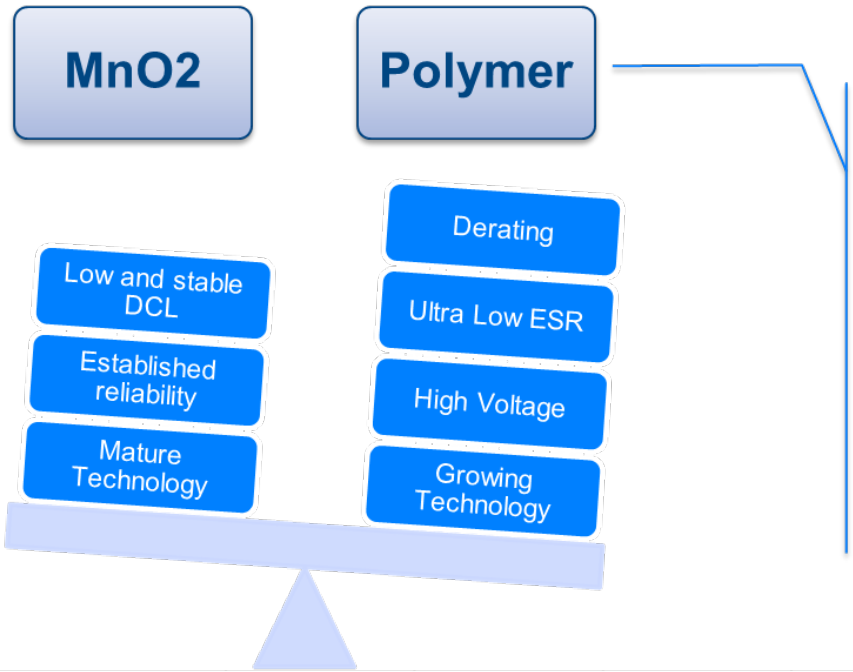
Well established Chemistry Lab

Highly Qualified Staff!

Ta SMD cap MnO_2 & KO for Space Apps

Pros & Cons of both technologies

Electronic Components KEMET CHARGED.

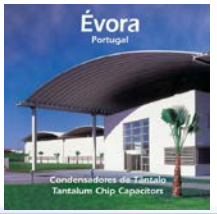


Successful where:

- Consumer
- Cloud infrastructure
- Screens that Connect
- Transportation
- Military & Aerospace

	Cap.	DCL	ESR	Derating	I Ripple	Failure mode	Cap. Stability
MnO2	**Excellent Volumentric efficiency**	**Low and stable DCL**	**Medium/ High** (0.1 up to Ohms level)	***50%** * FTECH/SBDS	**-**	**-**	**Over temperature and frequency**
Polymer	**Excellent Volumentric efficiency**	**Stable DCL** (higher than MnO2)	**Ultra Low** (Down to single digit)	**10% up to 10V 20% higher than 10V**	**Good capability**	**Benigne Failure mode**	**Over temperature and frequency**

Ta SMD cap MnO_2 & KO for Space Apps
Polymer project Evolution



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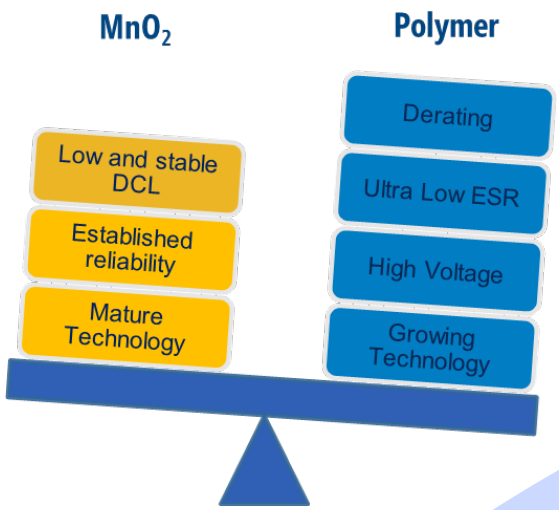


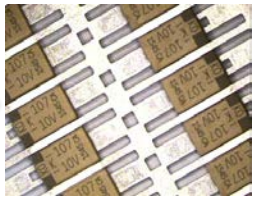
2012
WP1- Preparatory Evaluation

2013
WP2 - Samples Manufcturing

2013/14
WP3 - ETP

2015
Low Voltage – EPPL Aplication
Detail spec: ESCC 3012/005

2015
Extended Range High Voltage Sample Manufacturing



Samples Low Voltage Nov 2015!

Mar 2016
WP4 – ETP High Voltage Roadmap for KEMET T583 Series

Capacitance C_n (µF)	Rated Voltage U_R		
	6.3V	10V	16V
33			60, 70
47			70
68		45, 60, 100	
100	45	55, 80	
150	45, 55		

KOCAP Polymer Capacitors

Ta SMD cap MnO_2 & KO for Space Apps

KO – Low Voltage (LV) Applications

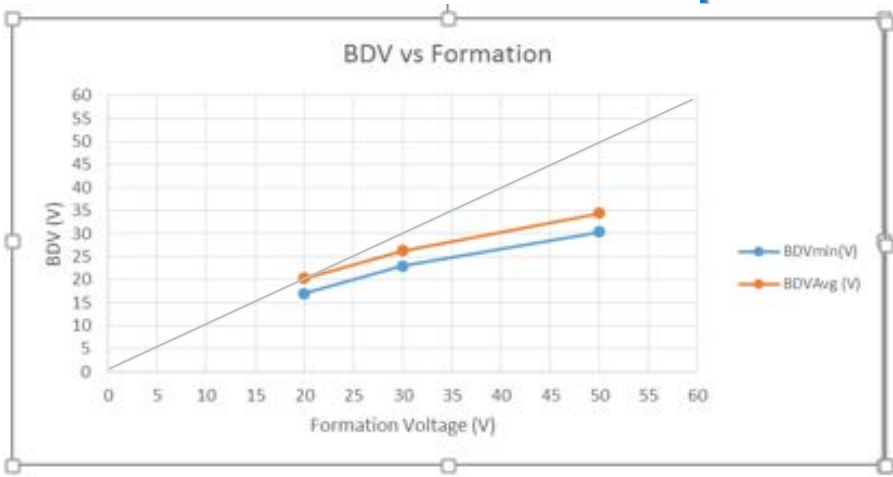
Capacitance C_n (µF)	Rated Voltage U_R		
	6.3V	10V	16V
33			60, 70
47			70
68		45, 60, 100	
100	45	55, 80	
150	45, 55		

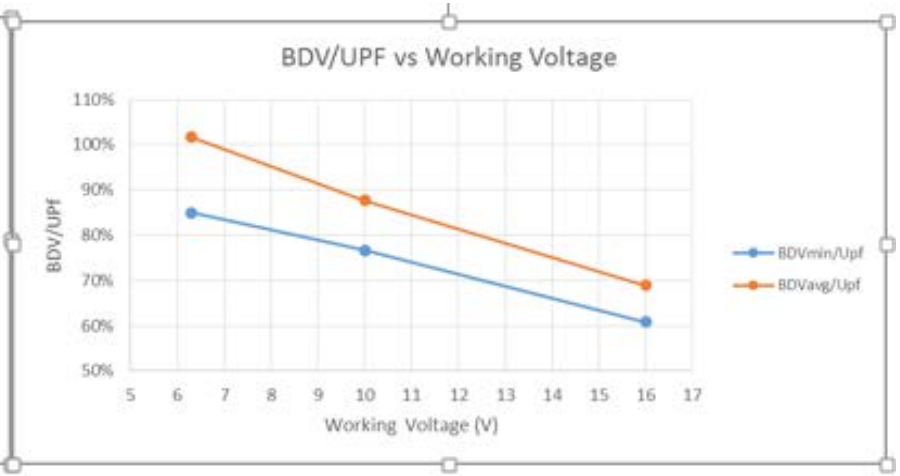
Selected representative corner types for 6.3, 10 and 16V

Evaluation Test Program:

TEST Nr	Evaluation Test Program Test Description	Precedence	Status
2Bi	Voltage Step Stress Test (VSST)	---	OK
2Bii	Temperature Step Stress Test (TSST)	2Bi	OK
2Biii	High Inrush Current Step Stress Test (SSST)	---	PASS
2Ci	Solderability / Adhesion	---	PASS
2Cii	Solderability /Humidity Sequence	---	PASS
2Cii	Moisture Resistance	---	PASS
3	Steady State Accelerate Life Test (T1/V1, T2/V2, T3/V3)	2Bi/ 2Bii	PASS
4	Operational Life Tests	---	PASS
5	Storage	---	PASS

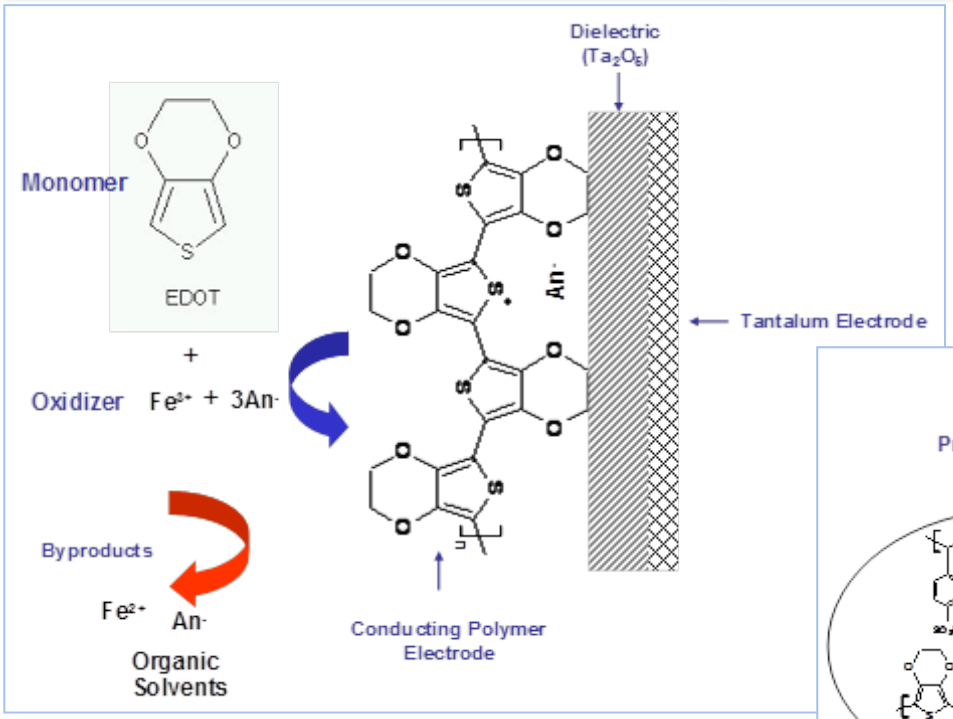
BDV behavior for "In-Situ" process:

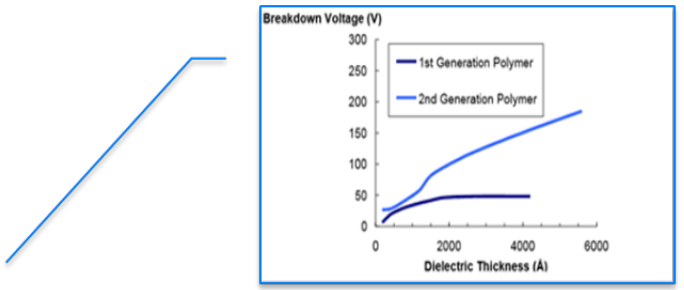


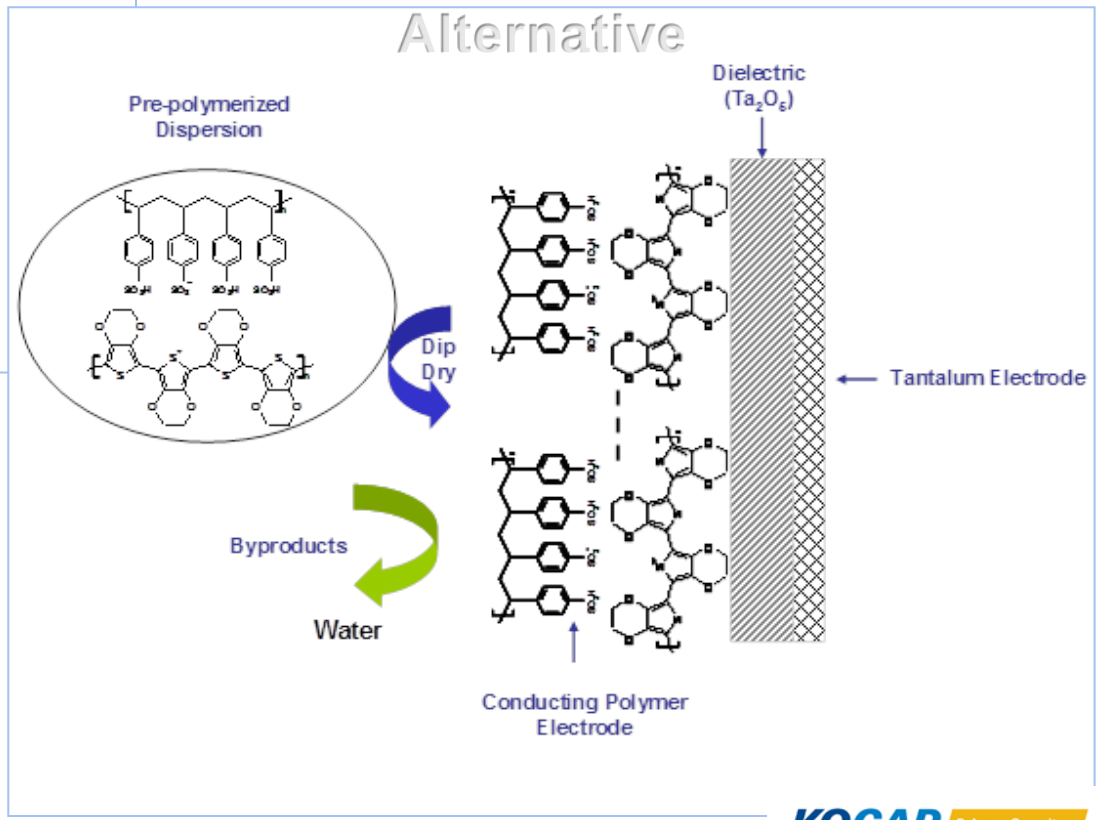


Ta SMD cap MnO_2 & KO for Space Apps

KO – Polymerization mechanisms



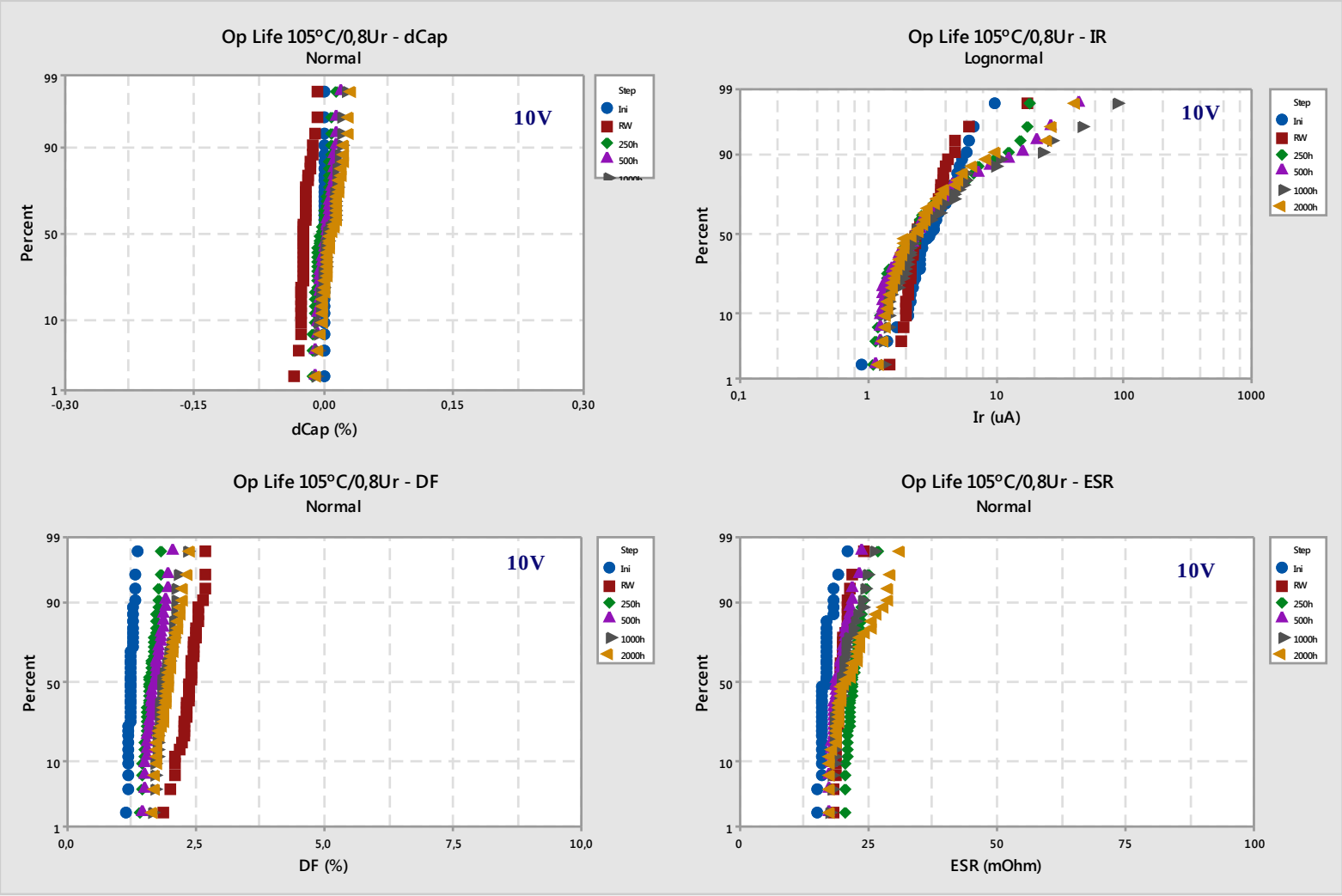




Residuals from the reaction can cause surface charge at the interface between the dielectric and the polymer affecting the potential barrier => High DC leakage and low BDV.

Ta SMD cap MnO_2 & KO for Space Apps

KO LV– Endurance Testing 105ºC/0.8*Ur 2000hrs

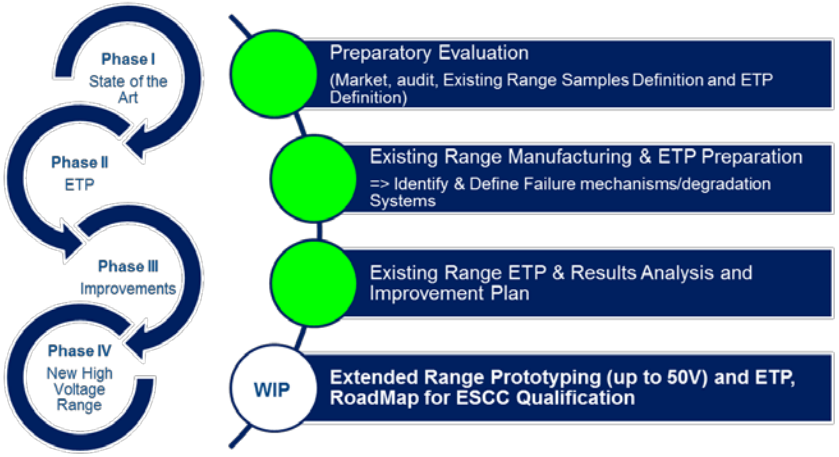


Example of Op Life Results for 105ºC/0,Ur 2000hrs for a 10V Application Capacitor

Ta SMD cap MnO_2 & KO for Space Apps

KO – High Voltage (HV) Applications

Develop a very Low ESR and High Voltage (50V) Ta SMD Cap in Europe for Space Aplications



Cap	Rated Voltage 16	20	25	35	50	63
6,8						
10					D (125mΩ)	
15			D	D (100mΩ)		
22		D	D			
33		D	D (100mΩ)			
47		D				
68						

Legend:
Corners — Parts submitted for ETP testing
Sister part types

Evaluation Test Program:

25V 35V 50V

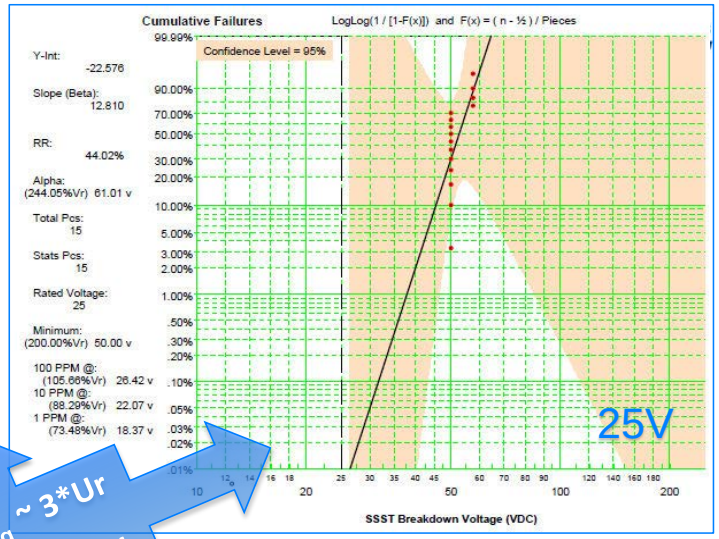
TEST Nr	Evaluation Test Program Test Description	Precedence	Status
2A	Thermal Shock	---	PASS
2Bi	Voltage Step Stress Test (VSST)	---	OK
2Bii	Temperature Step Stress Test (TSST)	2Bi	On-Going
2Biii	High Inrush Current Step Stress Test (SSST)	---	PASS
2Cii	Moisture Resistance	---	PASS
3	Steady State Accelerate Life Test (T1/V1, T2/V2, T3/V3)	2Bi/ 2Bii	Not Started
4	Operational Life Tests	---	Not Started
5	Storage	---	Not Started

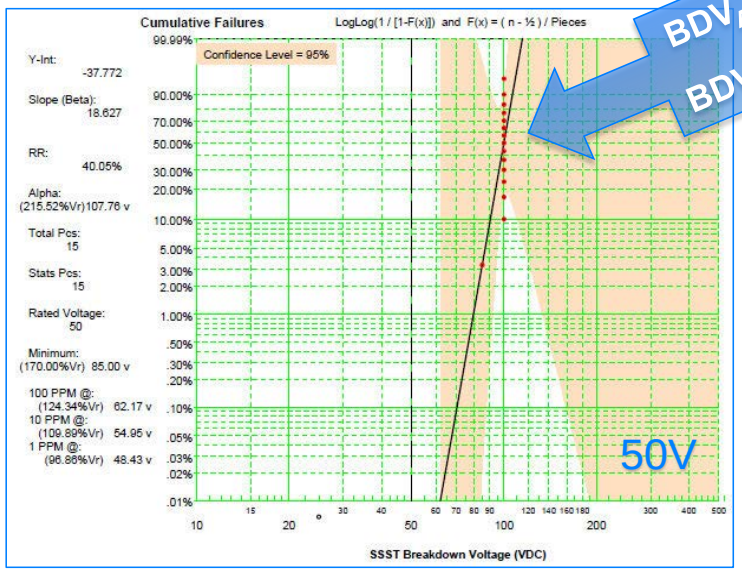
Ta SMD cap MnO_2 & KO for Space Apps

KO HV – Surge Step Stress Test (SSST)

Reliablity

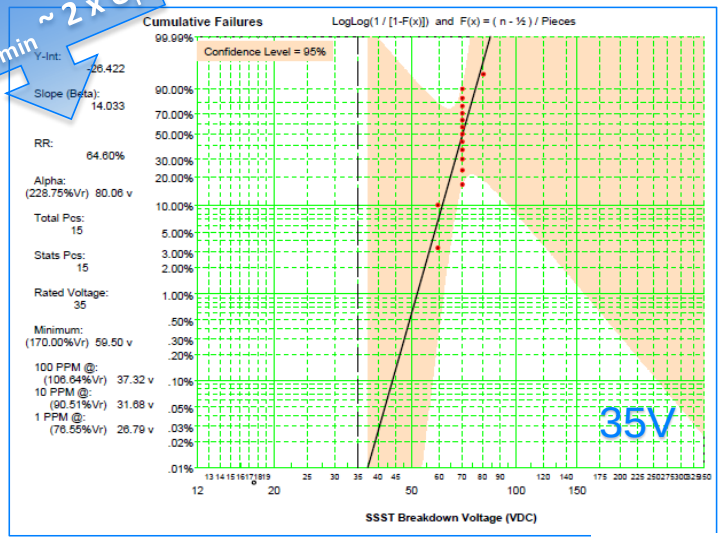
BDV behavior weakness overcome for High Voltage, keeping in line with Low Voltage!





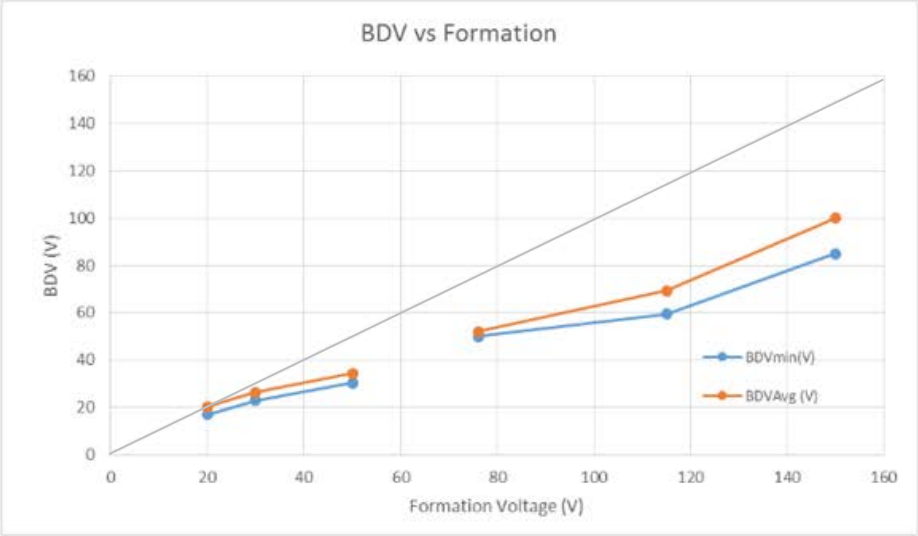
BDV_{Avg} ~ 3*Ur

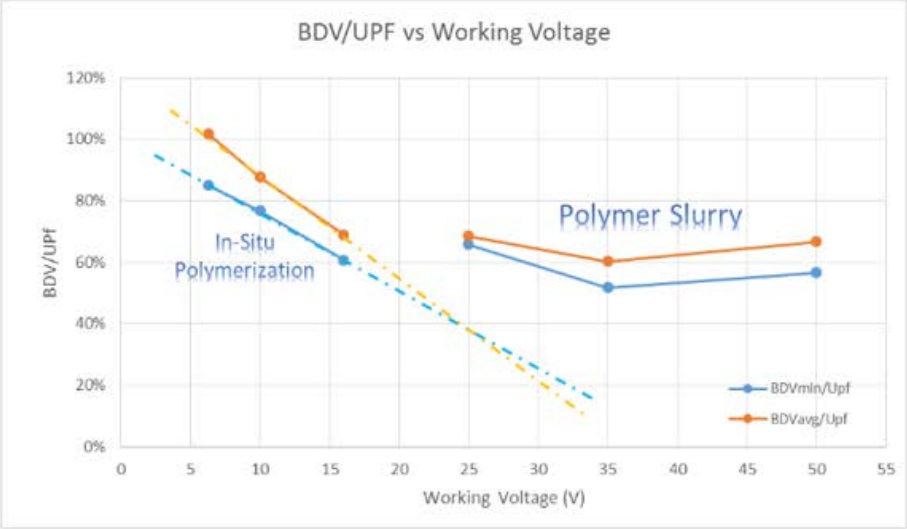
BDV_{min} ~ 2 x U_r



Ta SMD cap MnO_2 & KO for Space Apps
KO HV – 2nd Generation Process

BDV behavior for 2nd generation process:





The new hybrid allowed the reduction of the number of local chemical reactions, and consequent defect sites, improving the interface quality between the coating and dielectric

BDV Stabilized and descending behavior overcome => Higher voltages application!

Ta SMD cap MnO_2 & KO for Space Apps

MnO_2 @ 150ºC Project Evolution

Target Product Offering:

V_R (V DC)	4	6.3	10	16	20	25	35	50
C_R (µF)								
0.1							A	A
0.15							A	B
0.22							A	B
0.33							A	B
0.47						A	A B	C
0.68					A	A	A B	C
1				A	A	A	B	C
1.5			A	A	A	B	B C	D
2.2		A	A	A B	B	B	B C	D
3.3	A	A	A	A B	B	B C	C	D
4.7	A	A	A B	B	B C	C	C D	D
6.8	A	A B	B	B C	C	C D	D	X
10	A B	B	B C	C	C	C D	D	X
15	B	B C	C	C	C D	D	D	
22	B C	C	C	C D	D	D	X	
33	C	C	C D	C D	D	X		
47	C D	C D	D	D	X	X		
68	C D	D	D	D	X			
100	D	D	D	X				
150	D	D	D X	X				
220	D	X	X					
330	X							

2012
Kick-Off

Dec 2014
Samples Manufacturing & Evaluation

2015
Component Evaluation

2016
Samples Manufacturing for Qualification

2017
Qualification & EQPL entry

KEMET T483 Series

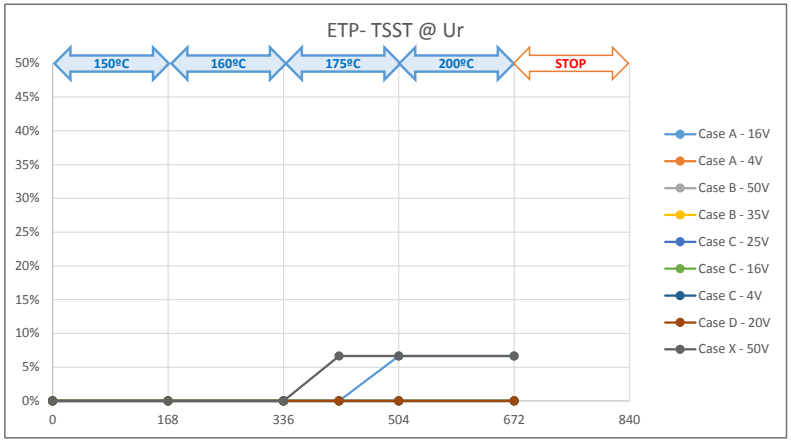
Ta SMD cap MnO_2 & KO for Space Apps

MnO_2 @ 150ºC - Project Evolution

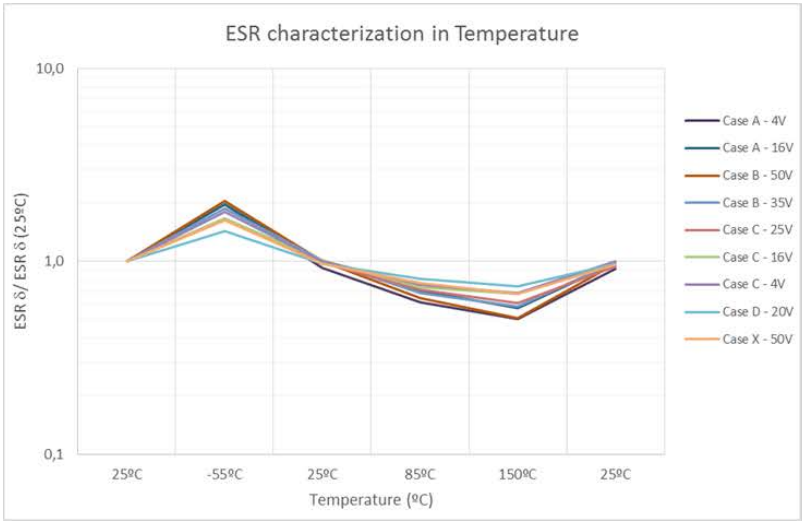
Evaluation Test Program:

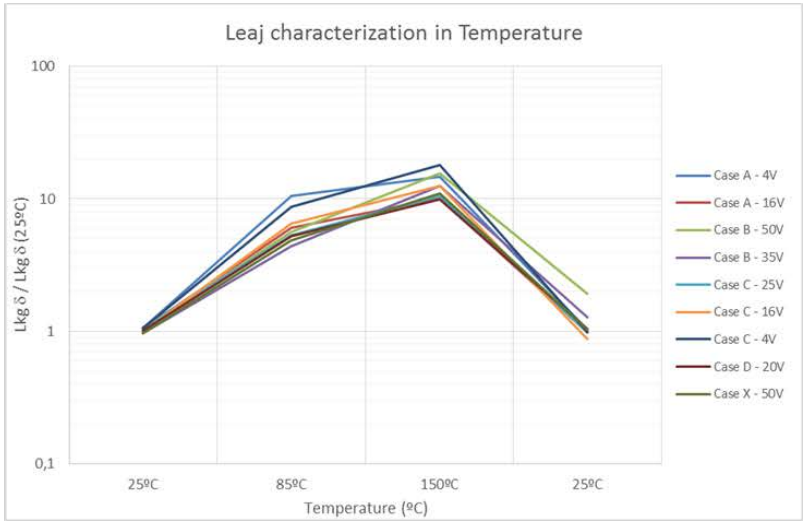
TEST Nr	Evaluation Test Program Test Description	Precedence	Status
2A	Thermal Shock	---	PASS
2Bi	Voltage Step Stress Test @ 150ºC (VSST)	---	OK
2Bii	Temperature Step Stress Test @ Ur (TSST)	2Bi	OK
2Biii	High Inrush Current Step Stress Test (SSST)	---	PASS
2Ci	Solderabilty/ Adhesion	---	Not Started
2Cii	Solderabilty/ Humidy Sequence	---	PASS
3	Steady State Accelerate Life Test (T1/V1, T2/V2, T3/V3)	2Bi/ 2Bii	Not Started
4	Operational Life Tests (@ 85ºC/ 150ºC)	---	Not Started
5	Storage @ 150ºC	---	Not Started

Temperature Stress Step Test:

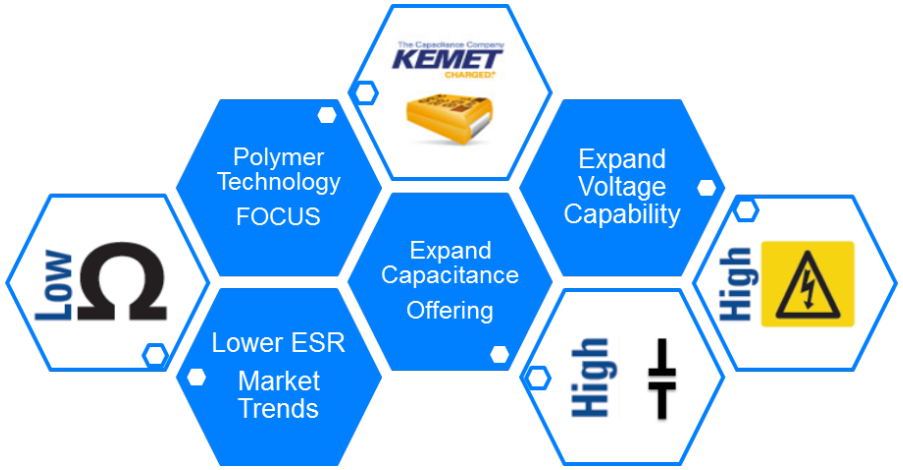


Temperature Stability from 4V->50V:





Ta SMD cap MnO_2 & KO for Space Apps
Path Forward



- Complete the ESA QPL for T583 KO Low Voltage Series
- Finish ESA ETP for the T583 KO High Voltage Series and apply to EPPL-part2
- Complete ESA ETP for T483 MnO_2 150ºC max op.Temperature
- Pursue space market trends and apply to new projects...

KEMET will continue its development efforts qualifying components of SMD Tantalum technology for Space applications with increasing harsh environmental conditions!

Thank You!

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Évora - Portugal
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