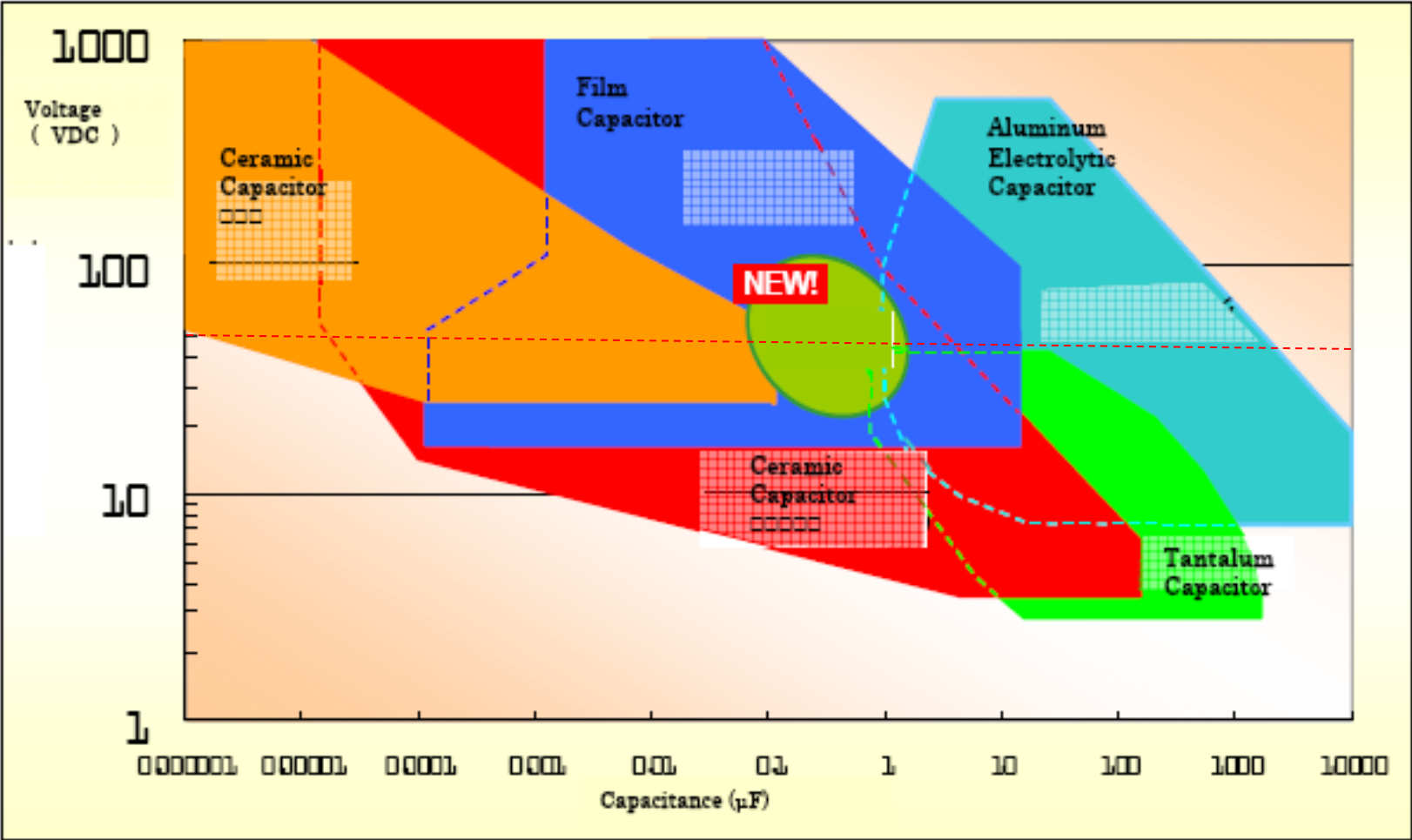


Effects of Moisture on Solid Tantalum Capacitors

By Y. Freeman and P. Lessner
ESA 2016

Capacitor World (Murata)



Amorphous Dielectric

Major Degradation Mechanisms in Tantalum and Niobium Based Capacitors

Part A.

Oxygen Migration and Effects of Thermal Treatment on the Dielectric
Properties of Anodic Oxide Films on Tantalum and Niobium

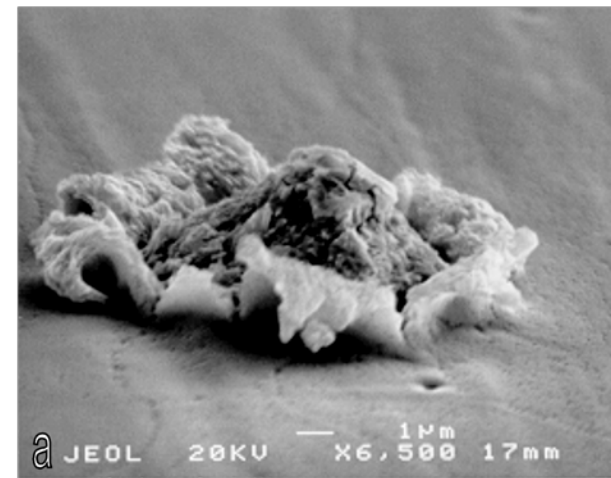
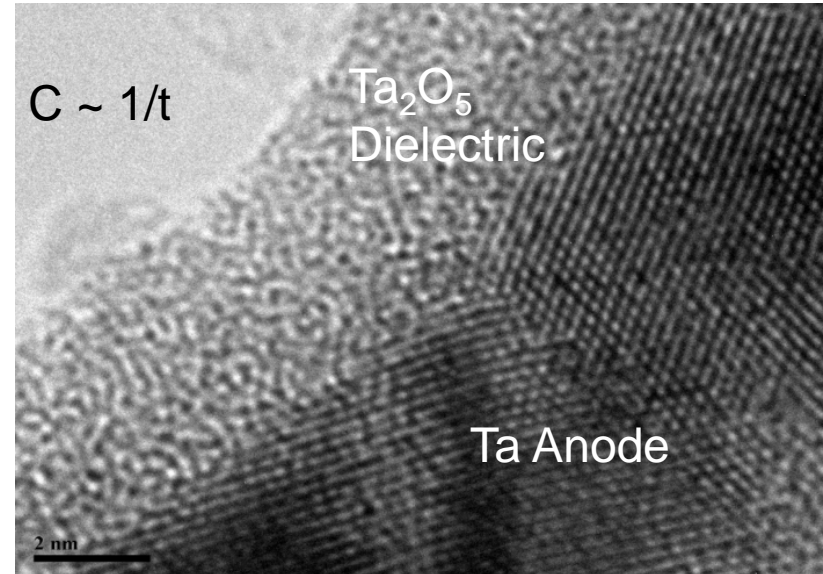
Dr. Terrance B. Tripp

Part B.

Crystallization of Anodic Oxide Films on Tantalum and Niobium

Dr. Yuri Freeman

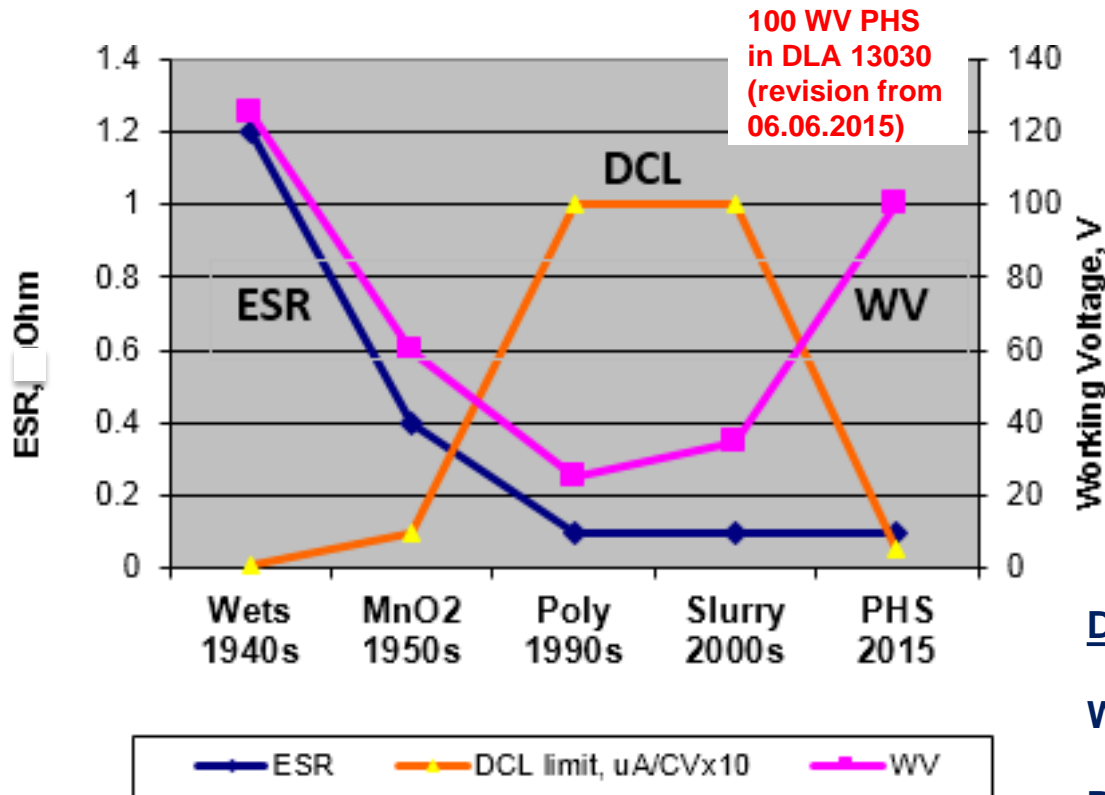
.....
Published in 2008 by
Components Technology Institute Inc.
904 Bob Wallace Ave. Site 117
Huntsville, AL 35801
256-536-1304



Evolution of Tantalum Capacitors

Polymer Hermetic Seal (PHS) Ta Capacitors

KEMET Patents on PHS

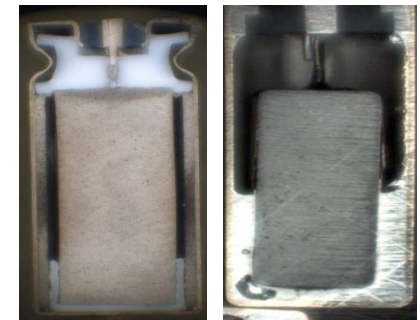


(12) United States Patent Freeman et al.	(10) Patent No.: US 8,310,815 B2 (45) Date of Patent: Nov. 13, 2012
(12) United States Patent Paulsen et al.	(10) Patent No.: US 8,441,265 B2 (45) Date of Patent: *May 14, 2013
(12) United States Patent Chen et al.	(10) Patent No.: US 8,379,371 B2 (45) Date of Patent: Feb. 19, 2013
(12) United States Patent Hushev et al.	(10) Patent No.: US 9,147,530 B2 (45) Date of Patent: Sep. 29, 2015
(12) United States Patent Qiu et al.	(10) Patent No.: US 7,563,290 B2 (45) Date of Patent: Jul. 21, 2009
(12) United States Patent Freeman	(10) Patent No.: US 7,671,603 B2 (45) Date of Patent: Mar. 2, 2010
United States Patent (19) Melody et al.	(11) Patent Number: 5,716,511 (45) Date of Patent: Feb. 10, 1998

Derating:

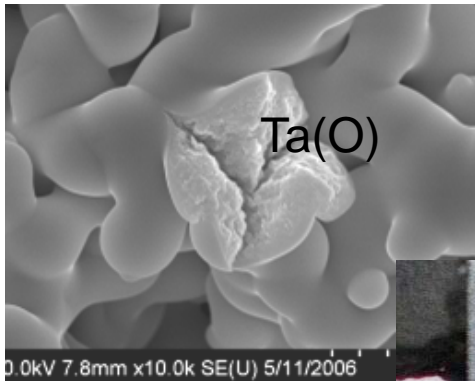
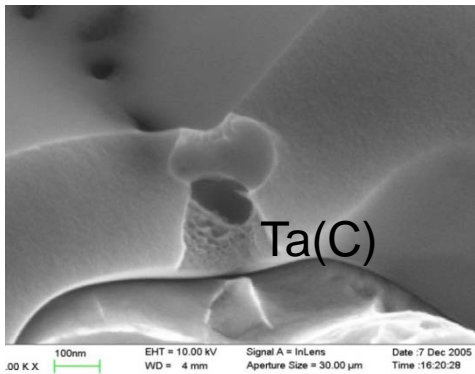
Wet: 50%

Poly: 20%

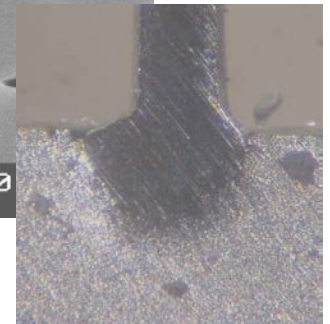
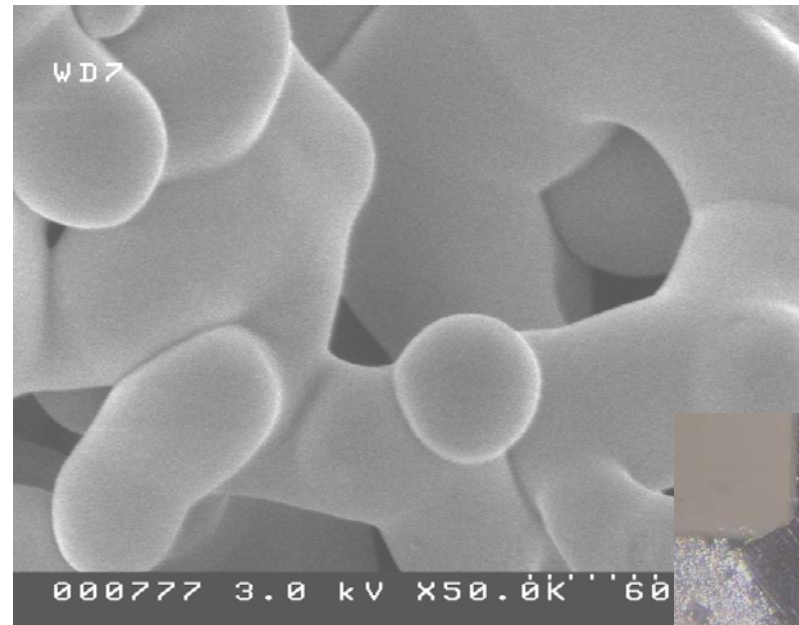


Flawless Technology (F-Tech)

Conventional Technology



F-Tech



Journal of The Electrochemical Society, **156** (6) G65-G70 (2009)
0013-4651/2009/156(6)G65/6/\$25.00 © The Electrochemical Society

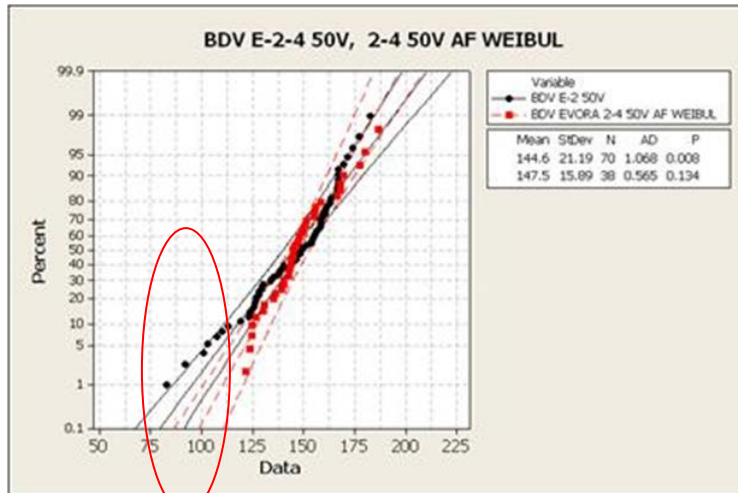


Electrical Characterization of Tantalum Capacitors with Poly(3,4-ethylenedioxythiophene) Counter Electrodes

Yuri Freeman,^a William R. Harrell,^{b,*} Igor Luzinov,^c Brian Holman,^{b,d} and Philip Lessner^{a,*}

Simulated Breakdown Screening (SBDS)

BDV Before vs. After SBDS

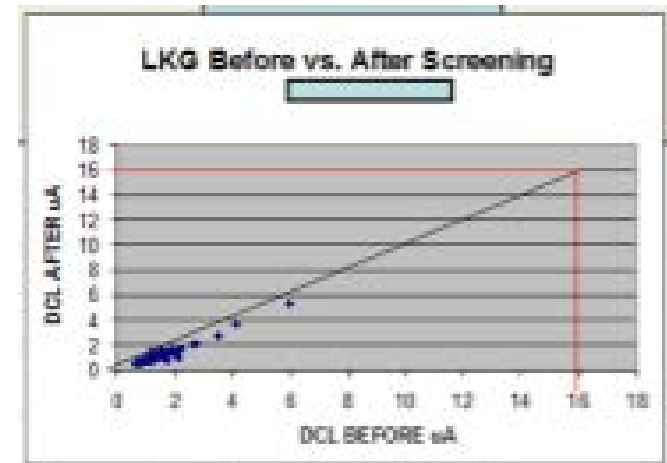


$$V = (1.1-1.5) \text{ BDV aver.}$$

HALT

Normal

Tail



(1) **United States Patent**
 Freeman et al.

(1) Patent No.: US 8,310,815 B2
 (2) Date of Patent: Nov. 13, 2012

(2) **United States Patent**
 Paulsen et al.

(1) Patent No.: US 8,441,265 B2
 (2) Date of Patent: *May 14, 2013

High Reliability Principles and Verifications in Solid Tantalum Capacitors. End-User's Manufacturing Processes

William Winkel, Edward Rich,

Northrop Grumman Corporation

The F-TECH Process Demonstrated Improved Capacitor Failure Rate Versus "Standard" Processing



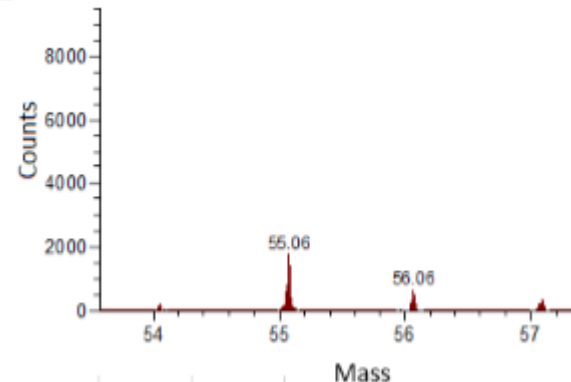
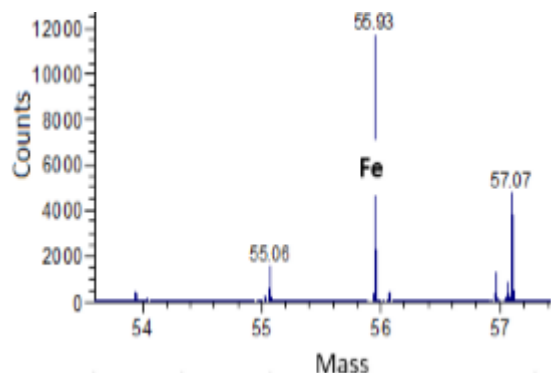
- Accelerated step-stress testing was performed to precipitate enough failures for characterization
- The failure rate of the Baseline profile is significantly lower than that demonstrated by M_nO_2 style capacitors manufactured to the "standard" processing with Mil-prf-55365 Weibull screening
- Exposure to moisture results in variability in capacitor failure rate

KEMET F-TECH Accelerated Step Stress Life Test Results		Measured Industry Average [Mil-Prf-55365]	
Test Profile	Measured FR_{Test} [85C, V = V_R , t = 42.25 hrs]	0.1% Lots Measured FR_{Test} [[85C, V = V_R , t = 42.25 hrs]]	1% Lots Measured FR_{Test} [[85C, V = V_R , t = 42.25 hrs]]
Baseline	3.64E-11	1.65E-03	2.60E-03
Aqueous Wash	6.94E-08	Not Measured	
Uncontrolled Use	2.63E-07		
Uncontrolled Storage	9.19E-09		
>= 3 Solder Cycles	1.78E-10		

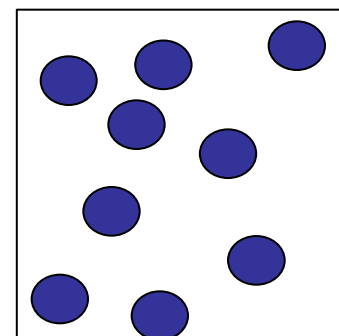
In-situ vs. Slurry PEDOT

In-situ Polymerization

Monomer + Oxidizer = PEDOT + Byproducts



Pre-polymerized PEDOT/PSS Dispersion (Slurry)



(12) **United States Patent**
Qiu et al.

(10) Patent No.: US 7,563,290 B2
(45) Date of Patent: Jul. 21, 2009

(19) **United States**

(12) **Patent Application Publication**
Merker et al.

(10) Pub. No.: US 2007/0064376 A1
(43) Pub. Date: Mar. 22, 2007

A1646

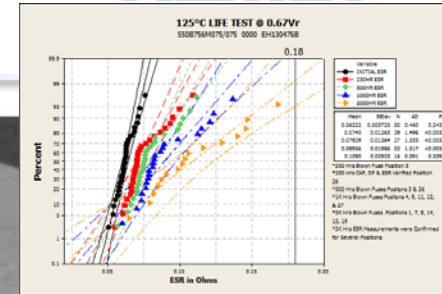
Journal of The Electrochemical Society, 159 (10) A1646-A1651 (2012)
0013-4651/2012/159(10)/A1646/6/\$28.00 © The Electrochemical Society



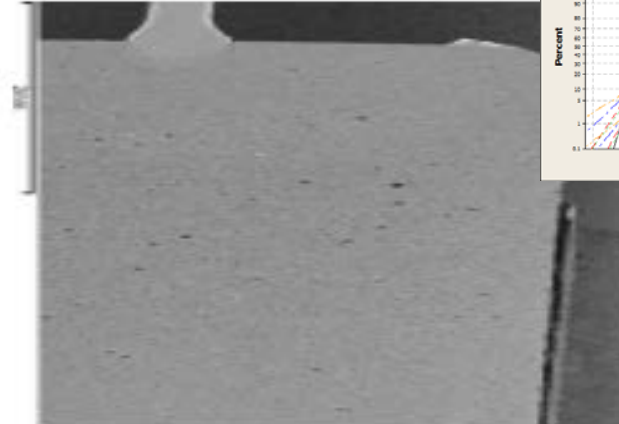
Electrical Characterization of High Voltage Polymer Tantalum Capacitors

Y. Freeman,^a G. F. Alapatt,^b W. R. Harrell,^{b,x} and P. Lessner^{a,*}

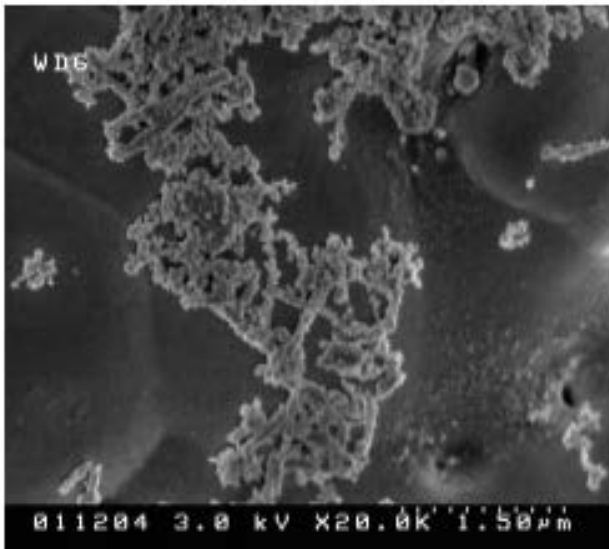
Moisture Related Failures in Ta Capacitors



Popcorn Effect



Delamination

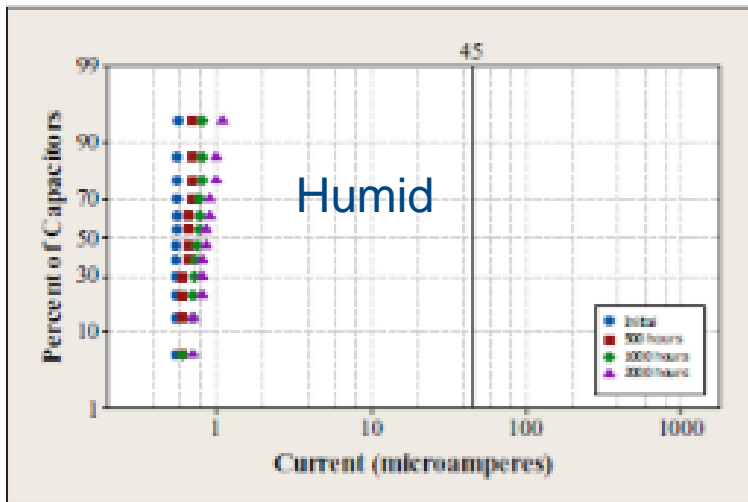


Ion Migration (Silver)

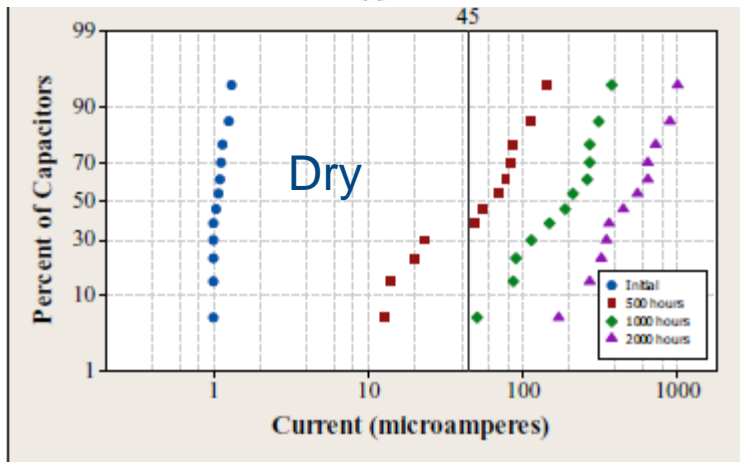


Tin Whiskers

Degradation in Dry Polymer Ta Capacitors



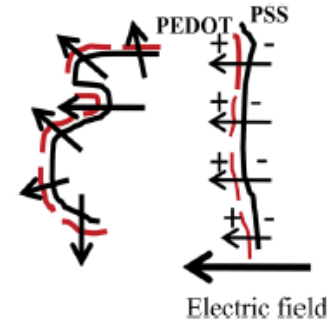
(a)



(b)

Figure 3. (a) DCL during Life test at 75 V and 85°C in humid 75 V PHS Ta capacitors. (b) DCL during Life test at 75 V and 85°C in dry 75 V PHS Ta capacitors.

Moisture as Plasticizer (MIS Model)



N70

ECS Journal of Solid State Science and Technology, 4 (7) N70-N75 (2015)



Asymmetric Conduction and Stability of Polymer Tantalum Capacitors

Y. Freeman,^a G. F. Alapatt,^b W. R. Harrell,^{b,x} I. Luzinov,^c and P. Lessner^{a,*}

F-Tech/Slurry/SBDS and Controlled Humidity in PHS

(12) **United States Patent**
Freeman et al.

(10) Patent No.: **US 8,310,815 B2**
(45) Date of Patent: **Nov. 13, 2012**

(12) **United States Patent**
Chen et al.

(10) Patent No.: **US 8,379,371 B2**
(45) Date of Patent: **Feb. 19, 2013**

ECS Journal of Solid State Science and Technology, 2 (11) N197-N204 (2013)
2162-8769/2013/2(11)/N197/8/\$31.00 © The Electrochemical Society

N197



Anomalous Currents in Low Voltage Polymer Tantalum Capacitors

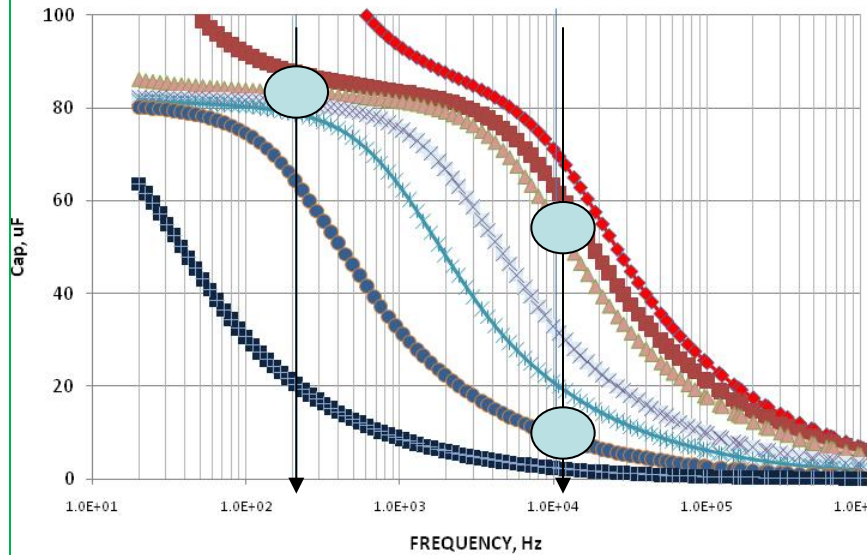
Y. Freeman,^a G. F. Alapatt,^b W. R. Harrell,^{b,x} I. Luzinov,^c P. Lessner,^{a,*} and J. Qazi^a

^aKEMET Electronics Corporation, 2835 KEMET Way, Simpsonville, South Carolina 29681, USA

Wets vs. PHS

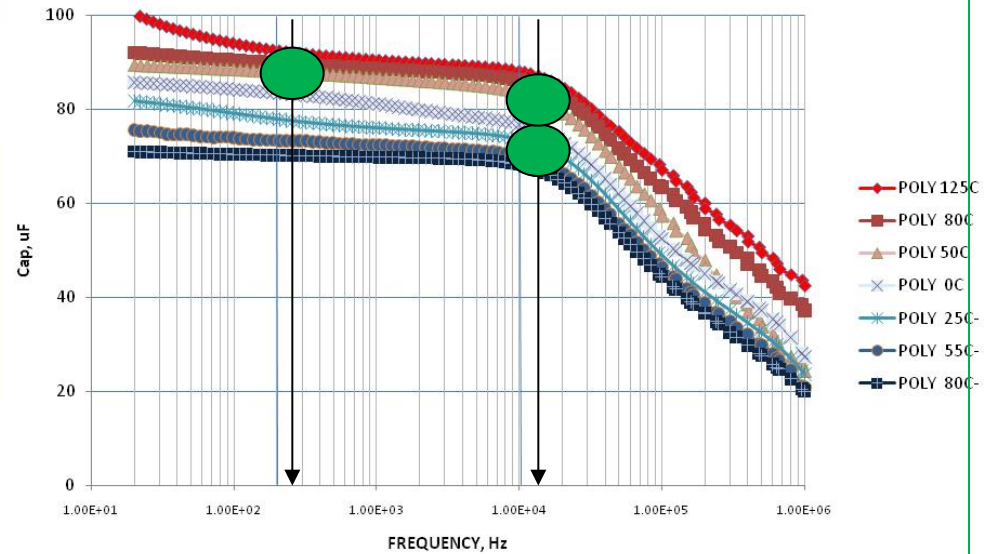
Wet 82 uF -75 V

Capacitance 82 uF -75 V WET



Poly 82 uF -75 V

Capacitance 82 uF -75 V POLY



SMD with F-Tech, Slurry, SBDS and Low Sensitivity to Moisture



Winter Dive in Siberia on January 19

T = -45C

