

Power-On Failures in Tantalum and Aluminum SMT Capacitors

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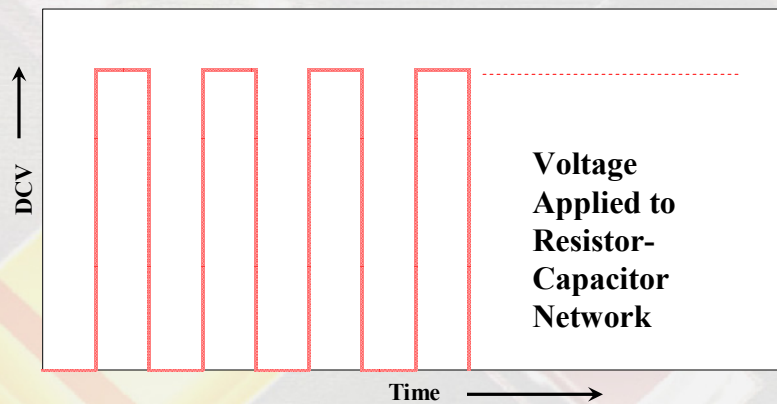
Conflict

- With 100% Electrical Screening,
 - Surge Voltage Test
 - Surge Current Test
 - +85C Leakage @ V_r
 - +25C Leakage @ $1.32 V_r$ (twice)
- why are failures observed at less than V_r ?

Outline

- 100% Electrical Screening
 - Surge Voltage Test
 - Surge Current Test
- Define mechanism for fault creation
 - CTE Mismatch
 - Time above T_g
- Crack Creation / Expansion
- Activating self-healing
- In-line IR-Exposure

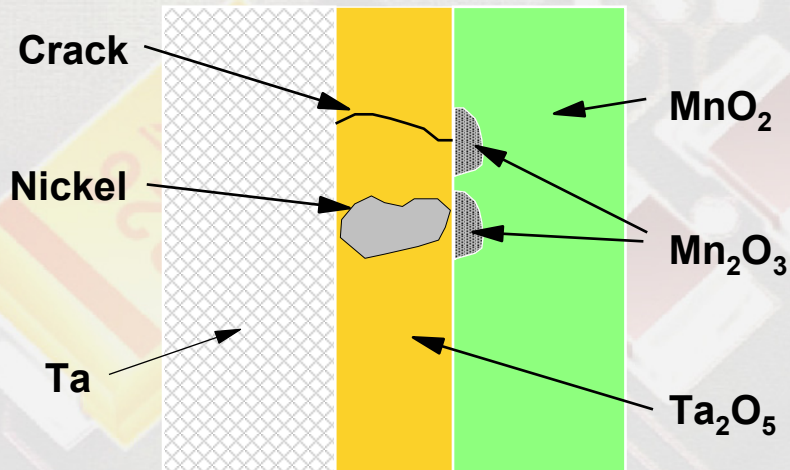
Surge Voltage Pulse Train



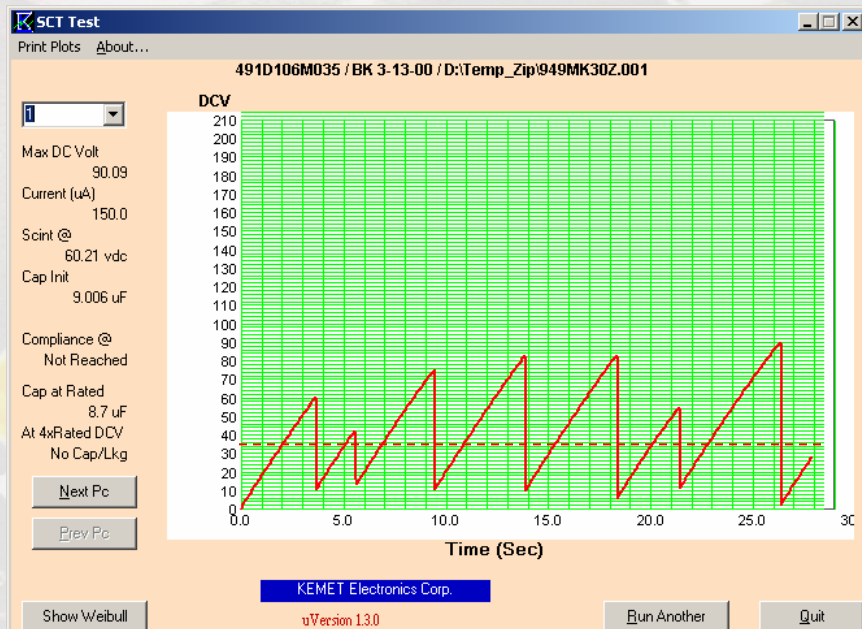
Voltage applied through resistor. Voltage across resistor-capacitor may be constant, but voltage across capacitor may not be.

Electrical Conditioning

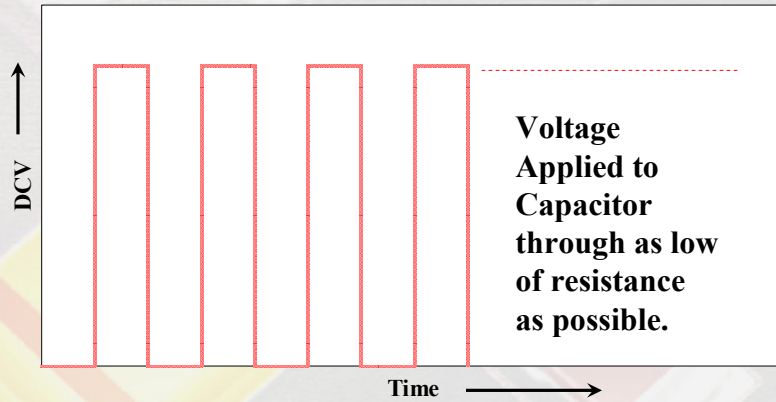
Healing Effect of MnO_2 Layer



Scintillations

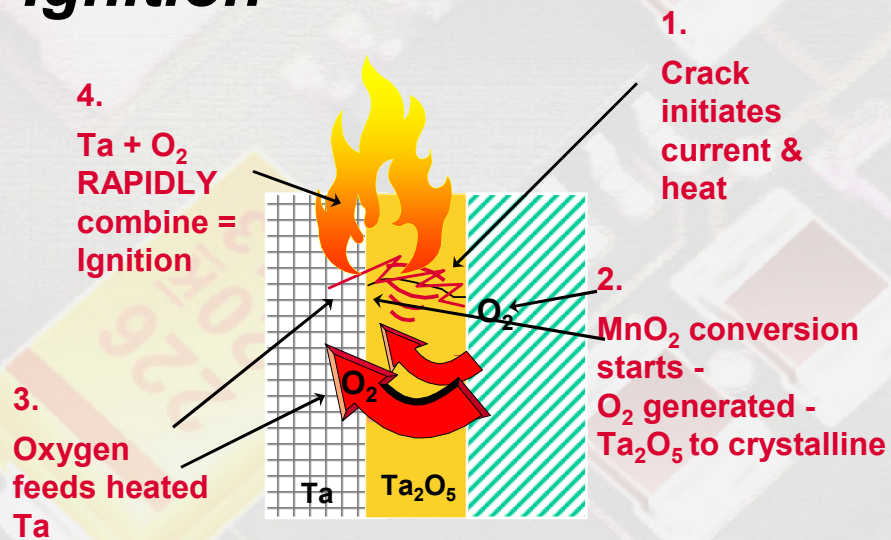


Surge Current Pulse Train

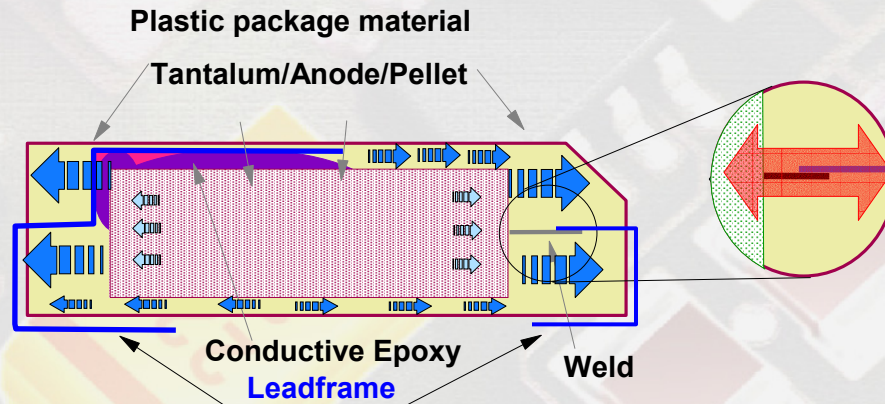


Voltage applied must appear across capacitor. High current leads to catastrophic failures – ignitions.

"Ignition"

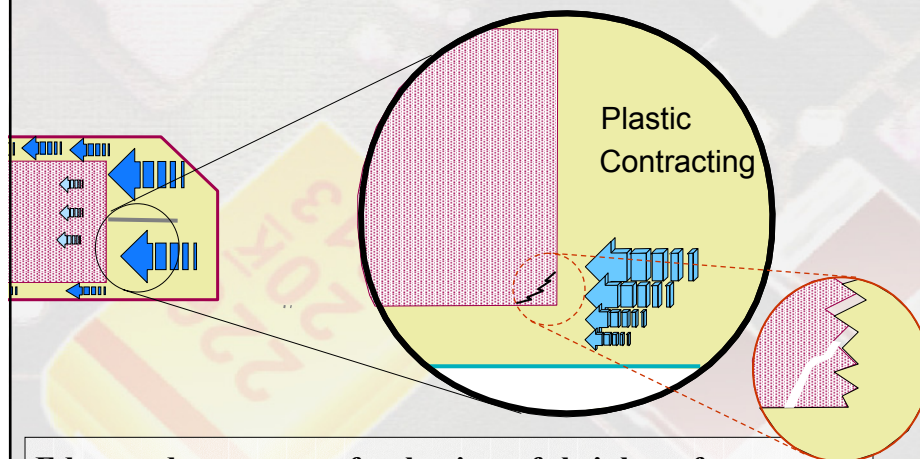


Solder Heat Expansion



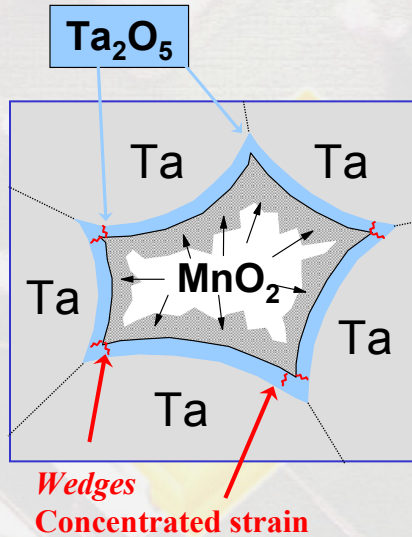
Differences in coefficients of thermal expansion cause stresses to build up within the structure, the mold compound tries to pull (shear) the capacitor apart!

Cooling and Contraction



Edges and corners are focal points of shrinkage forces. Crack can develop in pellet that fractures Ta_2O_5 dielectric sites. Full power application results in ignition - not self-healing.

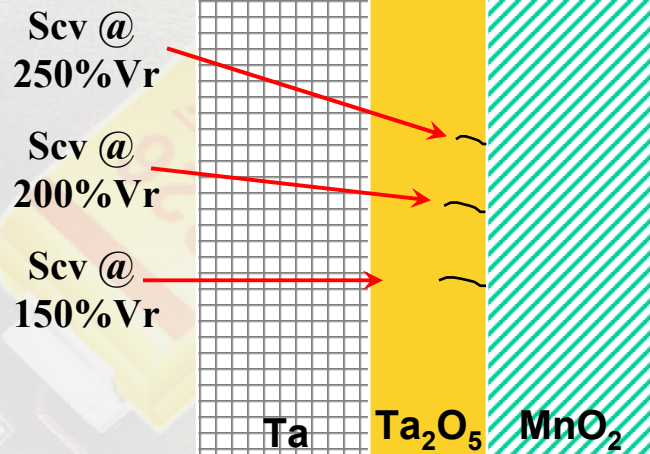
Induced Process Stress - MnO_2



In tantalum anode pellet, areas of constriction exist where tantalum particles form a closed loop around an open channel. The MnO_2 filling this enclosure is a hard, crystalline material. Impregnation process involves dip at $+25^\circ\text{C}$ and conversion at $+270^\circ\text{C}$. Stresses might be root of cracks *created or extended* in dielectric.

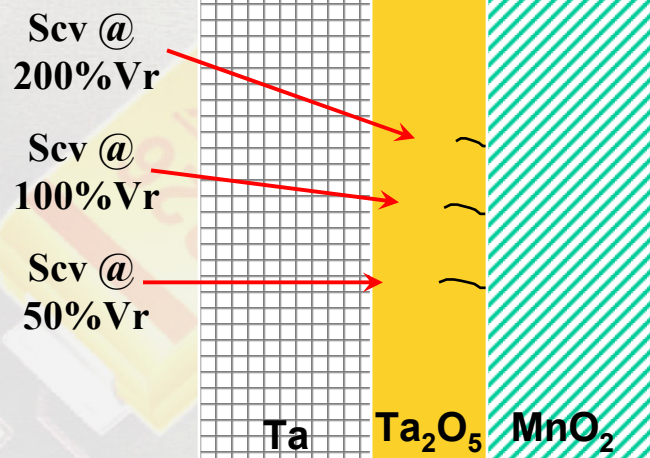
Variable Breakdown Levels Post 100% Electrical Test

Breakdown Relationship to Crack Severity

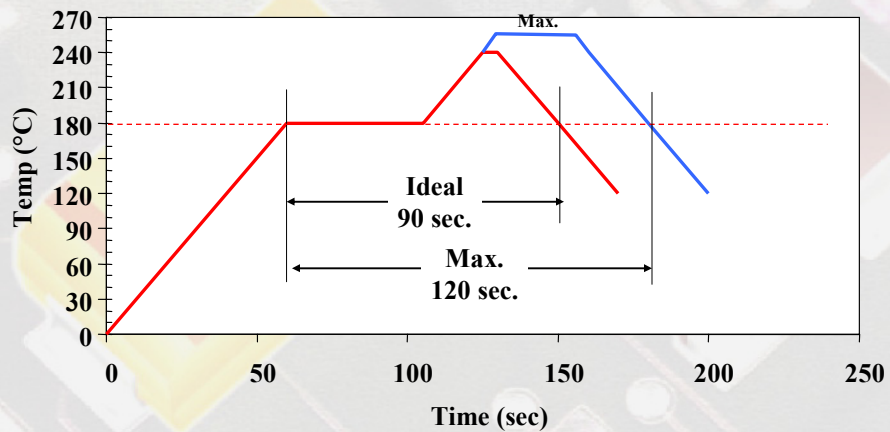


Variable Breakdown Levels Post Solder Process

Breakdown Relationship to Crack Severity

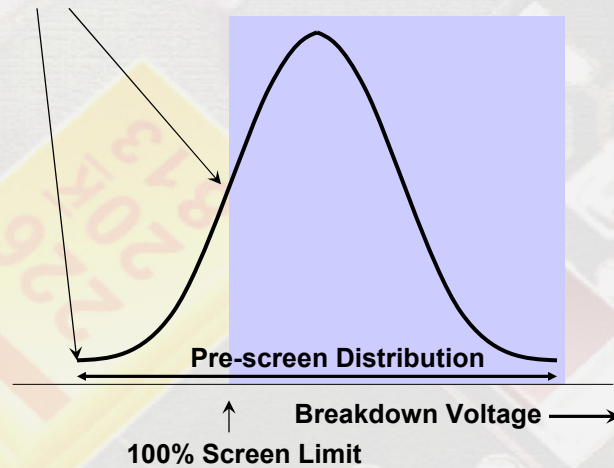


IR Solder Profile



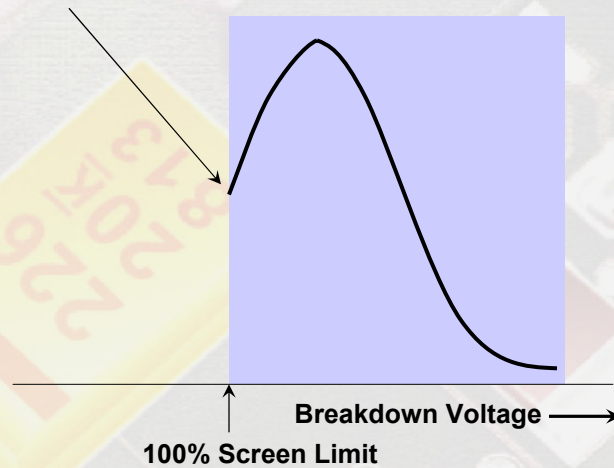
Screening Clips Distribution Tail

Raw Distribution includes pieces below Screen Limit



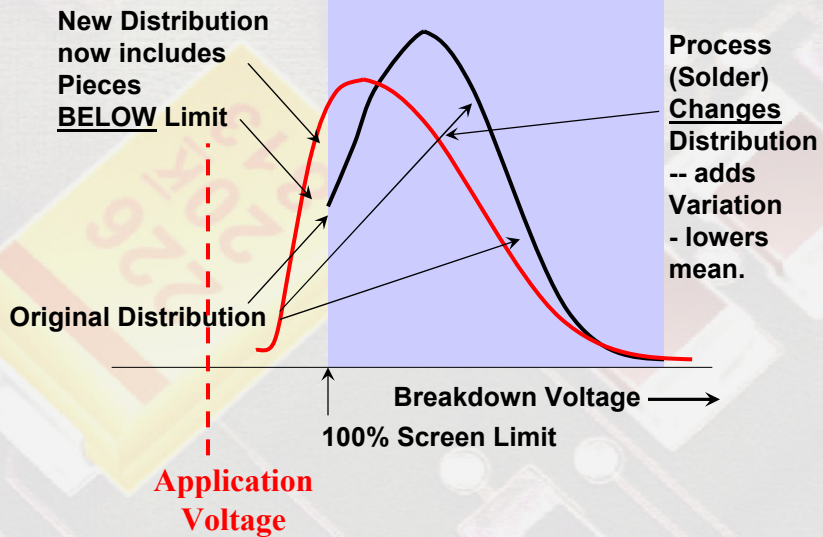
As Packaged Distribution

100% Screen eliminates Distribution below Limit

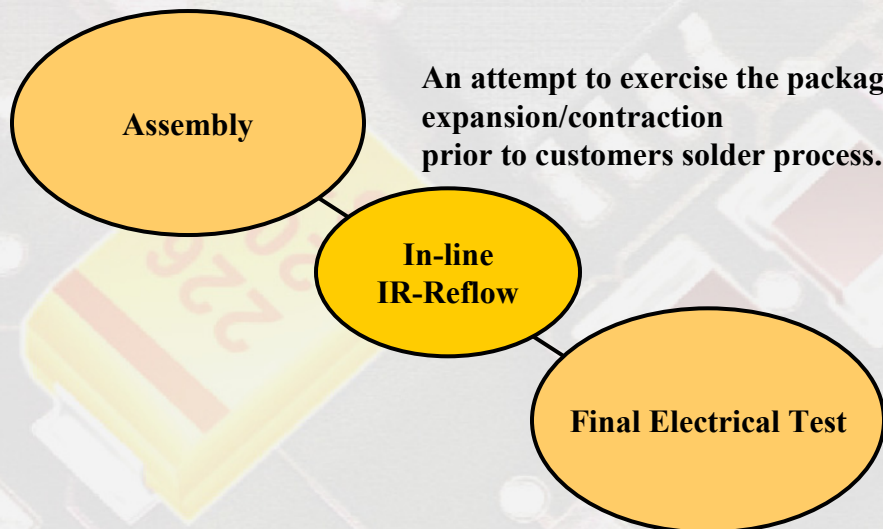


Redistribution

Forces create new, altered distribution after solder.



In-line IR Reflow



Median Values

	MnO ₂ Production (27 batches)	KO-CAP Production (37 batches)	AO-CAP Production (78 batches)
100 PPM @ (%V _r)	68%	114%	235%
FR @ 50%V _r (PPM)	9	0	0
FR @ 80%V _r (PPM)	226	5	0
FR @ 90%V _r (PPM)	478	19	0
FR @ 100%V _r (PPM)	1256	255	0

Conclusions

- **The 100% electrical testing of these devices does not preclude faults from developing within the device.**
 - The mismatch of CTEs for the materials used in these devices can create forces large enough to create new cracks or extend existing cracks during the solder process.
 - The severity of the solder process will have a direct impact to the magnitude of power-on failures.
 - The voltage capability of the device is defined by the level of stress applied to the part after mounting (proof).
 - The closer the peak application voltage is to the rated voltage of the part, the greater the number of turn-on failures.

Recommendations

- Establish a voltage capability of the capacitor through a high resistance.
 - 1 kOhm resistor most common
 - Apply highest voltage that capacitor will ever see.
- Remove the resistance.
- Capacitor has been “proofed.”