Electronic Components

KEMET

CHARGED.®

They’re JUST capacitors?

James Lewis
Marketing Director
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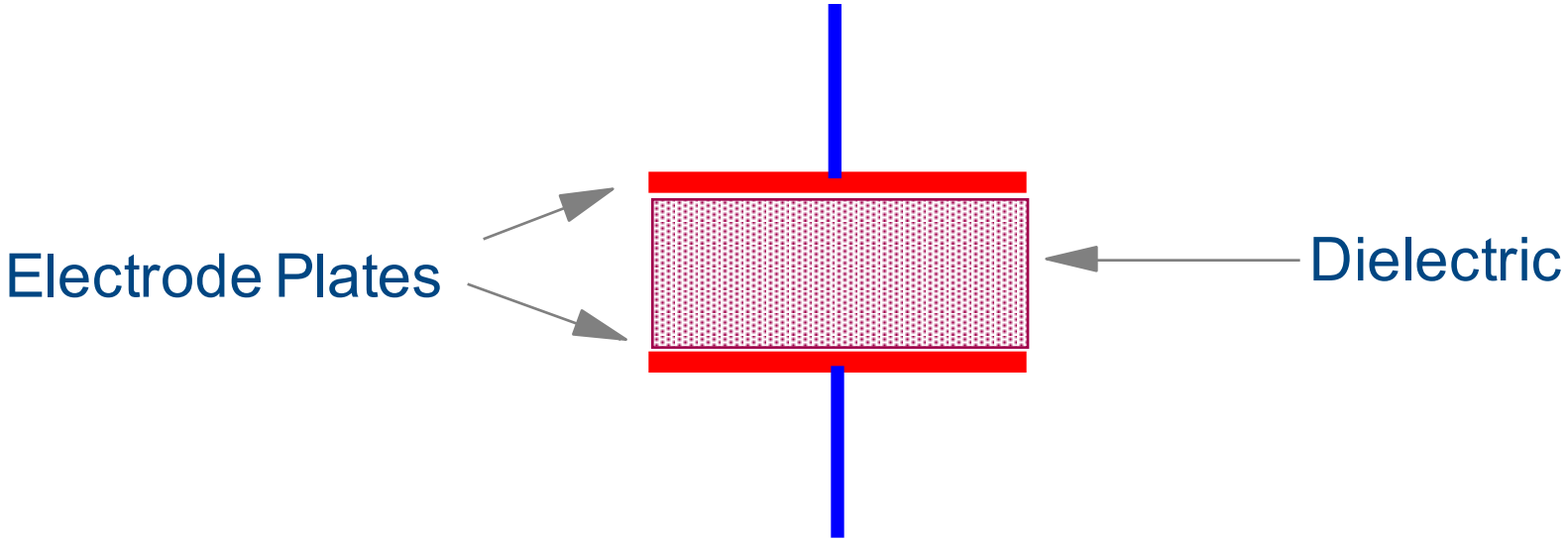
@baldengineer

Basic Capacitor

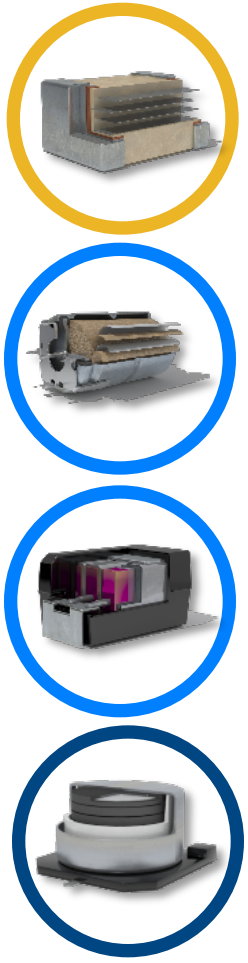


$$C = \frac{\varepsilon_0 K A (n-1)}{d}$$

Different materials make different capacitors

Topic List

- Ceramics
  - Why they lose capacitance
- Aluminum
  - Why they don't last forever
- Tantalum
  - Why are they are safe to use
- Supercapacitors
  - Why they are called super

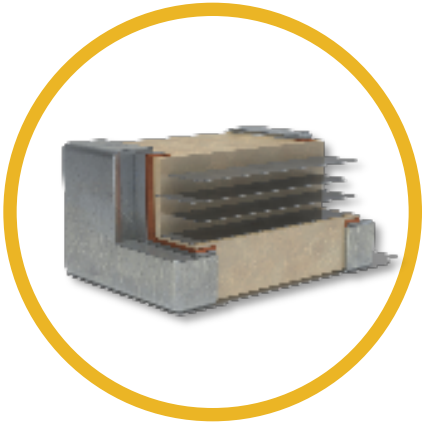


We need a context…

Capacitors should be voltage derated 50%

True Or False

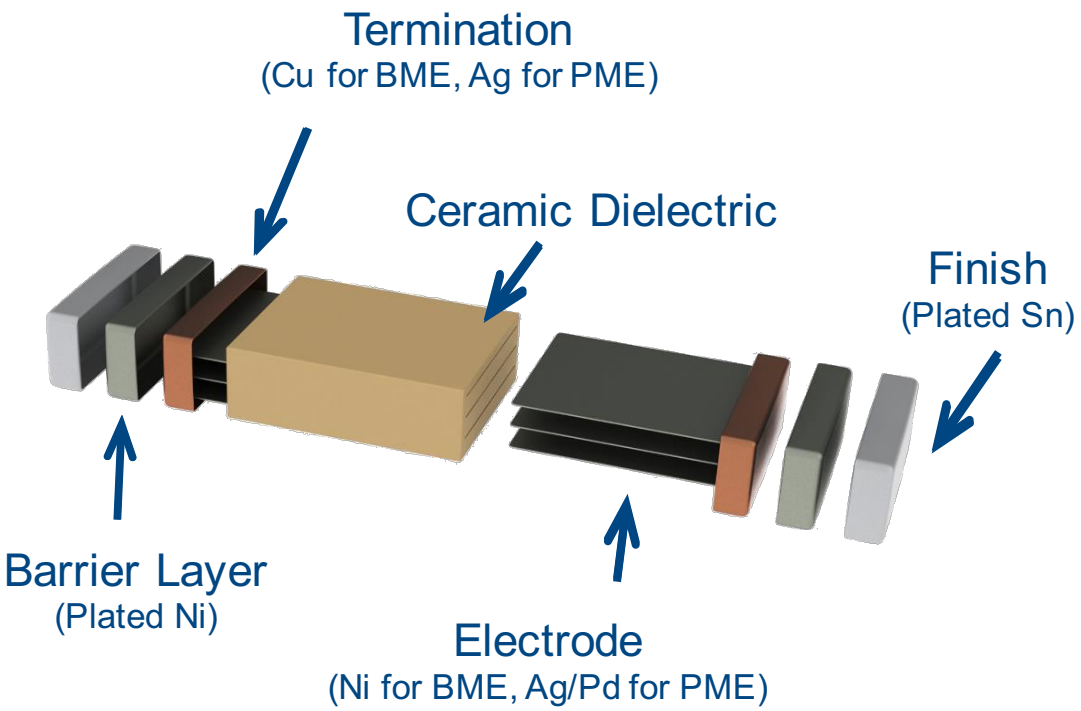
It Depends…

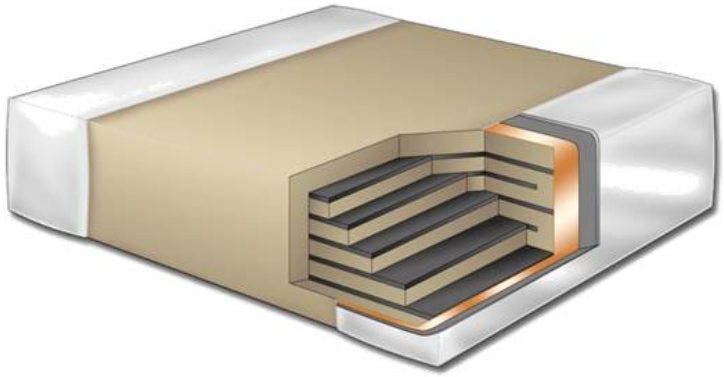


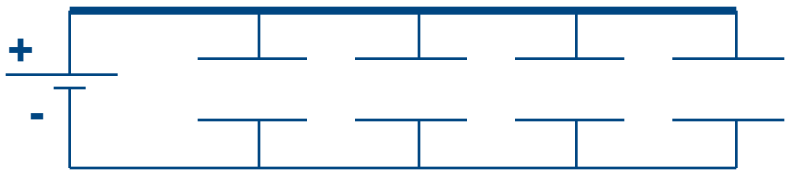
Ceramics

Multilayer Ceramic Capacitor (MLCC)

Typical Construction







Capacitances in parallel are additive

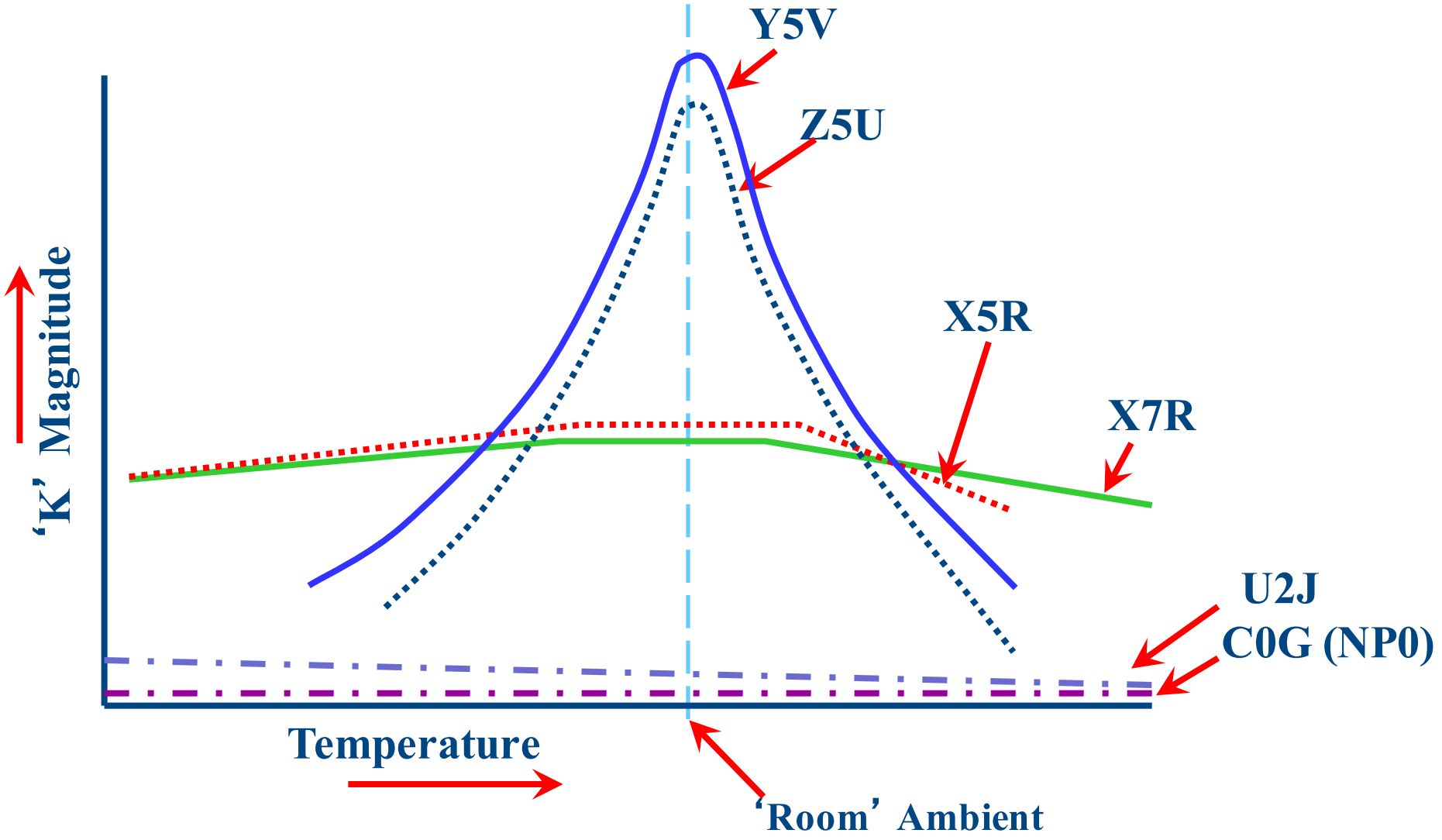
$$C_T = C_1 + C_2 + C_3 + \ldots C_n$$

$$C = \frac{\varepsilon_0 K A (n-1)}{d}$$

Max Capacitance is limited by “larger” layers

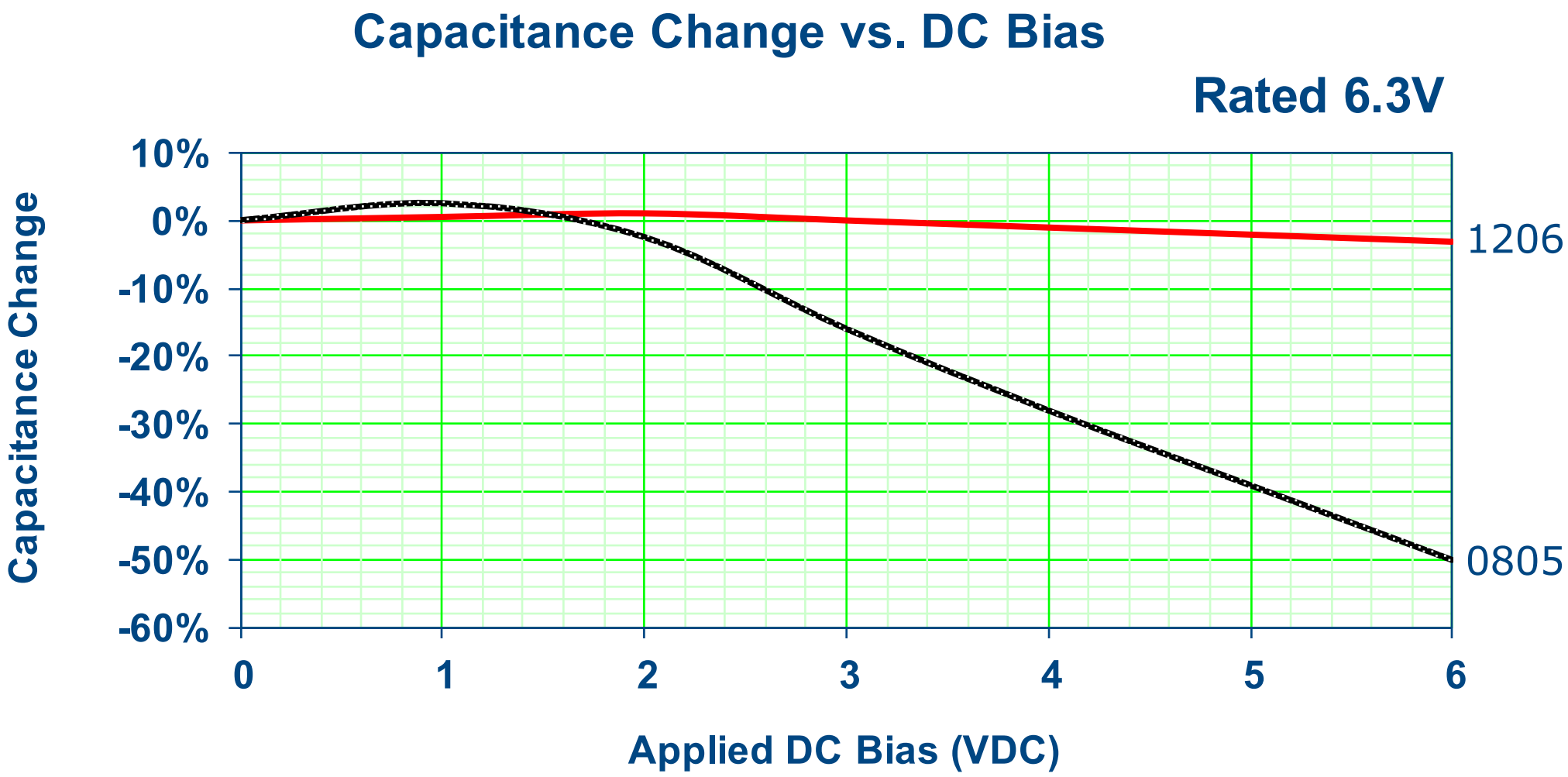
Relative Capacitance vs. Temperature

Temperature Coefficients



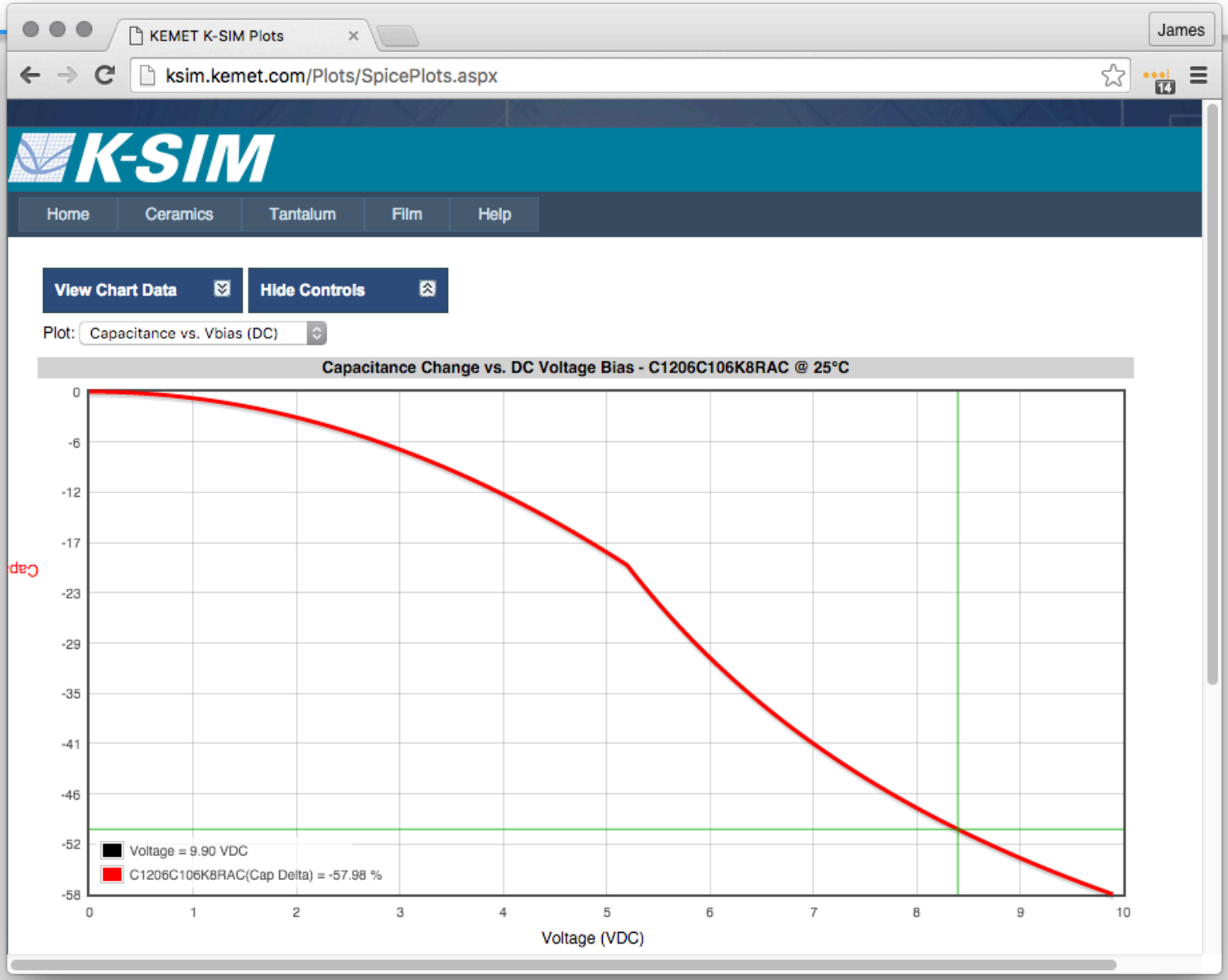
Voltage Coefficient (Class II and III)

1210 vs 0805, X7R, 10uF, 6.3V



How much capacitance do you really get?

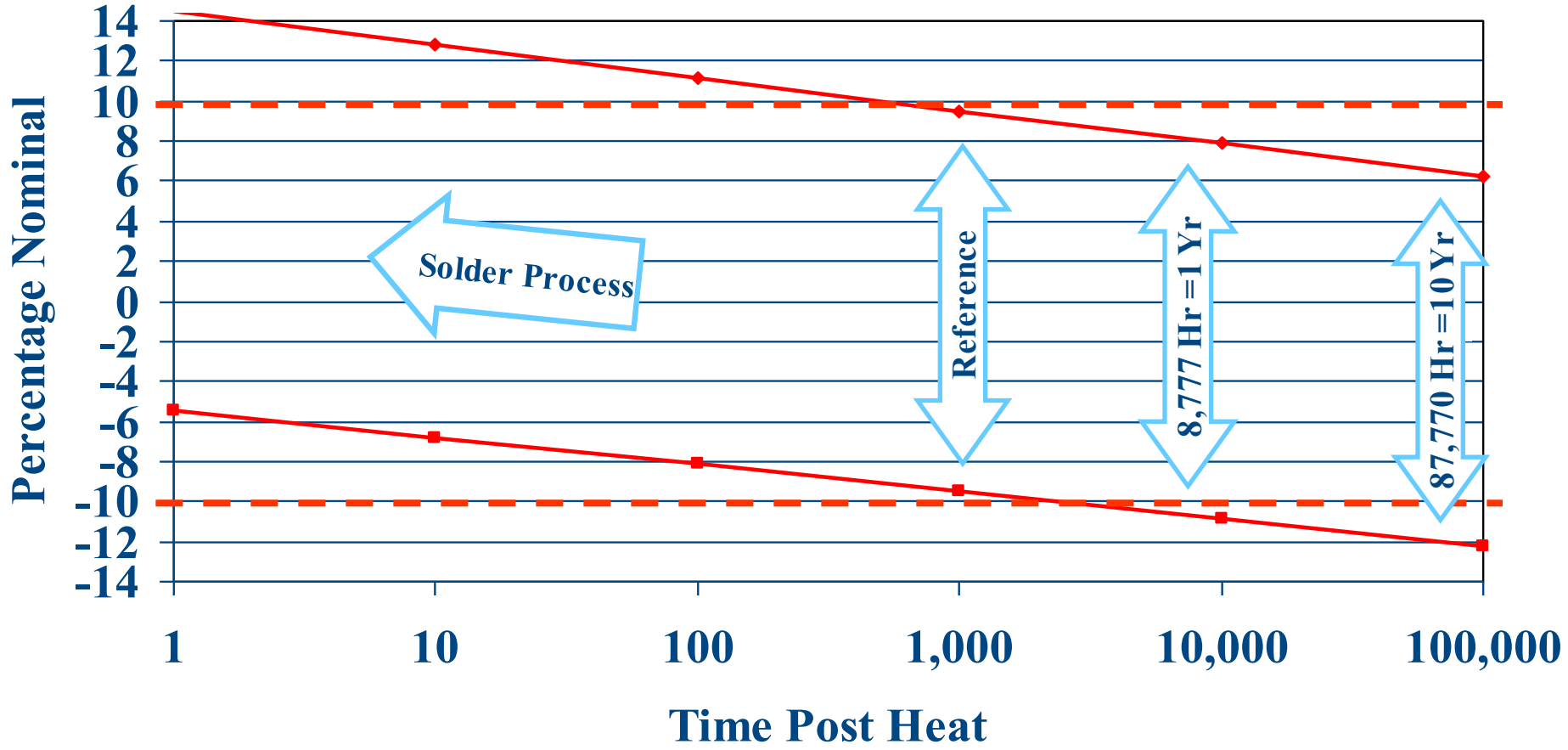
ksim.kemet.com



K-SIM: ESR, Z, SPICE Model, VCC, and S-Parameters

X7R Aging Rate

1.5% per Decade Hour (Limit)

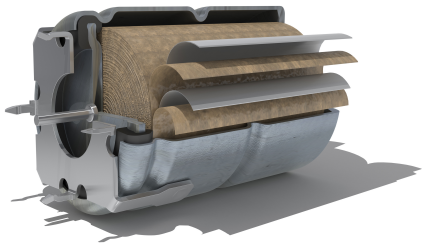


https://ec.kemet.com/aging-calculator-for-ceramics

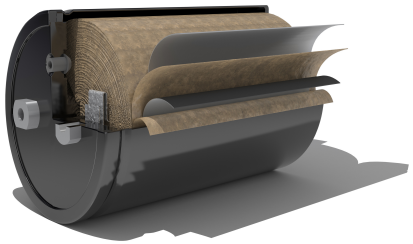
Aluminum Electrolytic

Aluminum Electrolytic

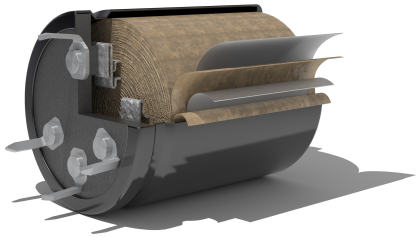
Form Factors



Axial/Radial



Screw Terminal



Snap-In

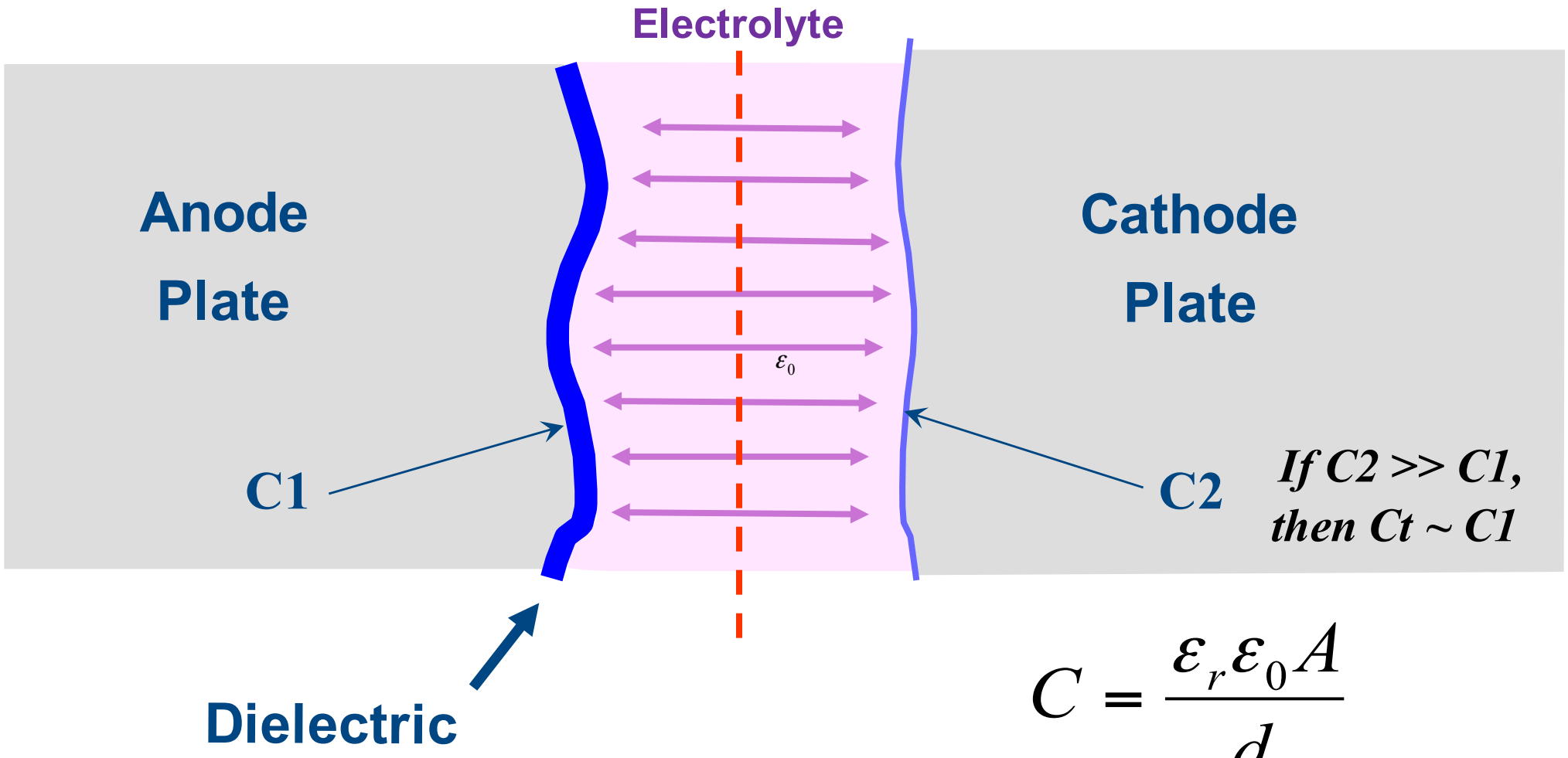
Single Ended

SMD

Motor Start

Same construction different form factors

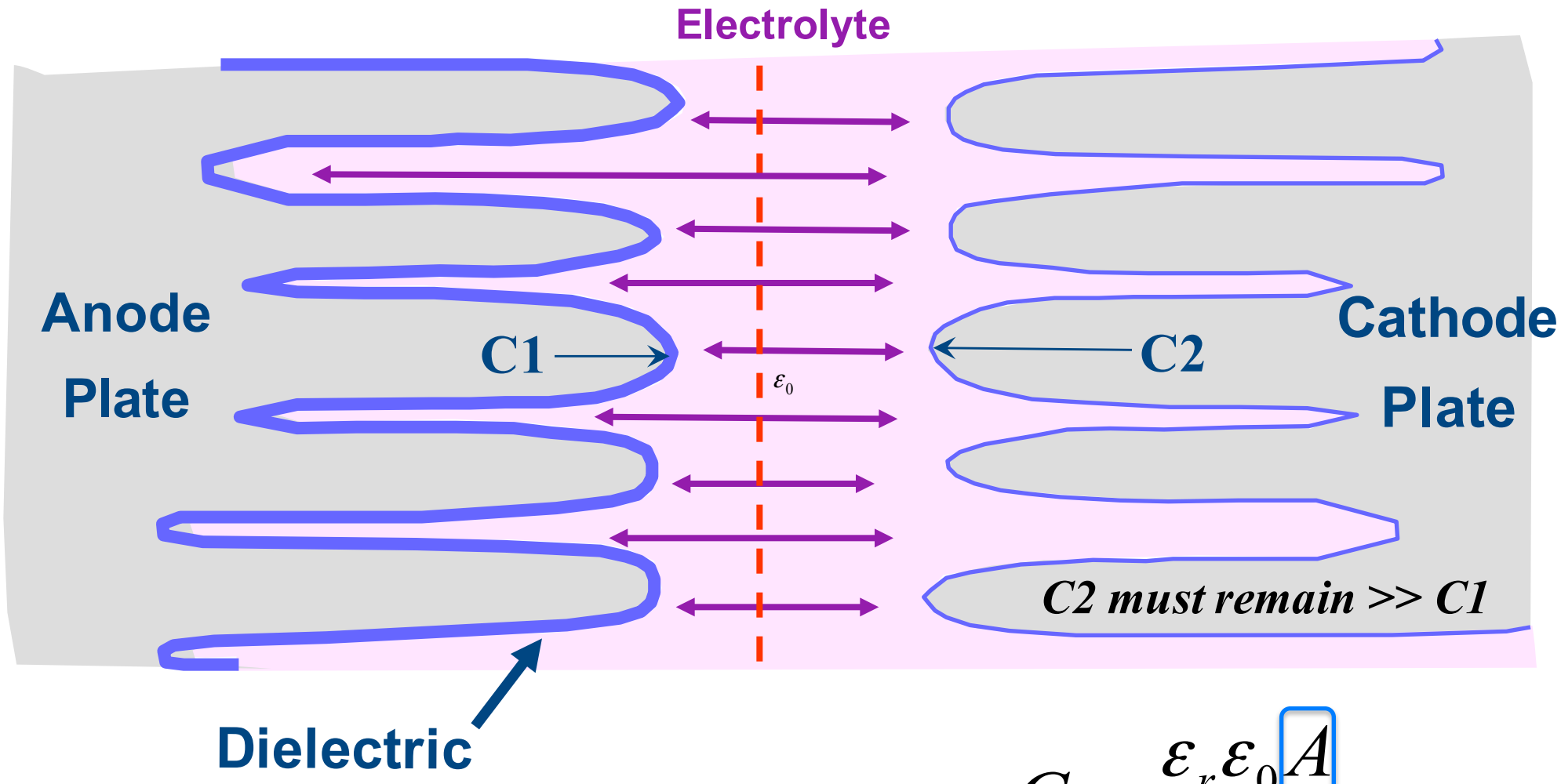
Aluminum Untreated Surface Area



$$C = \frac{\varepsilon_r \varepsilon_0 A}{d}$$

$$\varepsilon_r \left(Al_2O_3 \right) = 9$$

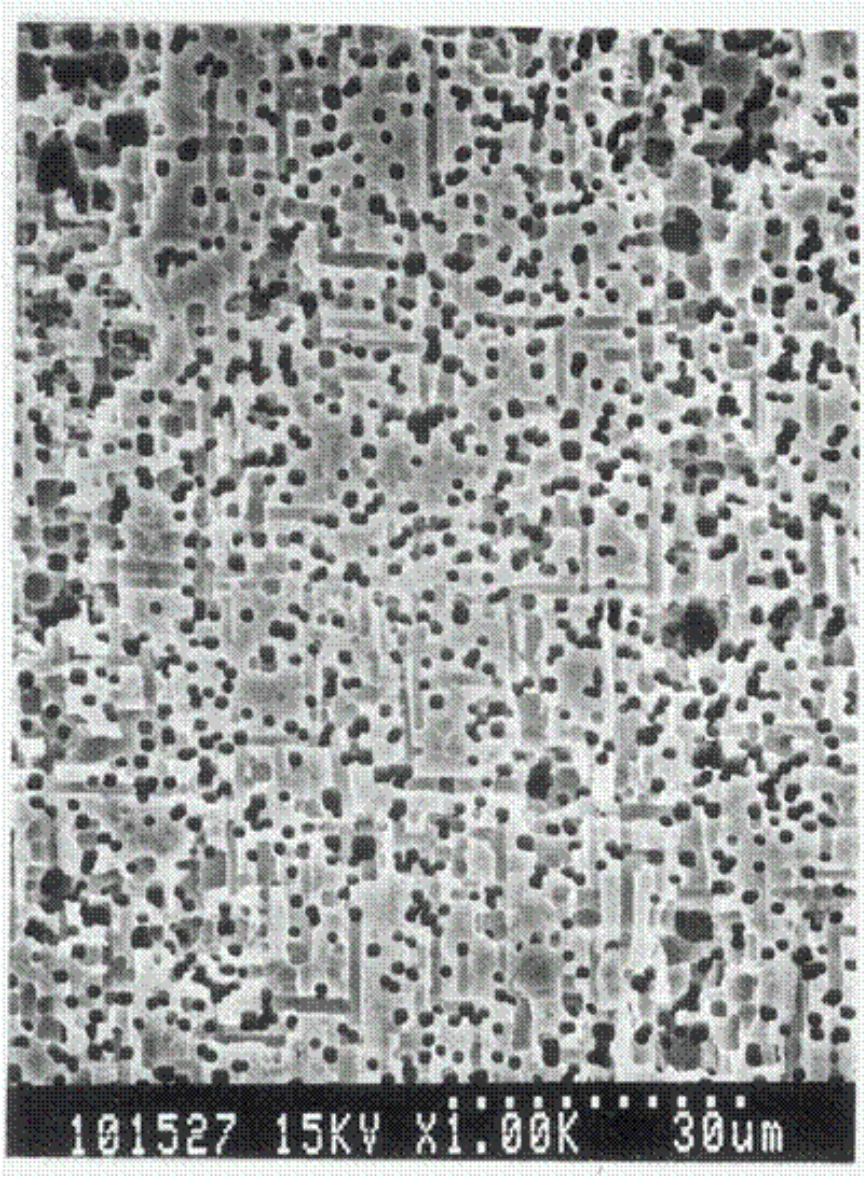
Aluminum Acid-Etched Surface Area

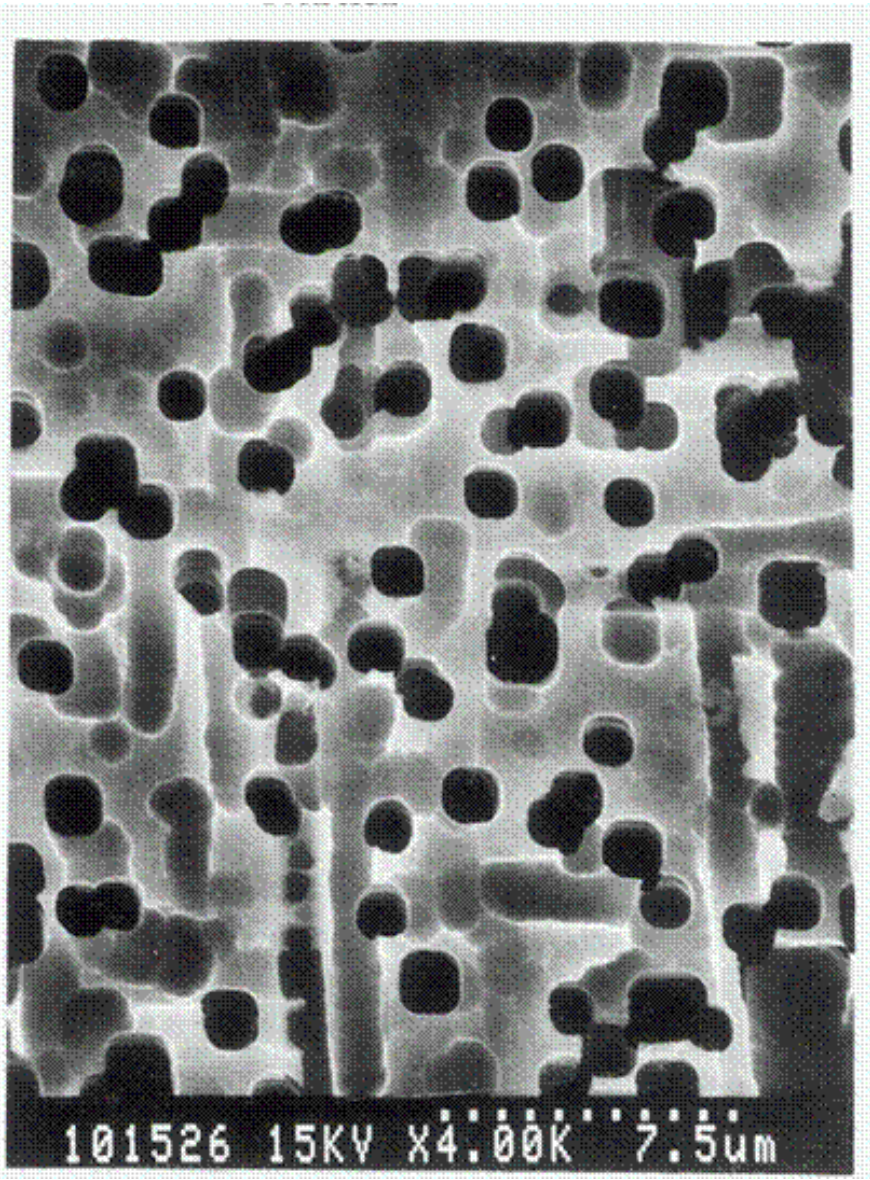


$$C = \frac{\varepsilon_r \varepsilon_0 A}{d}$$

Anode Foil

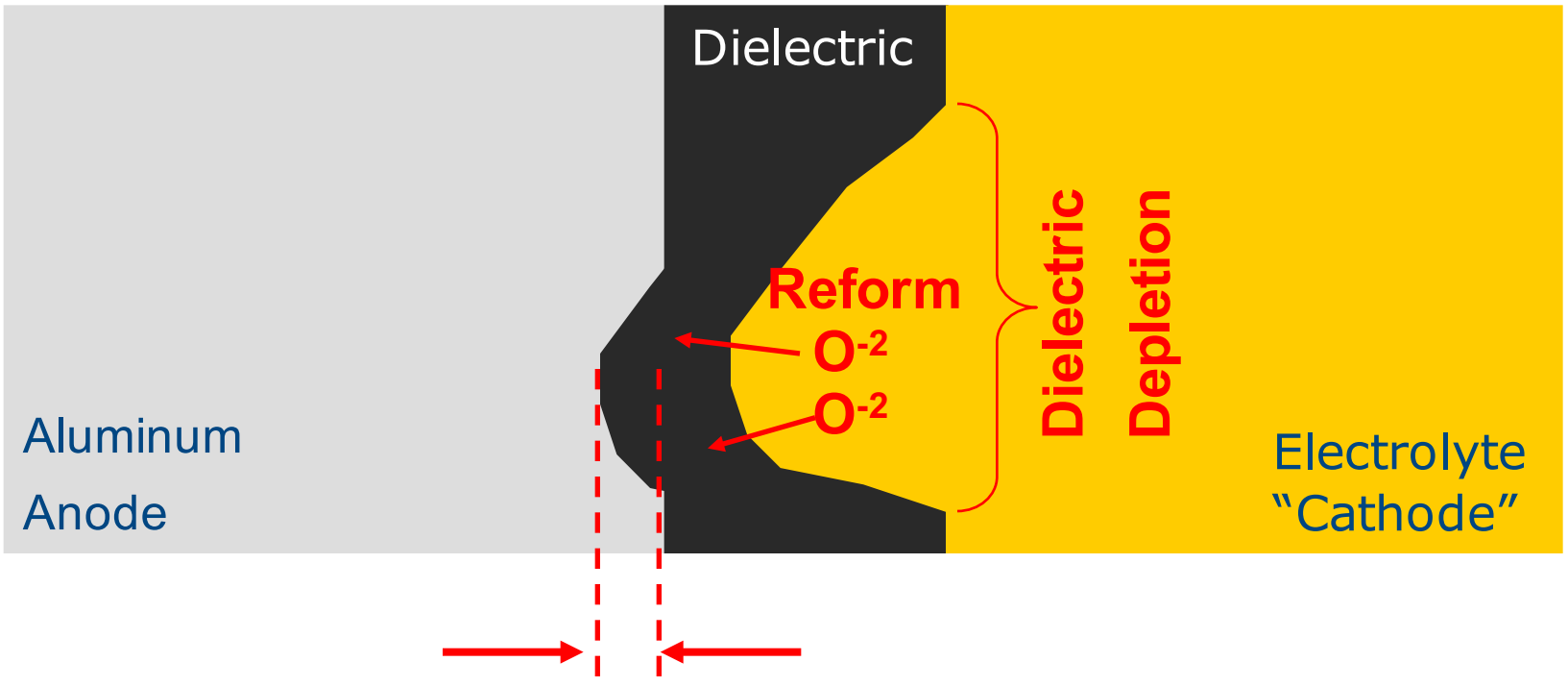
Etched Surface





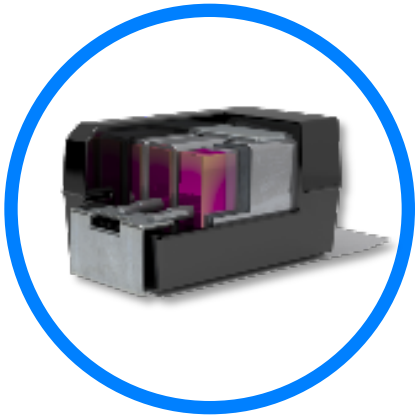
Reforming / Self-Healing Wet Aluminum

$$V_{Formation} > V_{Rating} > V_{application}$$



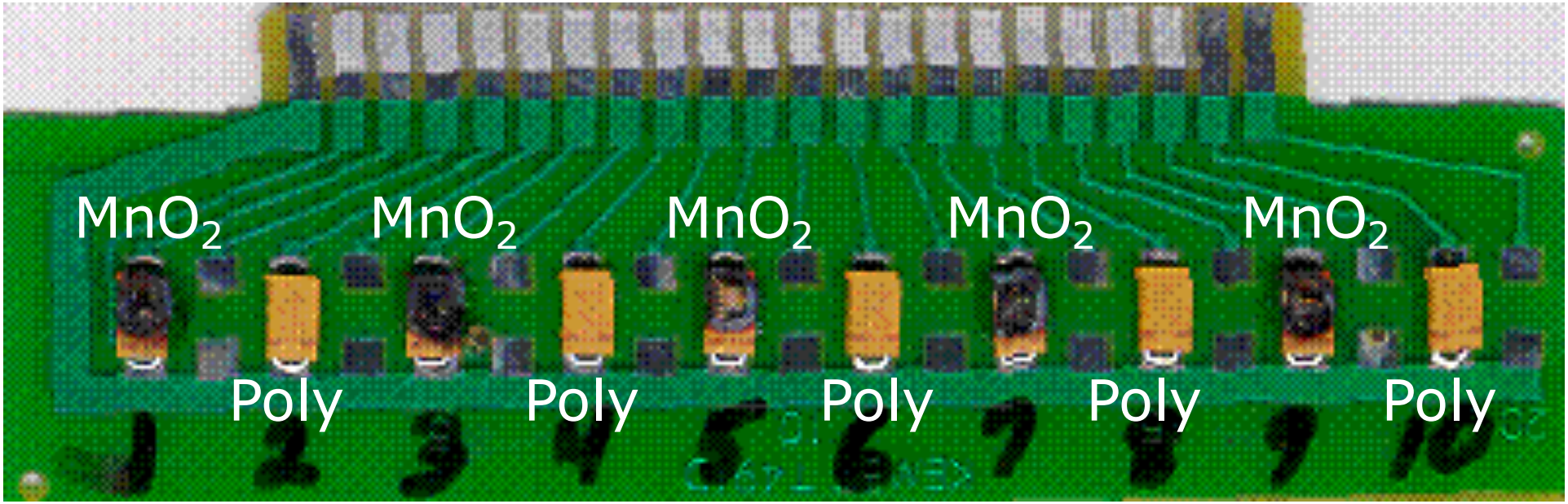
Reformed dielectric region

Voltage contributes to operational lifetime



Tantalum

All Tantalums explode… or do they?



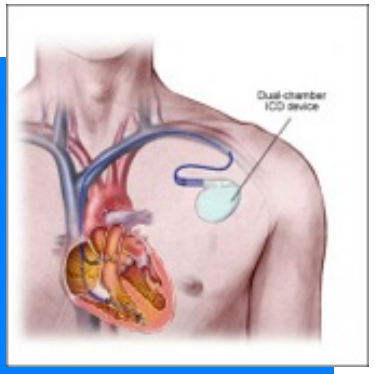
2x Rated Voltage,
applied with **reverse polarity** and
>**20 amps** of current.

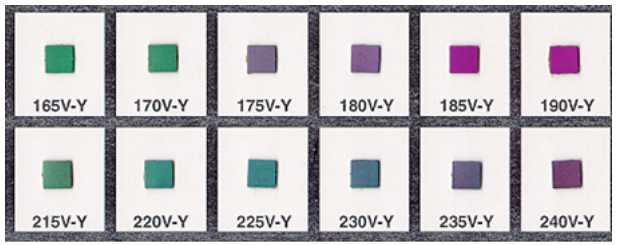
Every capacitor on this board failed as “short”

Why use Tantalum?

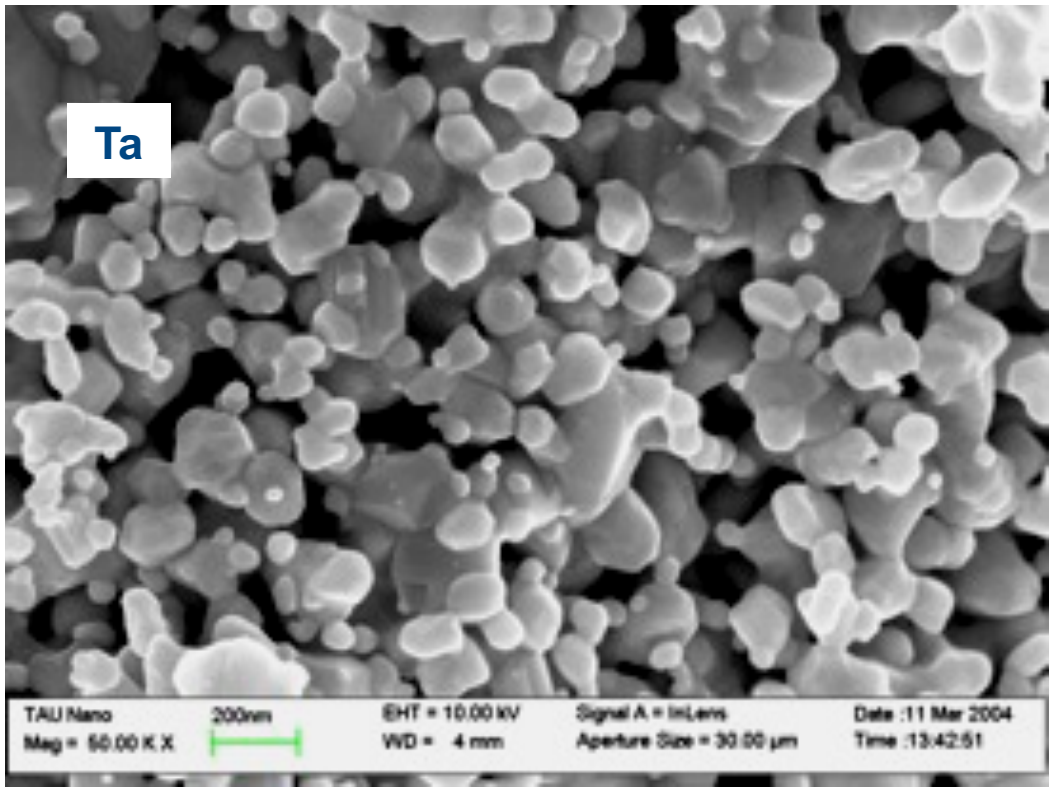
- Stable C (No Temp or Bias Effects), DCL (t)
- Reliable (Decreasing FR)
- Long Life (Exceeds Expected Life of All Hardware)
- Most Volumetrically Efficient (CV/cc, E/cc)

Military
Space
Medical
Automotive
Computers
Telecom

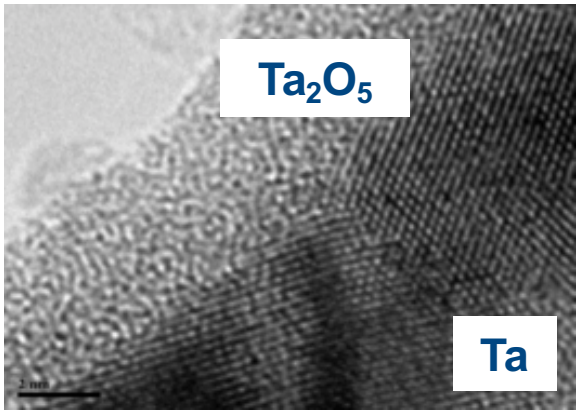


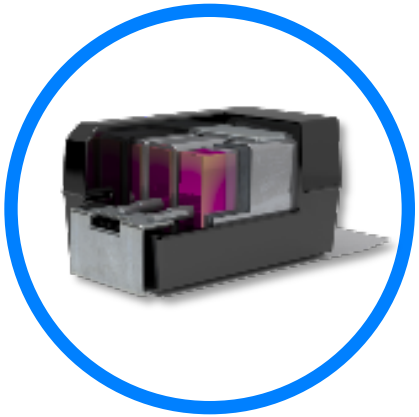


SEM of a Sintered Ta Anode



Ta Oxide Dielectric



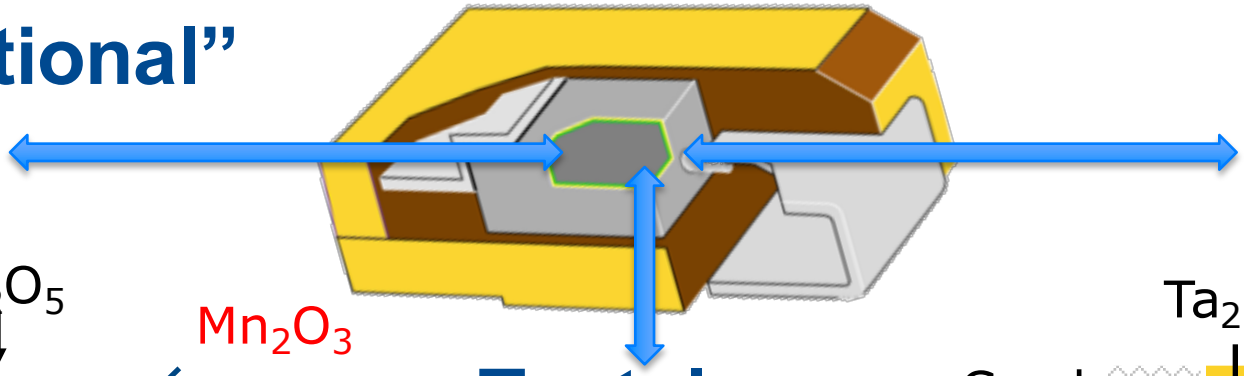


Polymer Electrolytic:
A “new” kind of capacitor

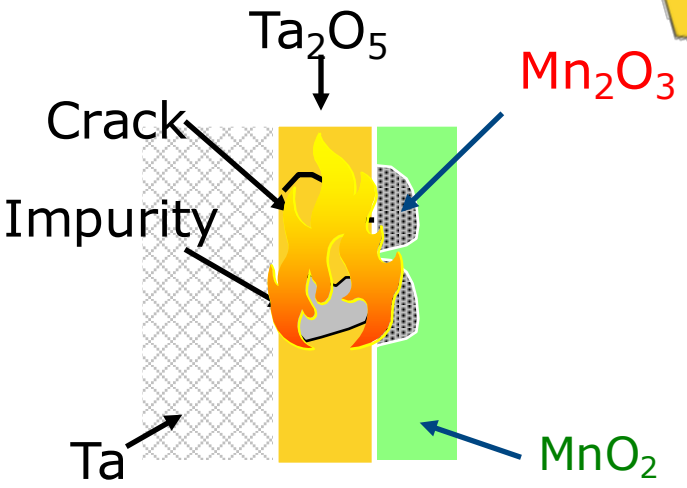
Difference in Self-Healing

Electronic Components KEMET CHARGED.

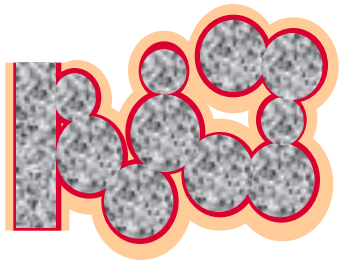
"Traditional" MnO_2



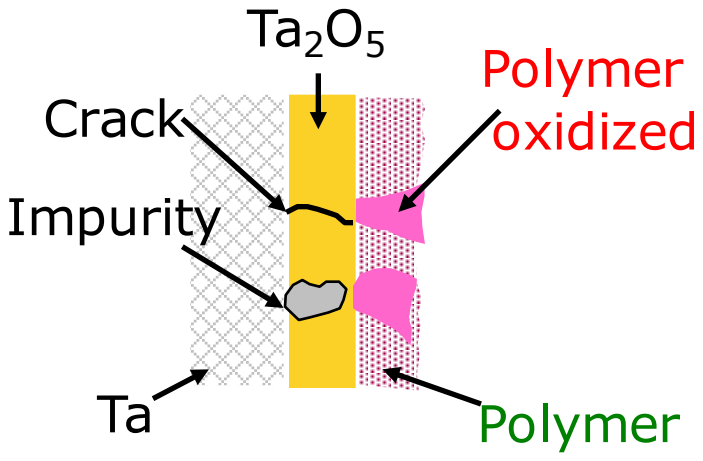
New Polymer



Current through fault generates enough heat and oxygen for ignition.



Tantalum



Conductive polymer consumes oxygen preventing ignition.

If a polymer fails, it fails safely.

Tantalum Voltage Derating

Depend on cathode material

	Ta-MnO_2	Ta-Poly KO V_R>10VDC	Ta-Poly KO V_R≤10VDC	Alum-Poly AO
100 PPM FR % V_{Rated}	68%	126%	197%	235%
@50% V_{Rated} FR(PPM)	9	0	0	0
@80% V_{Rated} FR(PPM)	458	4	1	0
@90% V_{Rated} FR(PPM)	1,700	12	2	0
@100% V_{Rated} FR(PPM)	6,310	35	8	0

- Typical derating guidelines:
  - Tantalum MnO_2: 50%
  - Tantalum Polymer: 20%(>10V), 10% (≤10V)
  - Aluminum Polymer: 0%!

Supercapacitors

What Is A “Super” Capacitor?

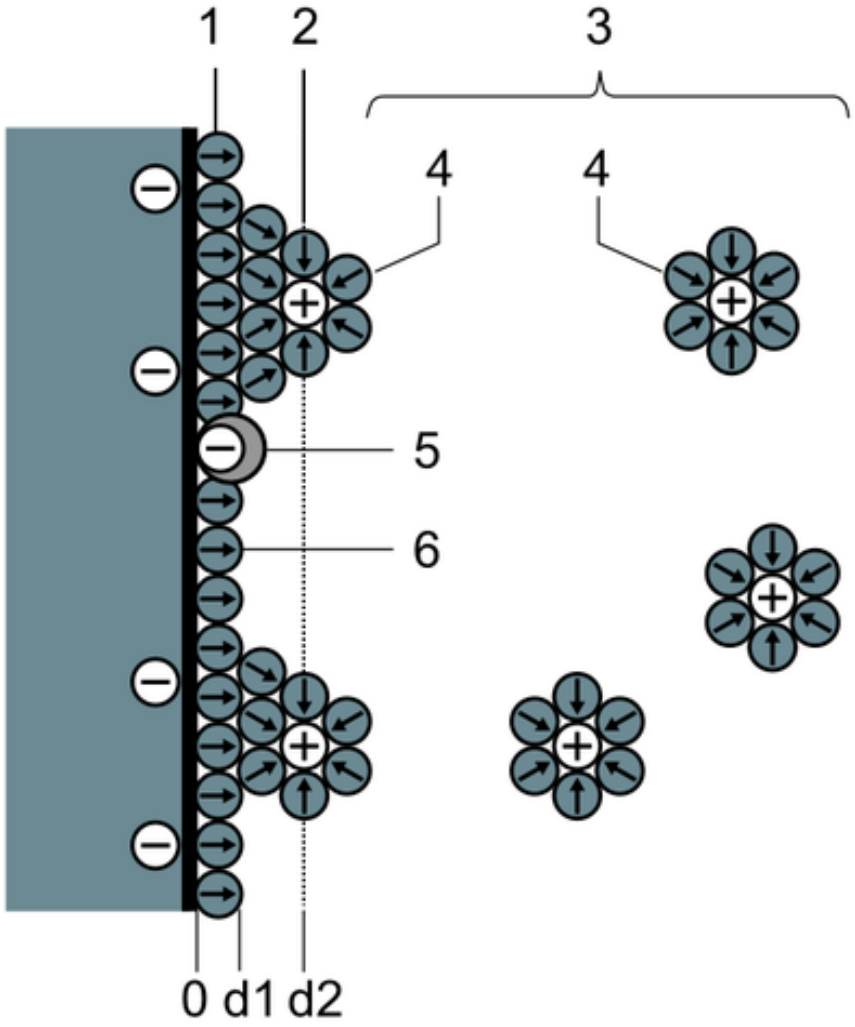
Electronic Components KEMET CHARGED.

APowerCap	EVerCAP	Super capacitor
BestCap	DynaCap	SuperCap

Electrostatic Double-Layer Capacitor (EDLC)

DLCAP		PseudoCap
EneCapTen		Ultracapacitor

(Electrical) Double Layers



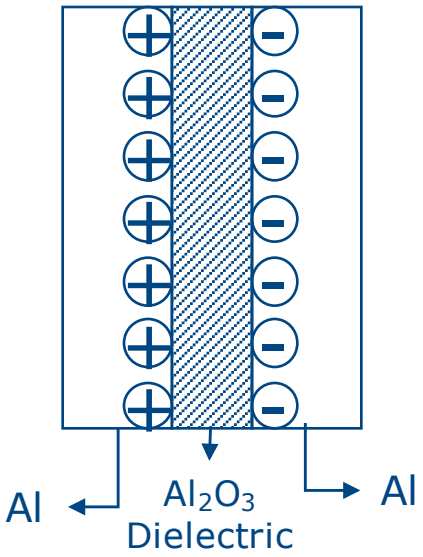
1. IHP Inner Helmholtz Layer
2. OHP Outer Helmholtz Layer
3. Diffuse layer
4. Solvated ions
5. Specifically adsorptive ions
6. Solvent molecule

Traditional and EDLC

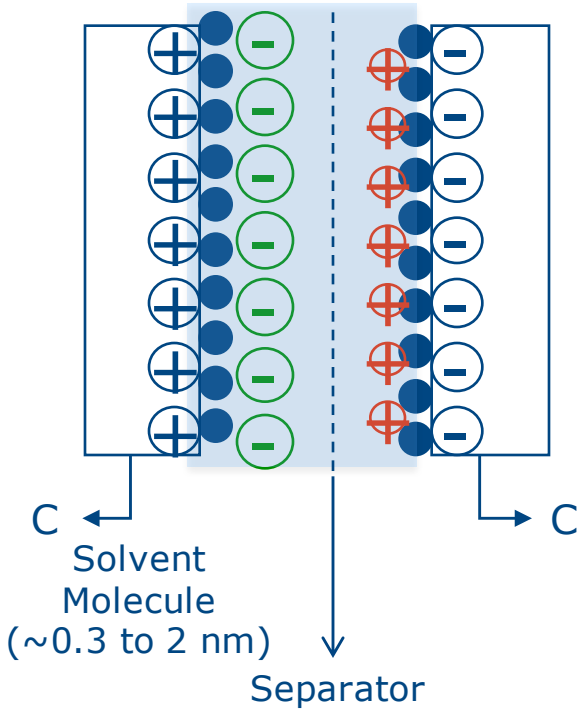
Comparison

Electronic Components KEMET CHARGED.

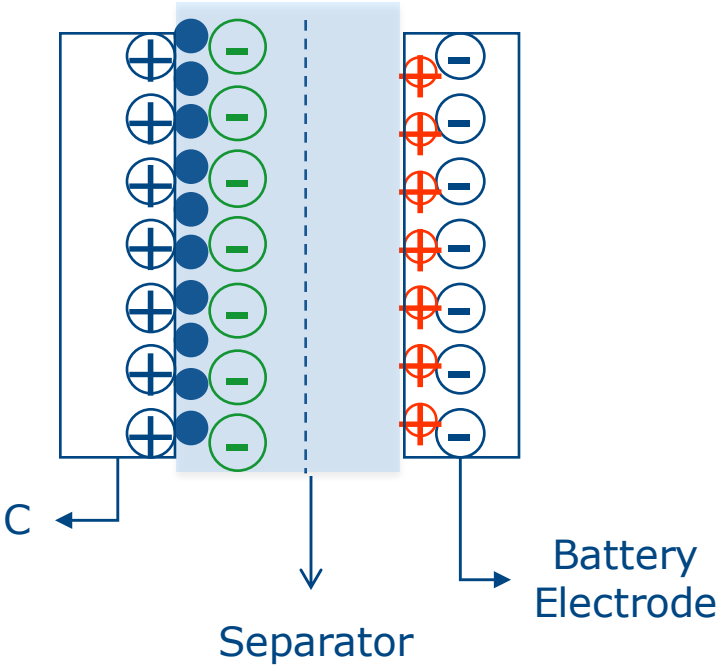
Aluminium Reference



Symmetric "Supercapacitor"



Asymmetric "Hybrid Capacitor"



$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 K A}{d}$$

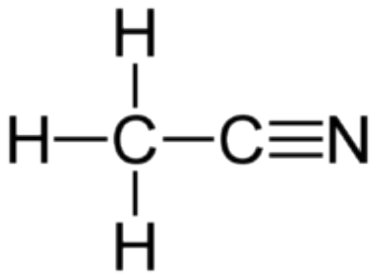
← Surface area of carbon

← Inner Helmholtz Layer

Electrolytes

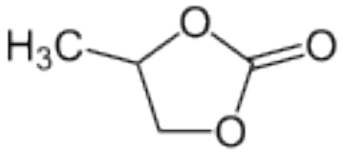
Acetonitrile

- CH_3CN
- Common for SC
- Dielectric constant: 37
- Burns to HCN
- BP: ~80°C



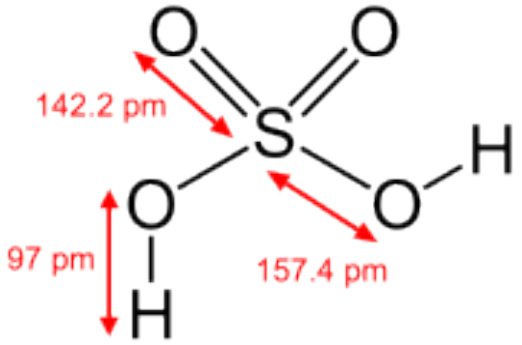
Propylene Carbonate (PC)

- $C_4H_6O_3$
- Dielectric constant: 64
- Destructive effect on graphite
- BP: ~240°C



Sulfuric Acid

- H_2SO_4
- Used in lead-acid batteries
- Dielectric constant: ~100
- BP: 337°C



Tools

Mobile Catalog Apps

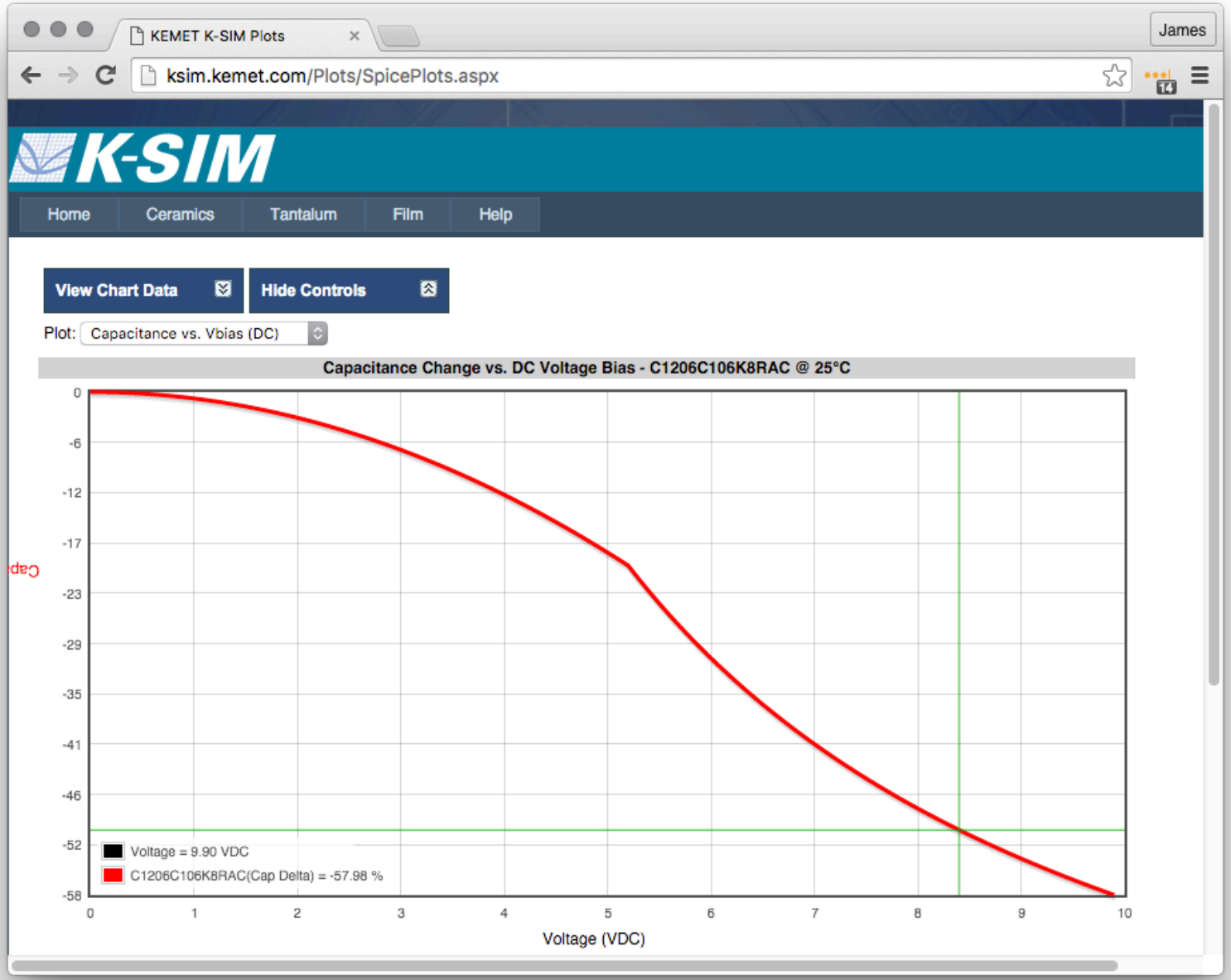
Access to over 350 catalogs and 4.8MM data sheets

Available on the App Store

ANDROID APP ON Google Play

www.kemet.com/mobileapps

ksim.kemet.com

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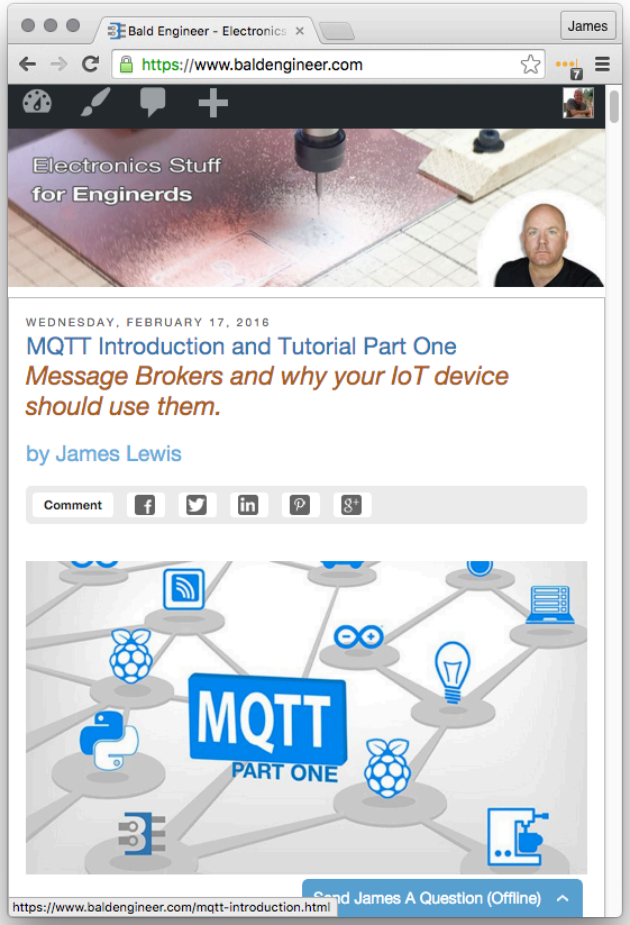
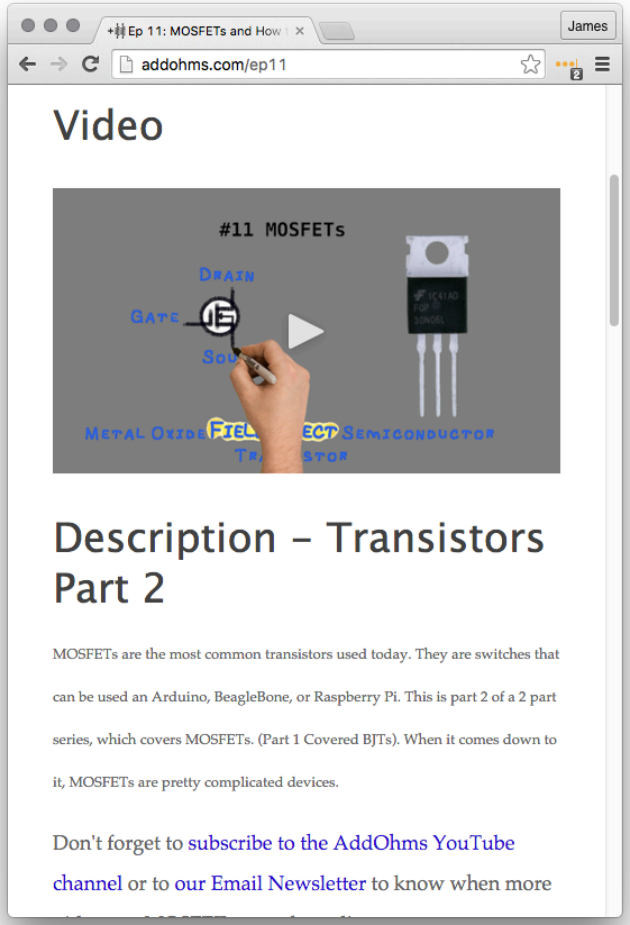


AddOhms



Capacitors should be voltage derated 50%

True Or False

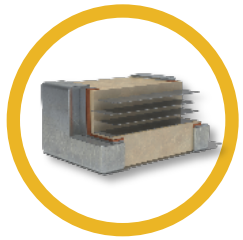
It Depends…

Summary

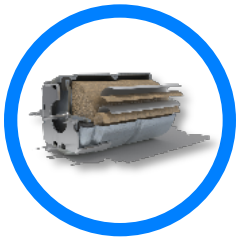
Electronic Components KEMET CHARGED.

Why do you voltage de-rate a capacitor?

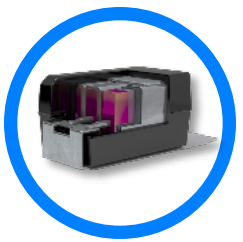
- Ceramic
  - More capacitance



- Aluminum Electrolytic
  - Longer operational life



- Tantalum
  - Power-On Reliability



- Supercapacitors
  - Operational Life

Slides: **www.baldengineer.com/hddg11**

Thank You!