AVX BME X7R Capacitors for Space

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QPL BME Capacitors for Space/Mil Applications

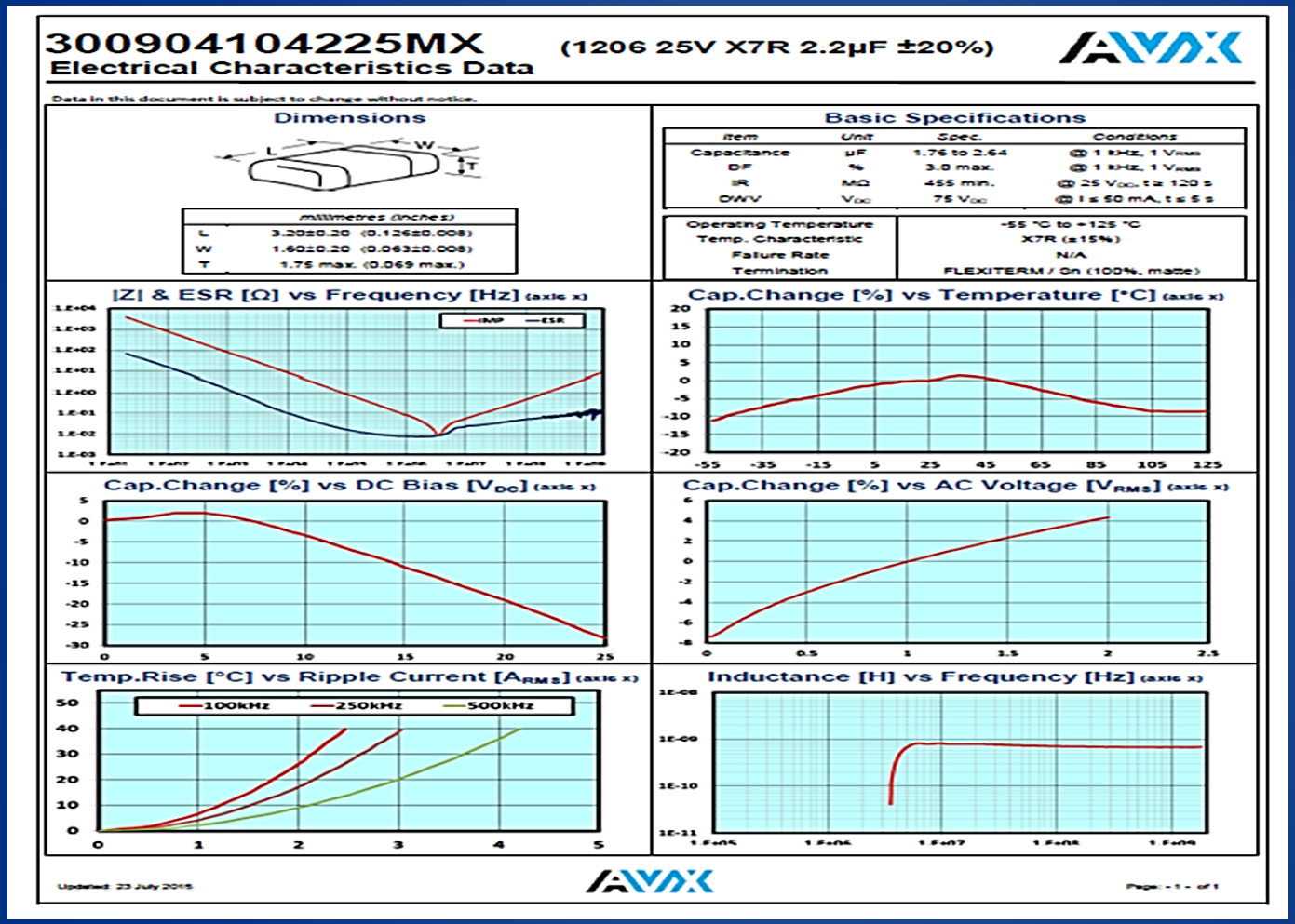
Contents

- BME Capacitors for Space / Military – Reliability and Performance data.
- Space grade BME Capacitor Structure and Micro-sectional analysis
- BME planned developments and opportunities
- Conclusion

Space / Military – Reliability and Performance data

- **Space and Military Grade BME QPL parts**
  - *Select Hi CV materials* with a proven quality - reliability heritage in field performance (Normally >= 5 years history required)
  - *Conservative designs* – no changes allowed once qualified/approved
  - *Stable electrical parameters* - (ESR, VC, TC, VBD etc)
  - *Controlled Material and Process* - restricted by ESCC PID controls
  - *External qualification requirements* - ESCC, NASA, Mil approvals needed plus Audit systems
  - *100% Acoustic Microscopy* Inspection
  - *100% Burn In* with defined failure levels
  - Lot C of C/Data packs

Space Electrical Characteristics Data
Stable as Material and Design rules are defined in PID



300904104225MX (1206 25V X7R 2.2µF ±20%)

Electrical Characteristics Data

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Data in this document is subject to change without notice.

Dimensions

	millimetres (inches)
L	3.20±0.20 (0.126±0.008)
W	1.60±0.20 (0.063±0.008)
T	1.75 max. (0.069 max.)

Basic Specifications

Item	Unit	Spec.	Conditions
Capacitance	µF	1.76 to 2.64	@ 1 kHz, 1 V_{rms}
DF	%	3.0 max.	@ 1 kHz, 1 V_{rms}
IR	MΩ	455 min.	@ 25 V_{DC}, t ≥ 120 s
DWV	V_{DC}	75 V_{DC}	@ I ≤ 50 mA, t ≤ 5 s

Operating Temperature	-55 °C to +125 °C
Temp. Characteristic	X7R (±15%)
Failure Rate	N/A
Termination	FLEXITERM / Sn (100%, matte)

Updated: 23 July 2015

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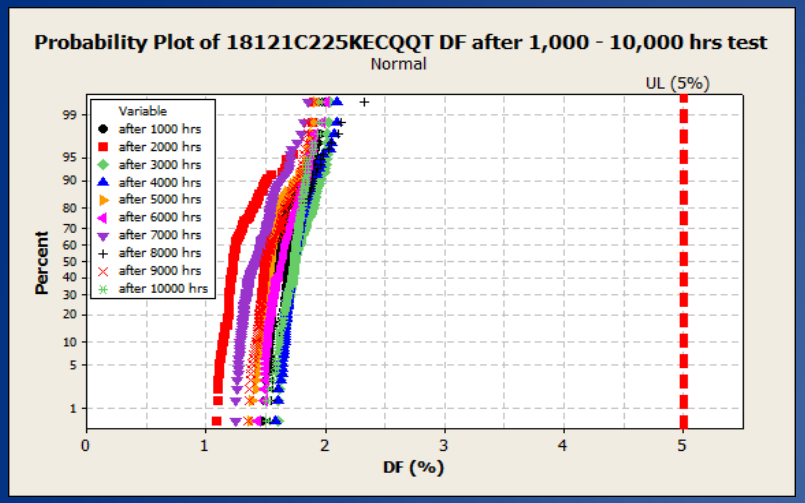
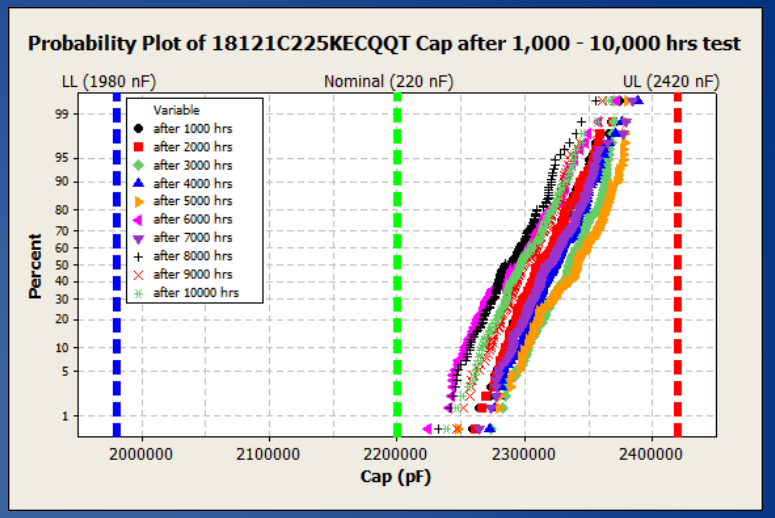
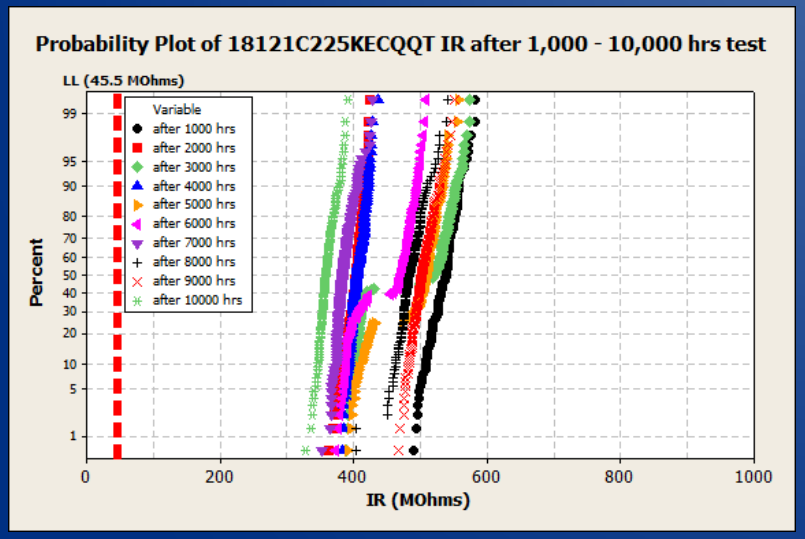
Long Term Standard Life Testing 10,000hrs for Aerospace Corp .

	Life Testing 2 x Rated Voltage @ 125 Deg C . Sample Size 125 pcs									
AVX Part number	1,000 Hrs	2,000 Hrs	3,000 Hrs	4,000 Hrs	5,000 Hrs	6,000 Hrs	7,000 Hrs	8,000 Hrs	9,000 Hrs	10,000 Hrs
18123C825K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
06033C184K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
12105C105K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
12065C105K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
08051C104K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
18121C225K	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

Long Term Life 10,000 hr Parametric Data
1812 100V 2.2uF







DPA section Space BME 1812 100v 2.2uF

131 Active Layers @ 18um per layer (Unfired)

High Acceleration Life Testing, HALT

- A number of BME part numbers have been tested on a HALT system to calculate the field life time by determining the Voltage exponent, N , and the Energy of Activation, Ea.

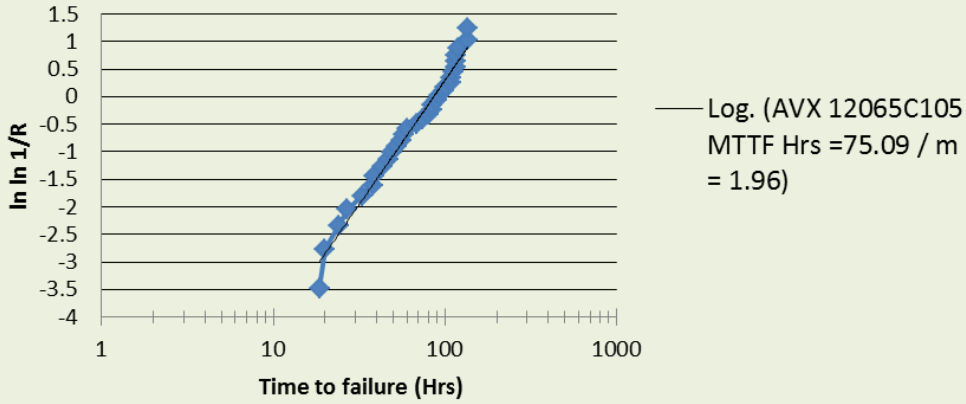
Part Number	Conditions		
12065C105	270 Volts 150 Deg C	285 Volts 150 Deg C	290 Volts 150 Deg C
12065C105	250 Volts 150 Deg C	250 Volts 155 Deg C	250 Volts 165 Deg C
12105C105	365 Volts 150 Deg C	370 Volts 150 Deg C	380 Volts 150 Deg C
12105C105	350 Volts 150 Deg C	350 Volts 155 Deg C	350 Volts 165 Deg C

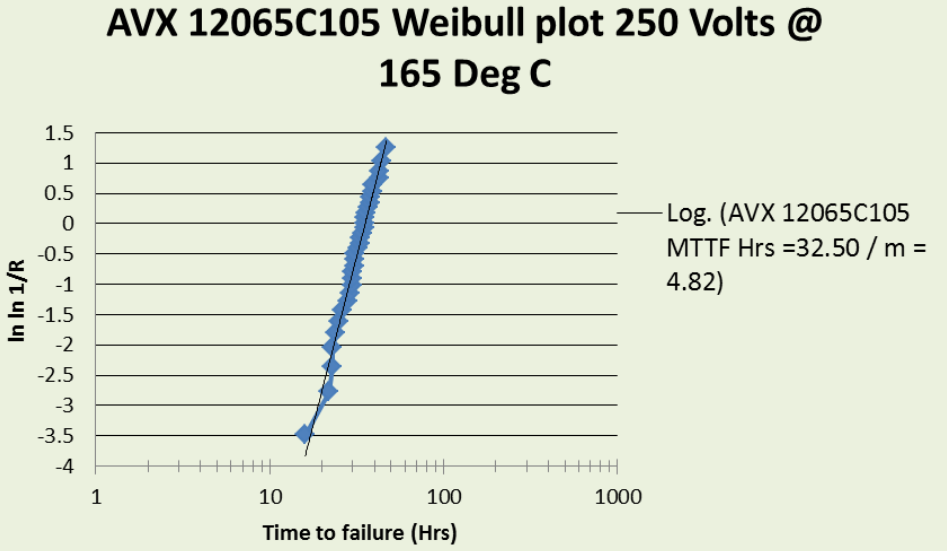
Acceleration Factors

The acceleration model used was the Propokowice and Vaskas, P – V model

Part number	Voltage Exponent	Energy of activation	MTTF (Yrs) 85 Deg C 1 x RV	MTTF (Yrs) 85 Deg C 0.5 x RV	MTTF (Yrs) 125 Deg C 0.5 x RV
12105C105	8.17	1.17	4.40E+06	1.27E+09	2.79E+07

HALT WEIBULL PLOTS





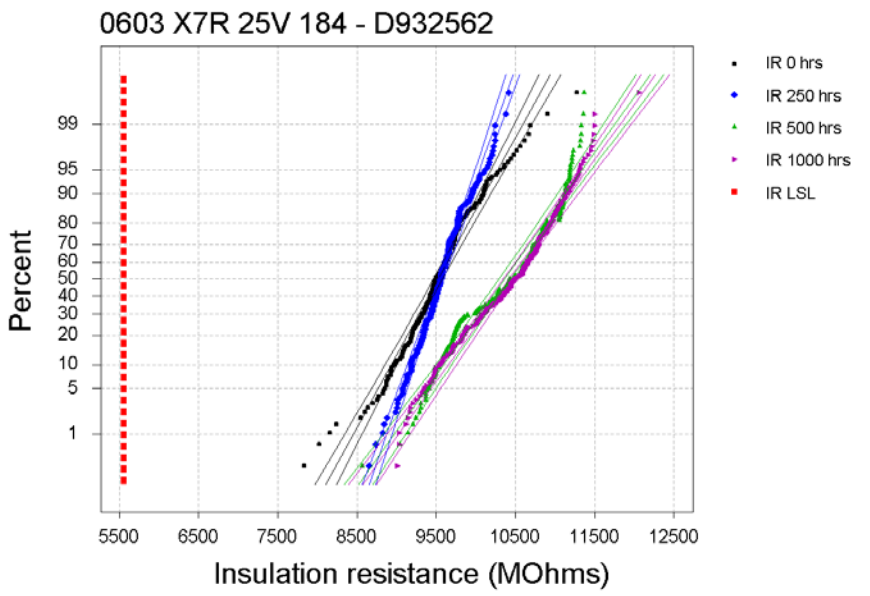
AVX Reliability on Space Level BME

Life testing at increased sample size and test voltage 3 X RV.
Large sample size, Military and Space
typically would be 40-120 pcs per part #

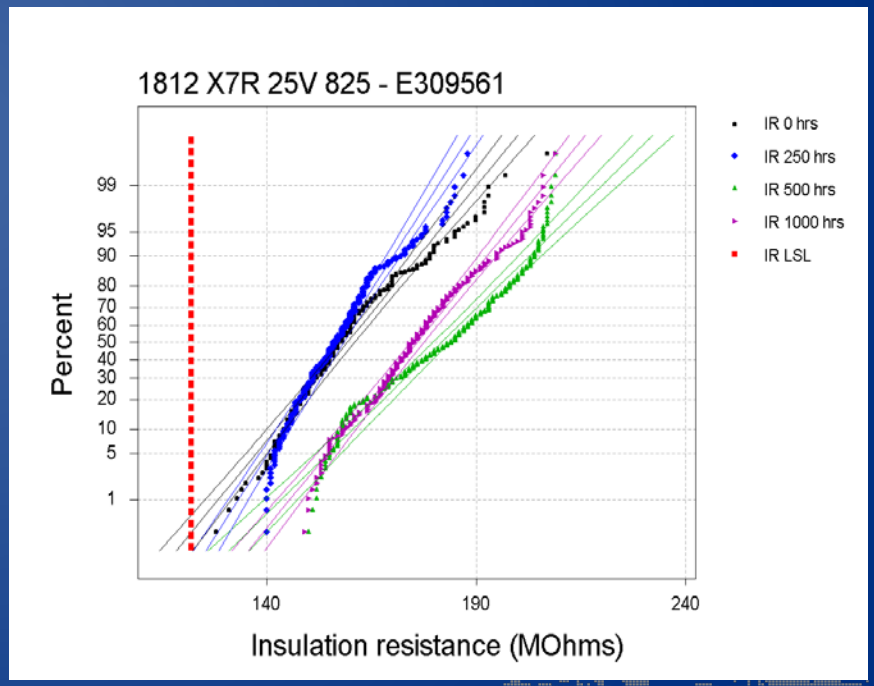
Part #	Capacitance (uF)	Rated Voltage (Vdc)	Fired Dielectric Thickness (microns)	Pcs on Life Test	Life Test Voltage (Vdc)	Life Test at 3X, 125°C		
						250 hrs	500 hrs	1,000 hrs
06033C184	0.18	25	6.0 - 6.5	500	75	0 / 500	0 / 500	0 / 500
18123C825	8.2	25	6.5 - 7.5	500	75	0 / 500	0 / 500	0 / 500

Accelerated 125°C Life Testing done at 3X rated,
rather than Military and Space standard of 2X

Reliability on Space Level BME @ 3 x rated voltage to 1000hrs "Insulation Resistance" parametric data



0603 180nF - no IR degradation seen after 1000hrs at 3X rated, 125°C Life Testing



1812 8.2uF - no IR degradation seen after 1000hrs at 3X rated, 125°C Life Testing

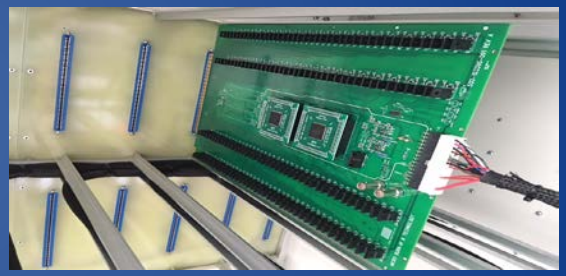
Space and Military High Reliability Screening Systems
BME and PME Screening

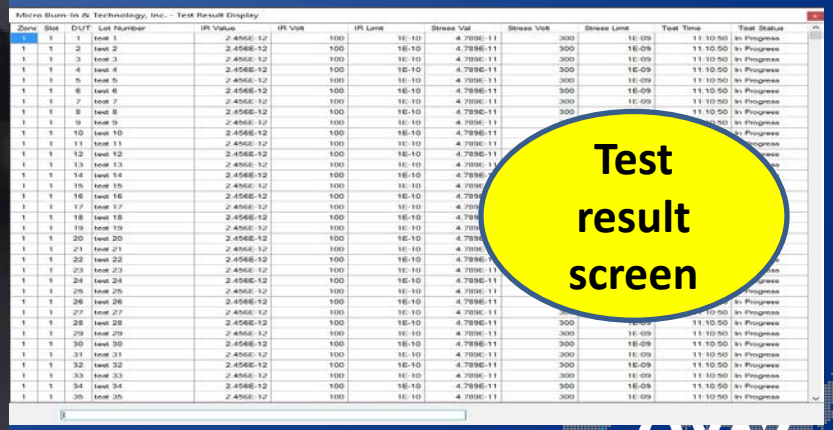
100% Sonoscan → **NASA & Mil**

100% Burn In → **ESA ,NASA & Mil**

New Burn in System with “ live “ monitored IR

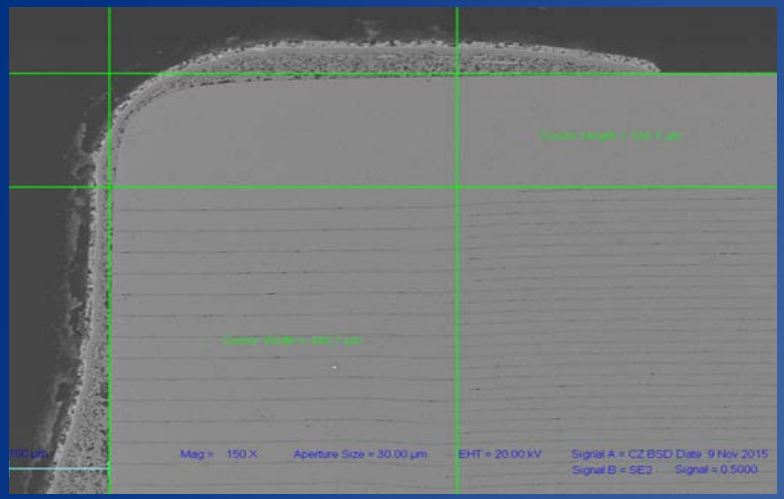
Scanner board

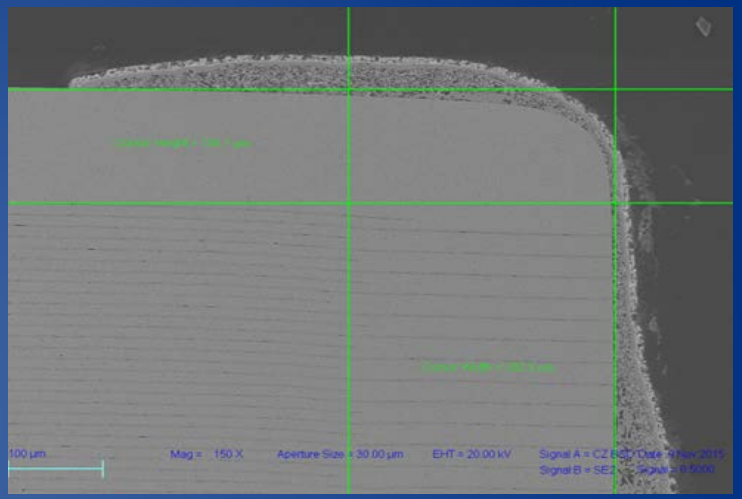




Test result screen

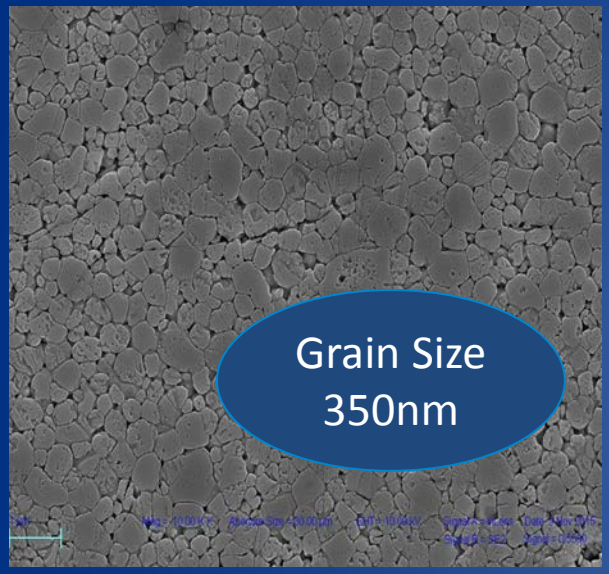
Space – Military Grade Design 1210 50V 1uF Part SEM and Images





SIZE 1210	Dielectric Thickness	Cover Layer Thickness	Side Margin	End Margin
Average (microns)	11.14	152.63	194.37	310.84
Specification NASA >=	7.112	40.64	25.4	40.64
	PASS	PASS	PASS	PASS

Space – Military Grade design 1210 50V 1uF part SEM and Image for Grain Size Calulation



3.2.1.6 Average Grain Size: Capacitors shall be measured for average grain size as specified in paragraph 4.4.2.

3.2.2 BME Capacitor Acceptance Criterion. Capacitor samples, processed as specified in paragraphs 4.4.1 and 4.4.2 herein and meeting the requirements of paragraph 3.2.1 herein, shall meet Equation 1 as shown below:

$$F_t = 1 - R_t = 1 - \left[1 - \left(\frac{\bar{r}}{d}\right)^{\alpha}\right]^{N} < 0.00001 \quad \text{Equation 1}$$

Where $\bar{r}$ is the measured average grain size, d is the average dielectric thickness, N is the total number of dielectric layers, $\alpha = 5$ for capacitors rated voltage > 100V and $\alpha=6$ for capacitors rated voltage $\leq$ 100V.

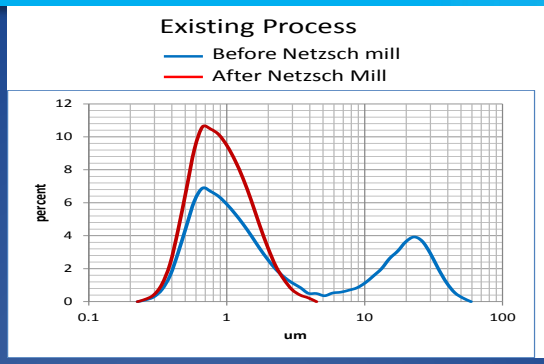
Size 1210				r	N	d				
Inter-sections 5 samples	S Ave	Scale	Grain ave	r ave	Layers	Diel .Thick	d ave	r ave / d ave	(r/d) power alpha	1-(r/d)power α
25	22.6	0.4	0.3539	0.3539	90	11.14	11.14	0.031776	0.000000001029385726571	0.9999999897061400000
22		alpha α								[1-(r/d)power α]powerN
20		6								0.999999907355292000000000000000
23										1- [[1-(r/d)power α]powerN]
23										0.000000092644707794242700000000
									NASA Spec. Compliant	TRUE

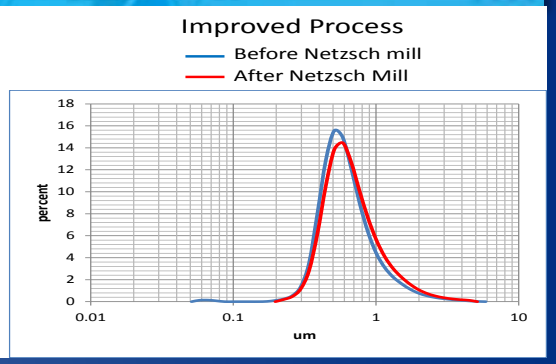
Material and Design Features for BME/PME X7R Space Grade <=100V

	Commercial	PME Space	BME Space
Materials	Multiple Ceramics, / Ni Electrodes . No Sn/Pb, Supply chain control ?	Single Ceramic / Pd/Ag Electrode . No Change	Single Ceramic / Ni Electrode . No change
Design Range	Layers ≤ 800 , Dielectric Thickness 1 – 15 um ,	Layer ≤ 200 , Dielectric Thickness ≥ 25 um	Layer ≤ 300 , Dielectric Thickness 7 um - 18 um
Margin Cover	Small as possible ≥ 50 um	Thickness ≥ 100 um , Large as possible	Thickness ≥ 100 um , Large as possible
Voltage	4 – 100 v	Greater than 25 v	Current Range 16 – 100 volts
QA	Random Sampling , 3rd Party suppliers	As per ESCC , 100 % Burn in , PID control, PDA limits	As per ESCC , 100 % Burn in , PID control, PDA limits

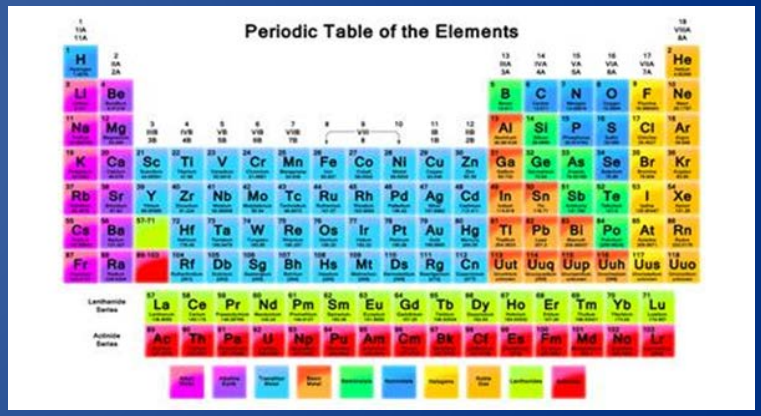
New Products BME : Enabling Technology

- Dispersion Technology
- Zeta Mill

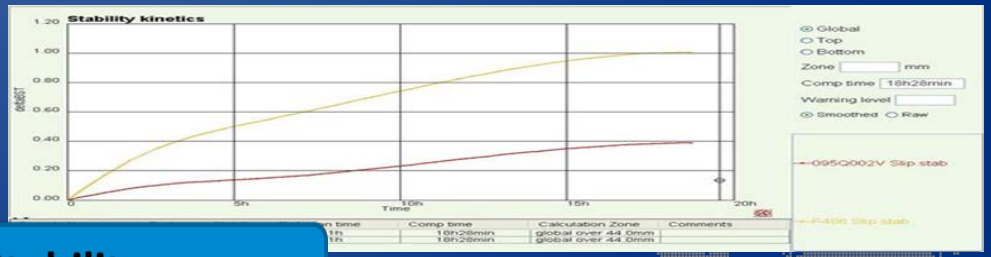




- Fundamental Studies of Dopants
- Dy, Y, Yb, Hf, Tb, Sm, Ho, Er, Gd
- Reliability, Breakdown voltage, K



- BT Coatings
- Analytical



- High Temp EIS, Activation Energy, Slip Stability

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BME Material Development
Collaboration on STEM Analysis with Aerospace Corp

AEROSPACE
Assuring Space Mission Success

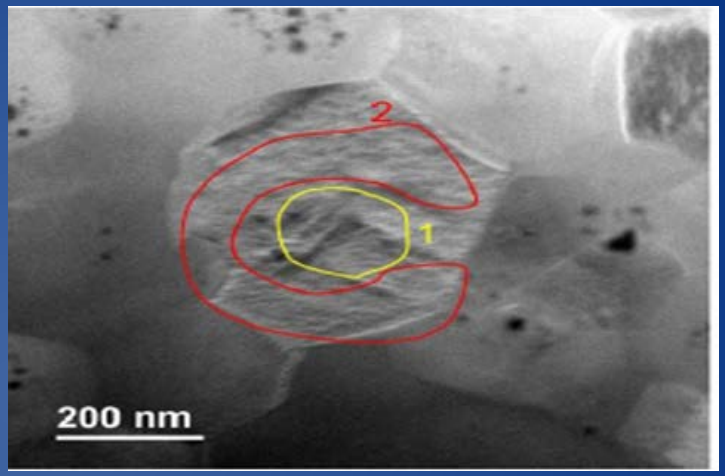
High Sensitivity / Sensitive but Unclassified (SBU) / Contains AVX Proprietary Information

Chemical Analysis (TEM/EDS) on Base metal Electrode Multilayer Ceramic Capacitors (BME MLCCs) manufactured by AVX Corp.

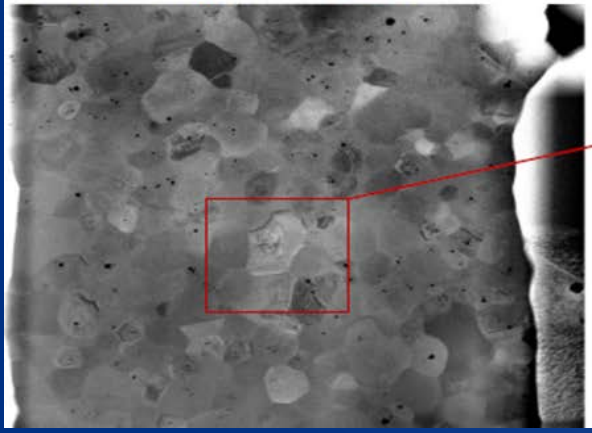
Talin Ayvazian, Zachary Lingley, Miles Brodie and Brendan Foran

Electronic Materials and Devices Section
Physical Sciences Laboratory / ETG
March 10th , 2015

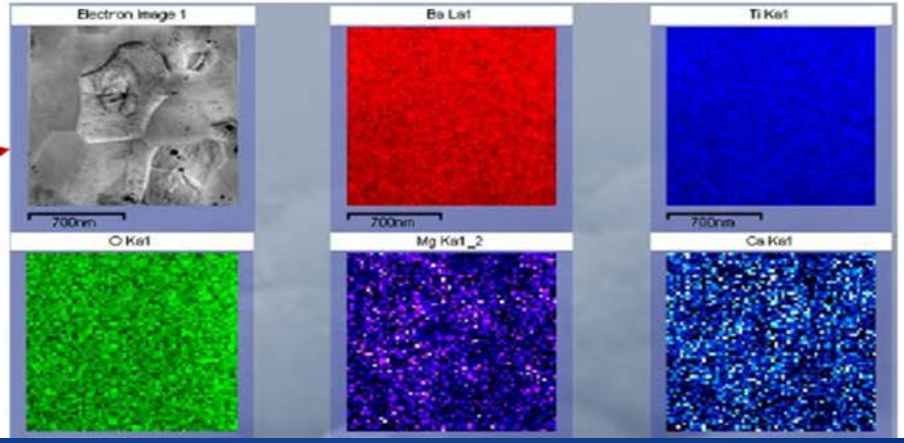
EDS spectrum compares chemical composition of core (1) and shell (2) regions.



STEM image of AVX_Lot 7



Chemical mapping (EDS) of AVX_lot 7



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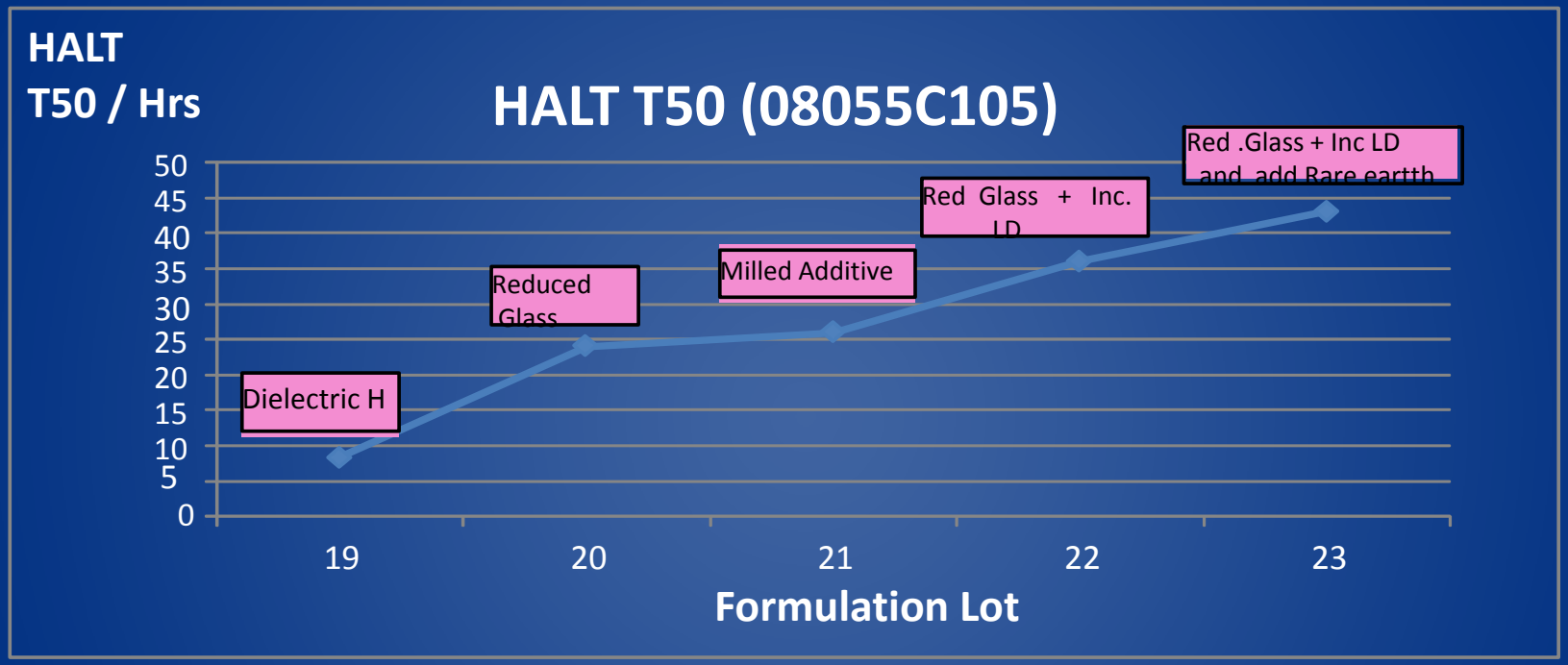
Material contributors to improving the HALT Performance for Hi CV range extension



- Lower Glass enabled 50V qualification @ 6.5um dielectric thickness
- 4 x Fold Improvement in HALT for Dielectric H formulation achieved by
  - Increased Laydown
  - Pre Milling the additives
  - Adding/Increasing the rare earth %

AVX QPL 3009041 BME X7R Capacitor Range with Development ranges

Case Sizes		0402			0603			0805			1206			1210			1812			2220		
Code	Value	16/25v	50v	100v	16/ 25v	50v	100v	16/25v	50v	100v	16/25v	50v	100v	16/25v	50v	100v	16/ 25v	50v	100v	16/ 25v	50v	100v
222	2.2nf																					
272	2.7nf																					
332	3.3nf																					
392	3.9nf																					
472	4.7nt																					
562	5.6nf																					
682	6.8nf																					
822	8.2nf																					
103	10nf																					
123	12nt																					
153	15nf																					
183	18nf																					
223	22nf																					
273	27nf																					
333	33nt																					
393	39nf																					
473	47nf																					
563	56nf																					
683	68nf																					
823	82nt																					
104	100nf																					
124	120nf																					
154	150nt																					
184	180nf																					
224	220nt																					
274	270nf																					
334	330nf																					
394	390nt																					
474	470nf																					
564	560nf																					
684	680nf																					
824	820nf																					
105	1ut																					
125	1.2uf																					
155	1.5uf																					
185	1.8uf																					
225	2.2uf																					
275	2.7ut																					
335	3.3uf																					
395	3.9uf																					
475	4.7uf																					
565	5.6uf																					
685	6.8ut																					
825	8.2uf																					
106	10uf	Key																				
126	12uf				In development																	
156	15uf				In production																	
186	18ut																					
226	22ut																					

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U.S.A. NASA and MIL Approvals

- ***NASA BME Spec released S-311-P-838 June 2015 . Approved April 2016***

  Data pack includes - Cross-section , Grain Size , THB @rated Voltage etc

  ***NASA* QPLD listing completed Feb 2016 .**

- ***New Mil Prf Thin Spec 32535* released Sept 2015 . Approval Estimated June 2017**

- **Includes both BME and PME technology .**
- **Coleraine and Czech facilities have " Mil" audit completed May 2016 .**
- **Manufacturing of qualification lots underway .**
- **This will include 0402 and 2220 sizes with a max cap of 22uF .**
- **Incudes Low Inductance capacitors 0306 , 0508**
- **Expect Mil Qualification to be completed through 1st half 2017**
- **Need to complete the long term testing 4,000 hr life data**

- **Gold termination parts on line for 12065C105K for USA customers .**

- **2,000 hrs life tested completed and Passed Feb 2016 .**
- **Life test 2,000hr data completed and Passed Feb 2016**
- **Plan to qualify Gold range with Mil and ESCC ranges .**

Conclusion

- **AVX's Space BME X7R capacitors have clear differences set out from their Materials , Design , Processing and Testing than other BME, commercial, products to meet the ESCC/NASA/Mil Standards**

- **In addition, AVX has carried out extensive reliability testing**
  - **EPPL, ESCC 3009041 , NASA S311P838**
  - **Long term life testing 10,000 Hrs , 2 x RV @ 125 Deg C**
  - **HALT and Weibul Analysis**
  - **SEM and STEM analysis**

- **The Space BME range is under qualification testing for the Mil Prf *32535*, including 4000 hrs life testing. Est June 2017**

- **Under evaluation is a range extension 0402 – 2220 e.g. 2220 50 volt 10 uf , 25 volt 22 uf .**

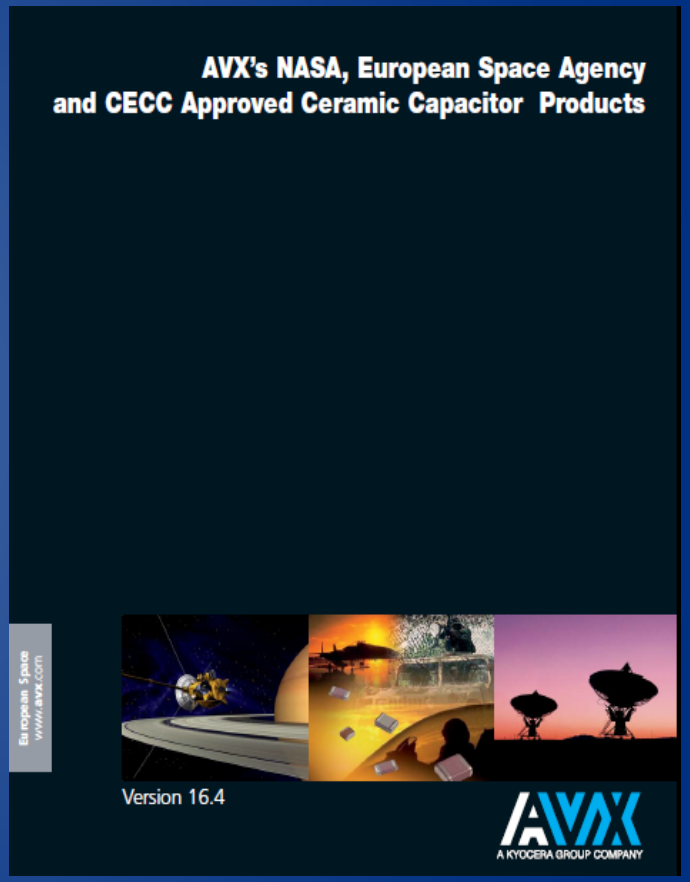
Acknowledgement

- ESCC Evaluation Test Program 2008-2013

  Base Metal Electrode Ceramic Capacitors studies
  (Contract No. 22484/09/NL/CP)

AVX ESCC Approved Ceramic Capacitors

ESCC Approved AVX Ceramic Capacitor Ranges		
AVX App Series	**Ceramic Capacitor Type**	**Series Type**
ESCC 3001030	Cap Ceramic fixed Type II	CH/CV Stacked
ESCC 3001034	Cap Ceramic fixed Type II High Volt , 1 Kv – 5 Kv	CH/CV Stacked
ESCC 3009034	Cap Ceramic fixed Type II High Volt , 1 Kv – 3 K v	1812 - 1825
ESCC 3009	TPC Cap Ceramic Type I & II , 25 - 200 volt	0805 - 2220
ESCC 3009041	Cap Ceramic Type II,	0603 - 1812



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Thank you