



# POLYMER TANTALUM CAPACITORS WITH SUPPRESSED SENSITIVITY TO WATER CONTENT

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# Outline

## Tantalum/Niobium oxide Electrolytic Capacitors

**Liquid electrolyte**

**MnO<sub>2</sub>**

**Polymer**

**WET / Ta anode**

- ionic conduction
- hermetically sealed
- + surge robust
- + high voltage
- + high temperature
- temperature dependent
- frequency dependent
- electrolyte leak possible

**Solid - MnO<sub>2</sub> / Ta anode**

- electronic conduction
- + high temperature
- well established reliability
- failure mode
- voltage limited
- ESR higher
- 50% derating

**Solid - MnO<sub>2</sub> / NbO anode**

**electronic conduction**

**Surge Currents**

**surge current at 25°C**

**significantly higher energy needed**

**total surge energy till 2.4ms**

**AVX Confidential**

## Transient (Anomalous) Currents

**TCJ D10uF/35V**

**current decreases slowly when polymer cathode is very dry**

- the phenomenon is
  - reversible = no permanent dielectric damage
  - dependant on temperature – low temperatures is the worst case
  - more pronounced for pre-polymerized cathode material
  - not limited to AVX product only

**DRY HUMID DRY**

**25°C**

**dry, 125°C**

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## Temperature Cycling Currents

**TCJ D10uF/35V**

- online measurement of current
- when voltage is applied at -55°C current is high, but drops after temperature increase

**Current [mA]**

**Temp [°C]**

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## Anomalous Charging Currents

**TCJ D10uF/35V**

- charging of dry capacitors - charging rate 120V/s
- temperature sensitive – anomaly is between -55 to 65°C

**charging current**

**current at 30V**

**MnO<sub>2</sub>**

**Polymer**

**AVX Confidential**

## Improvement by Technology (DOE)

**TCJ Y33uF/25V**

**Charging Current (reflow + 1 hour) @ 20V (0.8xUr)**

**Parameter C**

**Parameter B**

**Parameter A**

**dU/dt = 120 V/s**

**limit**

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## Improvement of Hermetically Sealed Capacitors

**22μF/100V hermetically sealed polymer**

**short time current measurement**

**charging rate 120V/s**

**the old technology**

**Improved**

**AVX Confidential**

## Improvement of J-Cap™ Undertab

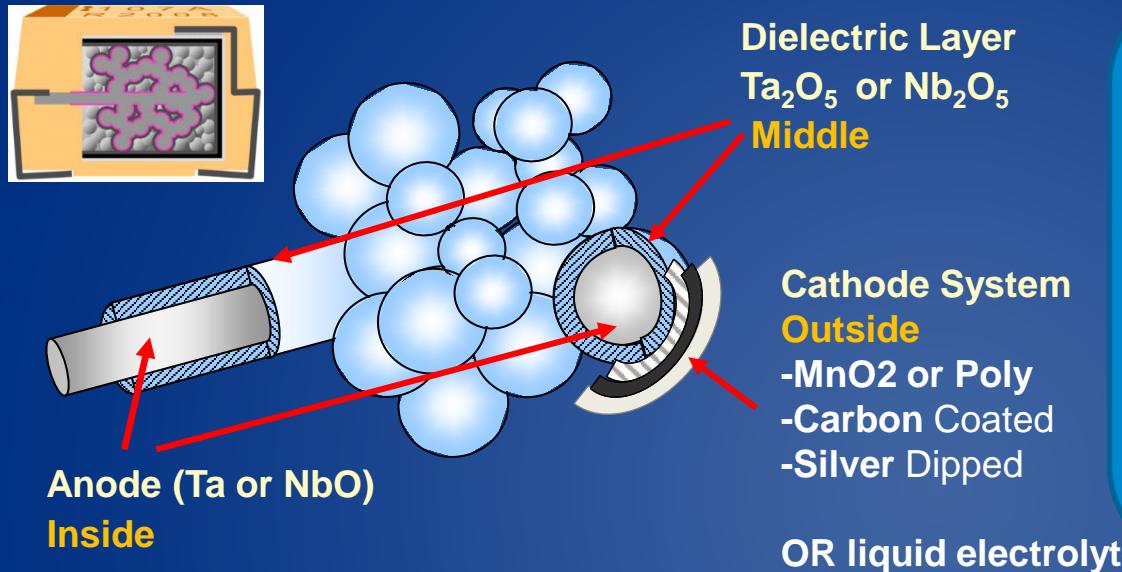
**TCN X47uF/35V**

**from drypack, reflow, reflow+125°C, reflow+150°C**

**reference line = customer DCL limit @ 5 minutes**

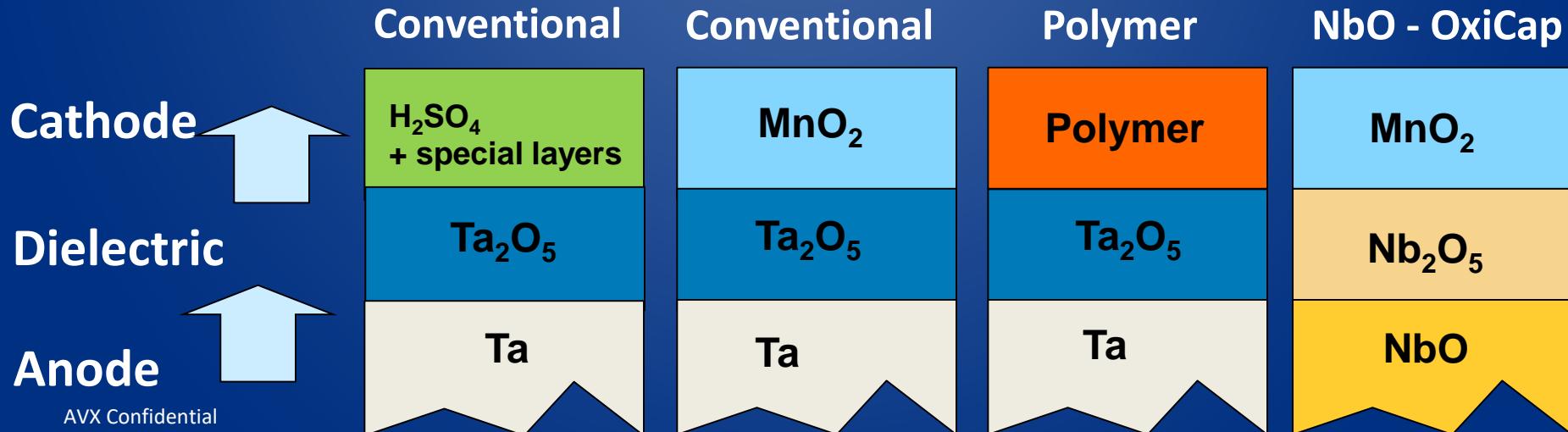
**AVX Confidential**

# Tantalum/Niobium oxide Electrolytic Capacitors



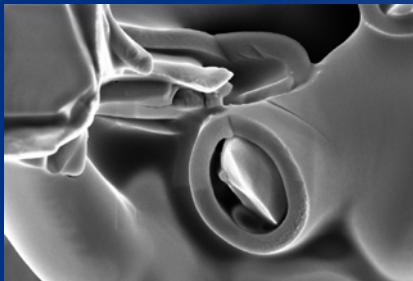
## general benefits

- high capacitance
- volumetric efficiency
- parametric stability
- long service lifetime
- long-term reliability

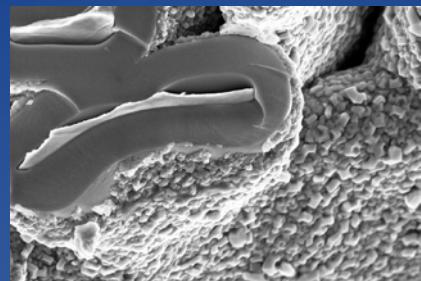


# Tantalum/Niobium oxide Electrolytic Capacitors

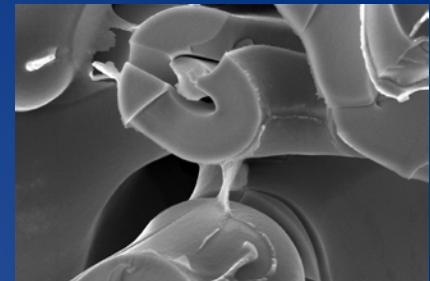
Liquid electrolyte



MnO<sub>2</sub>



Polymer



## WET / Ta anode

ionic conduction  
hermetically sealed  
+ surge robust  
+ high voltage  
+ high temperature  
+ high capacitance  
- temperature dependent  
- frequency dependent  
- electrolyte leak possible

## Solid - MnO<sub>2</sub> / Ta anode

electronic conduction  
+ high temperature  
+ **well established reliability**  
- derating  
- failure mode  
- ESR higher  
- medium voltage limited

## Solid - MnO<sub>2</sub> / NbO anode

electronic conduction  
**+ high reliability and safety**

+ low derating  
- low voltage/temp. limited  
- ESR higher

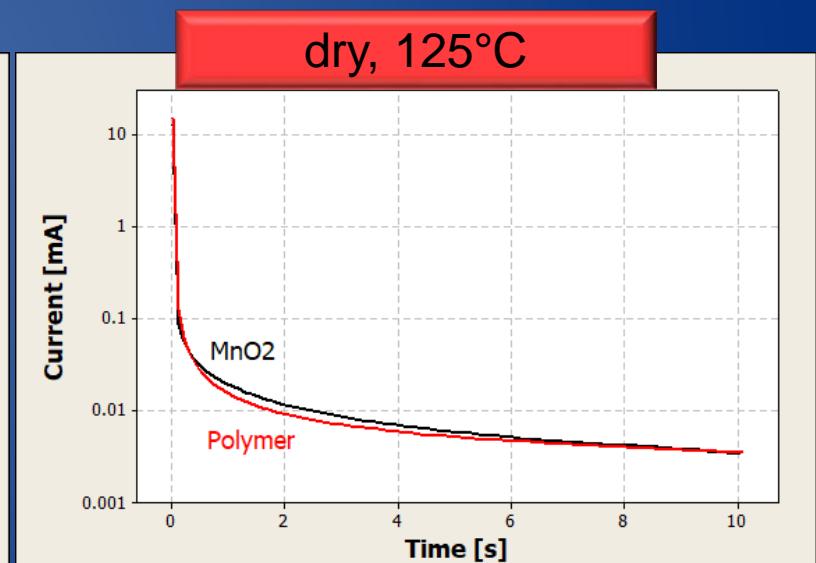
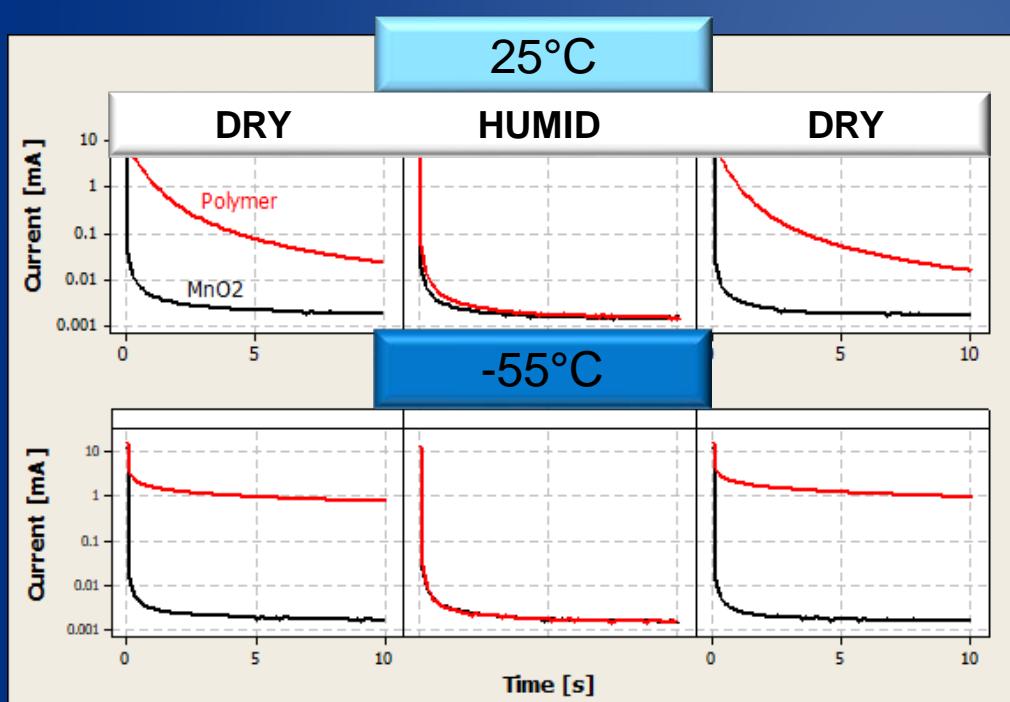
## Solid – Polymer / Ta anode

electronic conduction  
+ low ESR  
+ safe failure mode  
+ high voltage  
+ low derating  
- temperature limited  
- humidity & oxygen sensitive  
- **specific issues**

# Transient (Anomalous) Currents

TCJ D10 $\mu$ F/35V

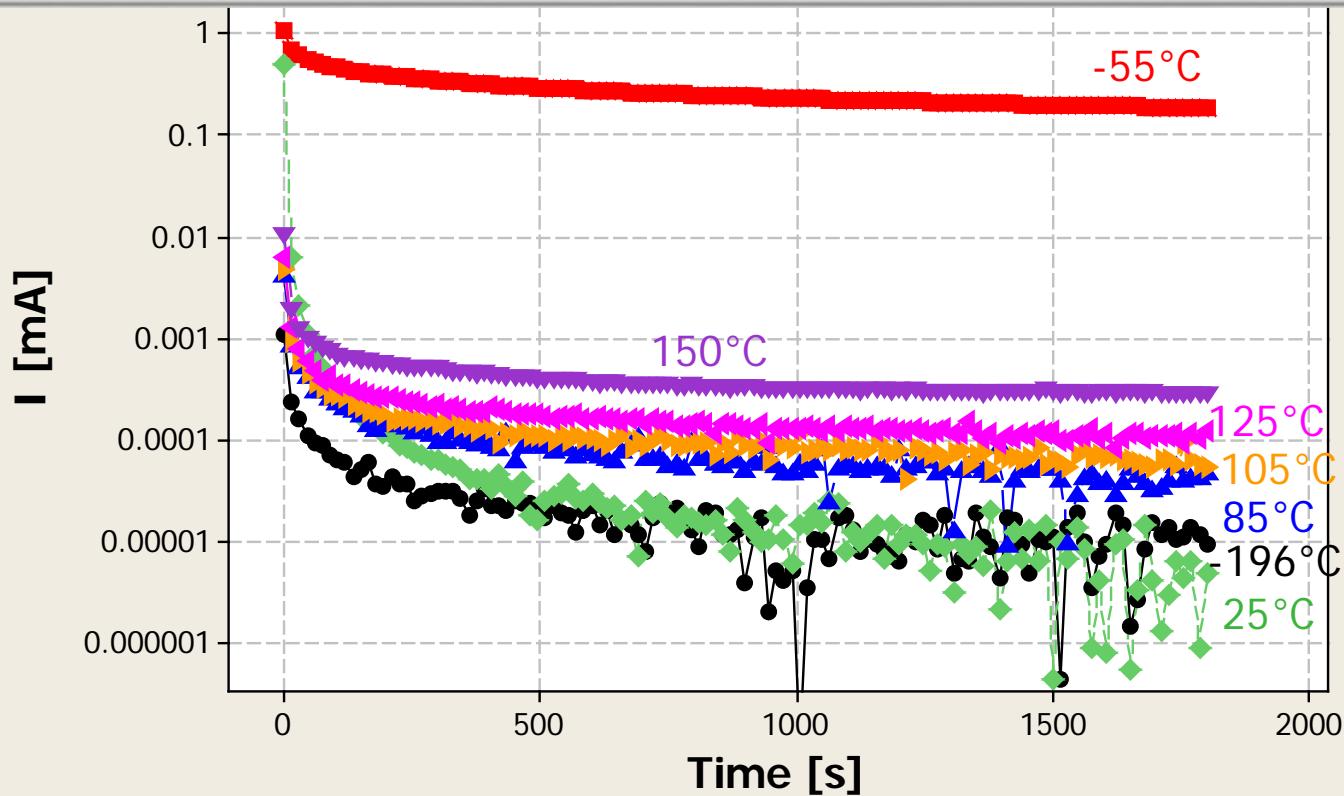
- current decreases slowly when polymer cathode is very dry
- the phenomenon is
  - reversible = no permanent dielectric damage
  - dependant on temperature – low temperatures is the worst case
  - more pronounced for pre-polymerized cathode material
  - not limited to AVX product only



# DC Leakage Currents at temperatures

- with longer time measurement (30 min)
  - at -55°C current is still high
  - at other temperatures current is stabilised

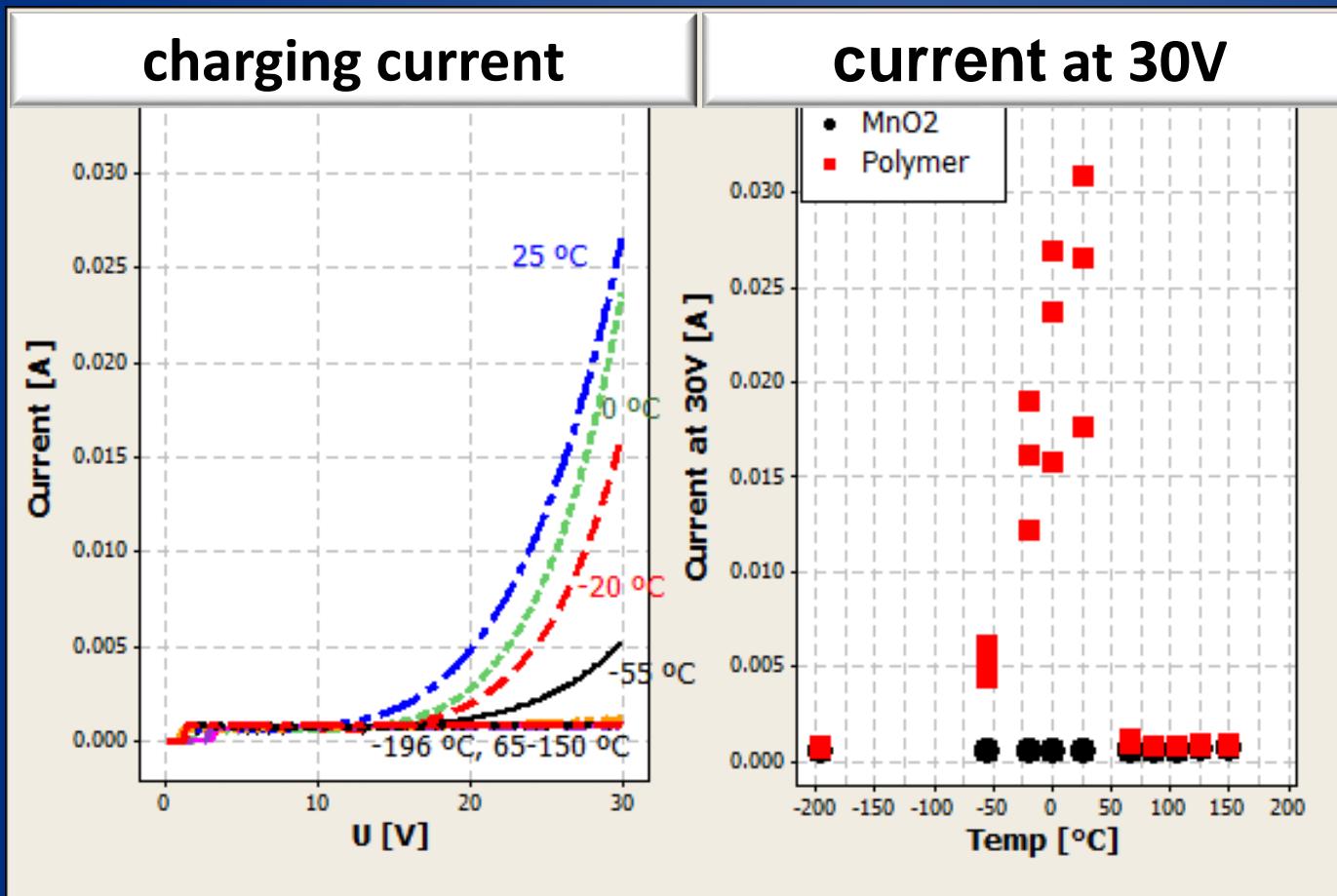
Current measured at rated voltage for 30 minutes



# Anomalous Charging Currents

TCJ D10 $\mu$ F/35V

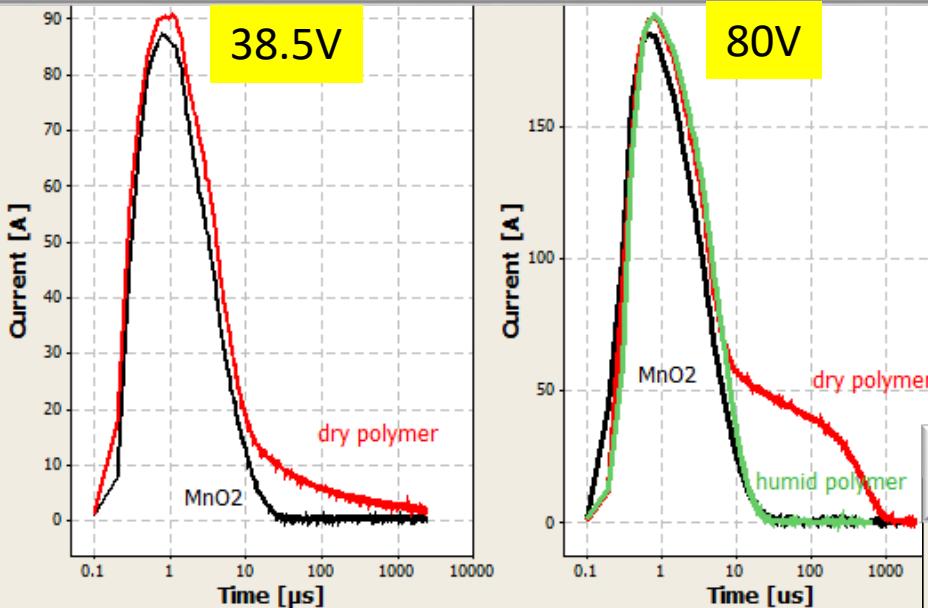
- charging of dry capacitors - charging rate 120V/s
  - temperature sensitive – anomaly is between -55 to 65°C



# Surge Currents

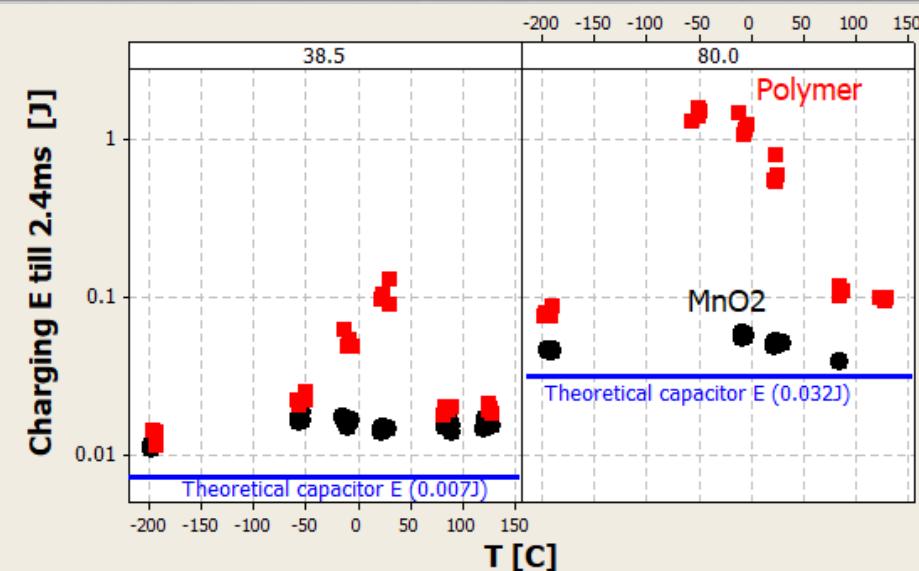
TCJ D10 $\mu$ F/35V

surge current at 25°C



significantly higher energy needed

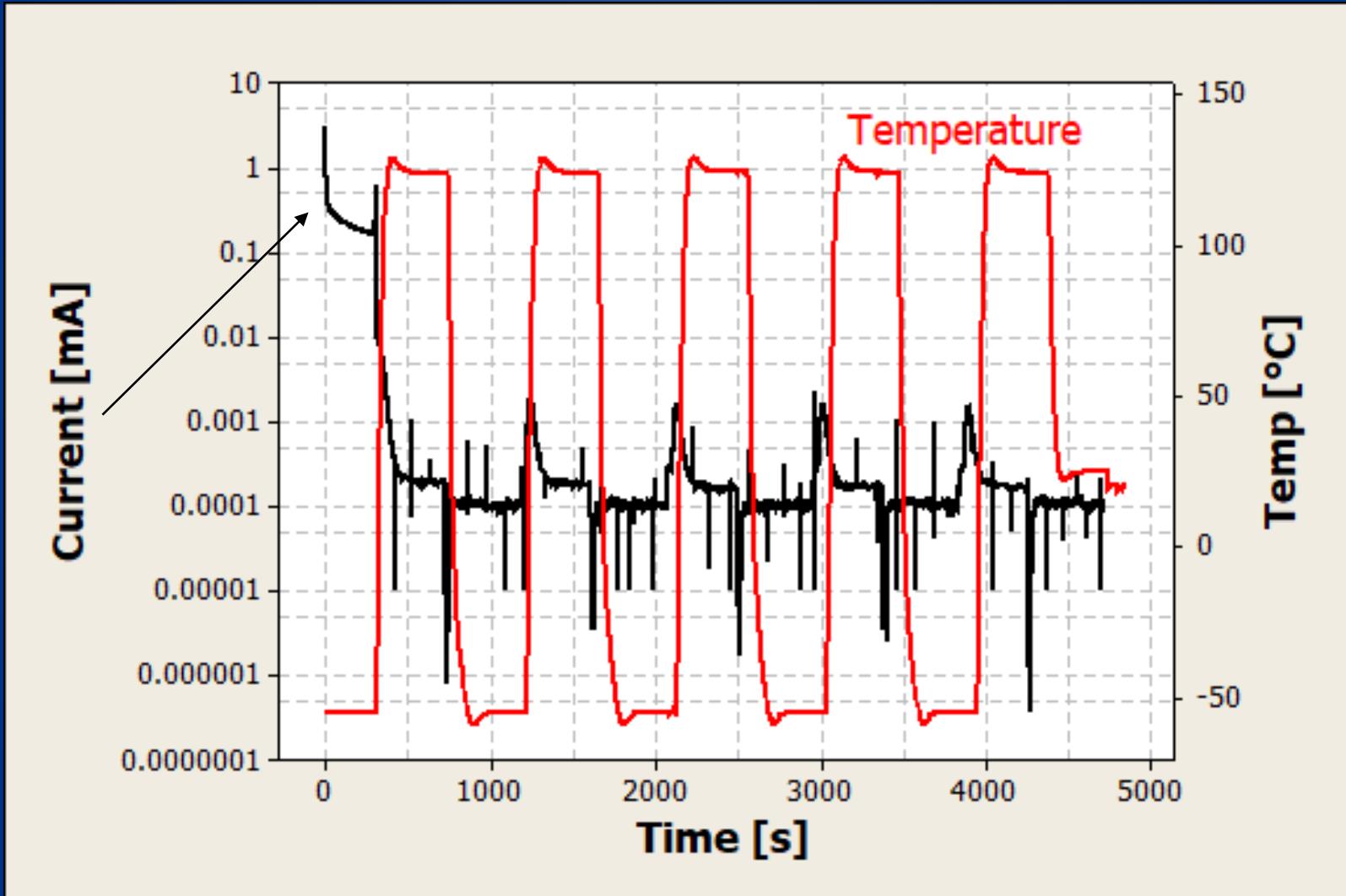
total surge energy till 2.4ms



# Temperature Cycling Currents

TCJ D10 $\mu$ F/35V

- online measurement of current
- when voltage is applied at -55°C current is high, but drops after temperature increase



# Summary

Higher charging currents can occur under specific conditions:

- polymeric cathode
- extremely dry conditions
- temperatures -55°C to +65°C



- after soldering
- hours at elevated temp.
- long time under vacuum
- dry hermetically sealed

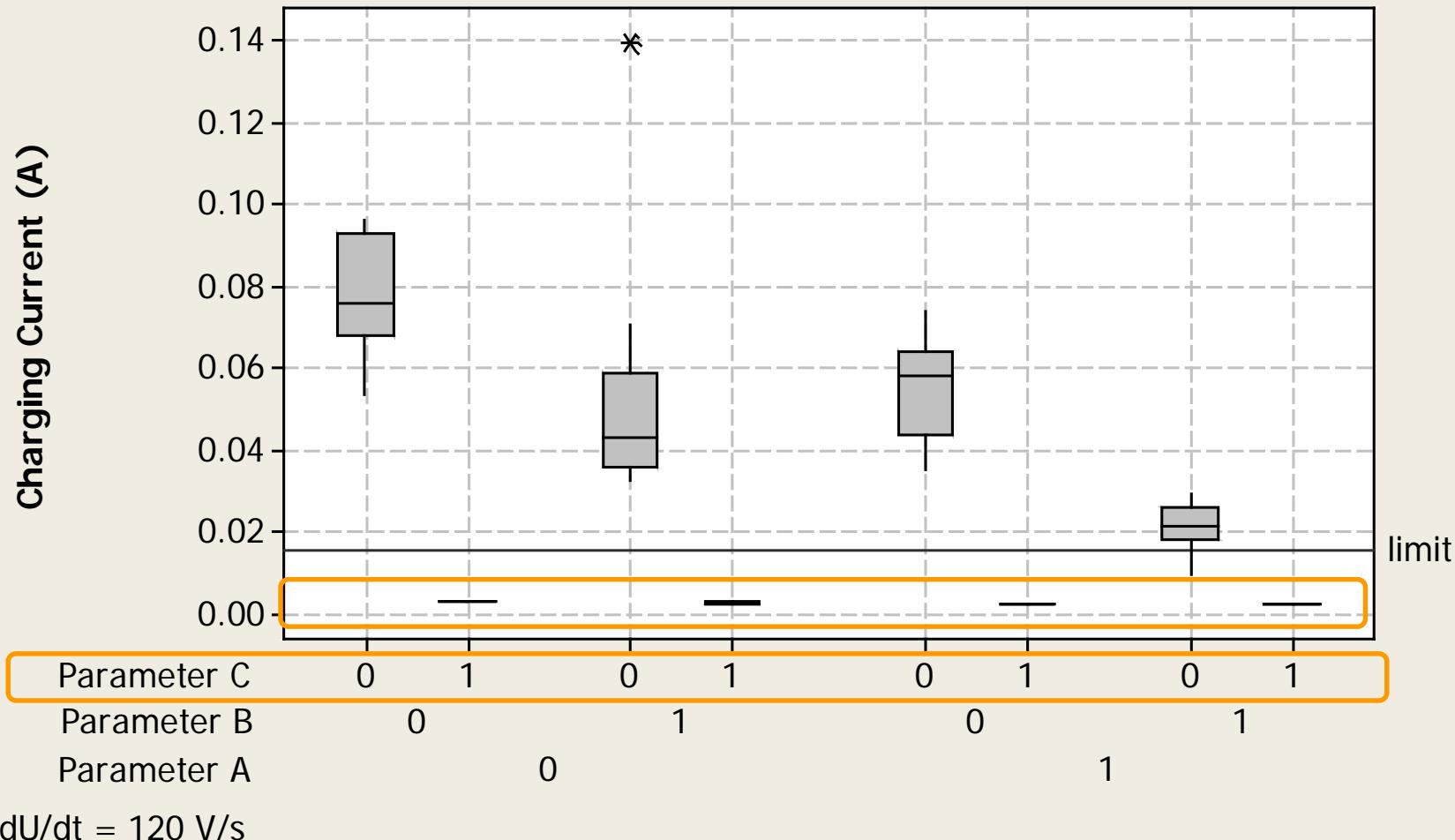
Potential practical impacts:

- difficulties with DC leakage measurement
- problems with charging just after soldering
- high currents when switch on after no bias and dry conditions
- high currents at temperatures below zero

# Improvement by Technology (DOE)

TCJ Y33 $\mu$ F/25V

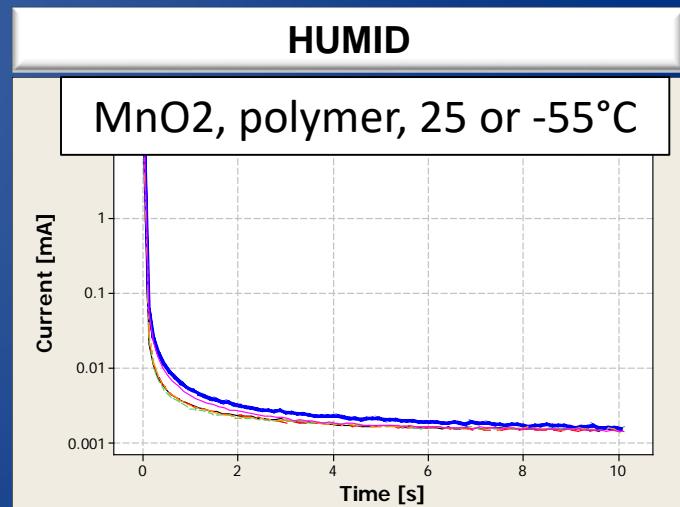
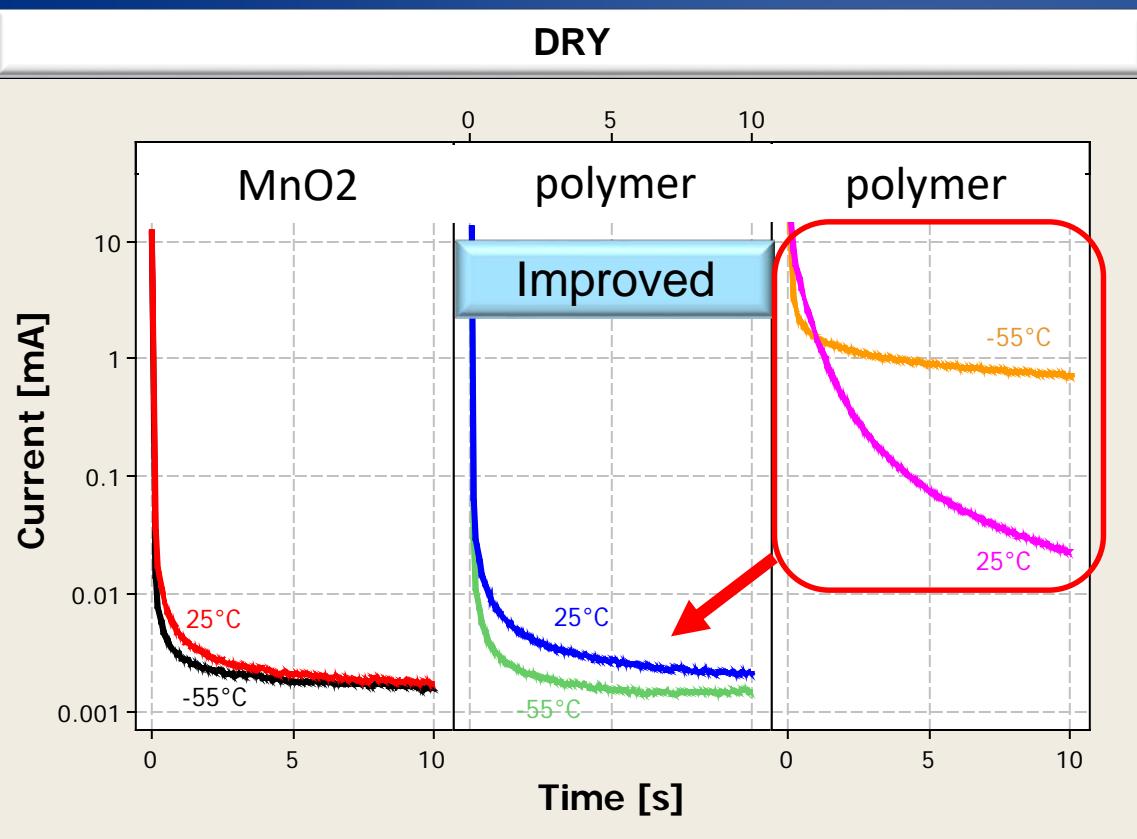
Charging Current (reflow + 1 hour) @ 20V (0.8xUr)  
TCJY336M025#



# Improved Technology Results

TCJ D10 $\mu$ F/35V

current drops fast for improved technology



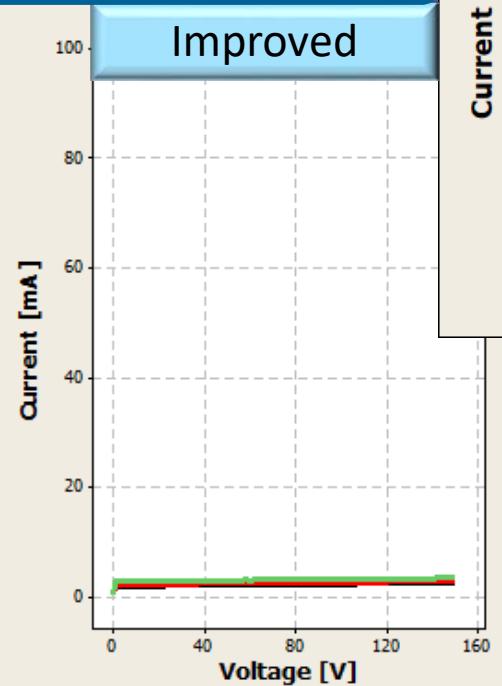
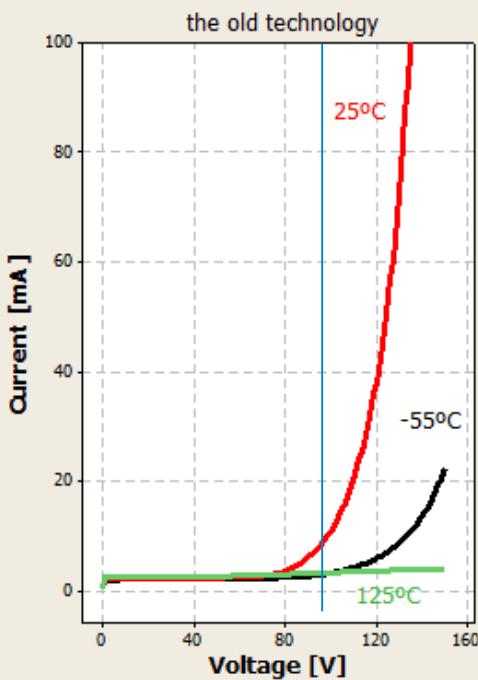
# Improvement of Hermetically Sealed Capacitors

TCH 9 22 $\mu$ F/100V

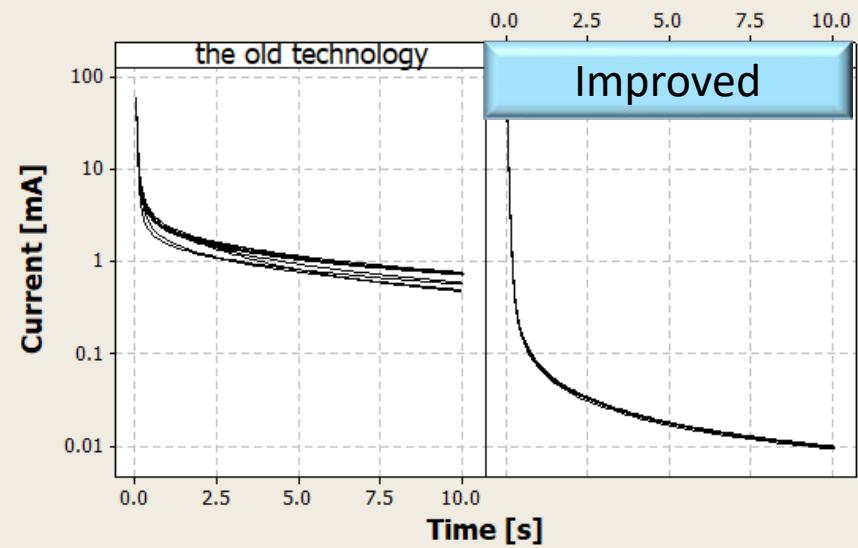


22 $\mu$ F/100V hermetically sealed polymer

charging rate 120V/s

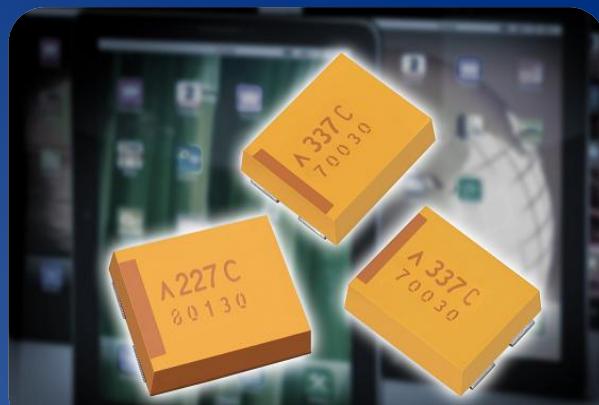
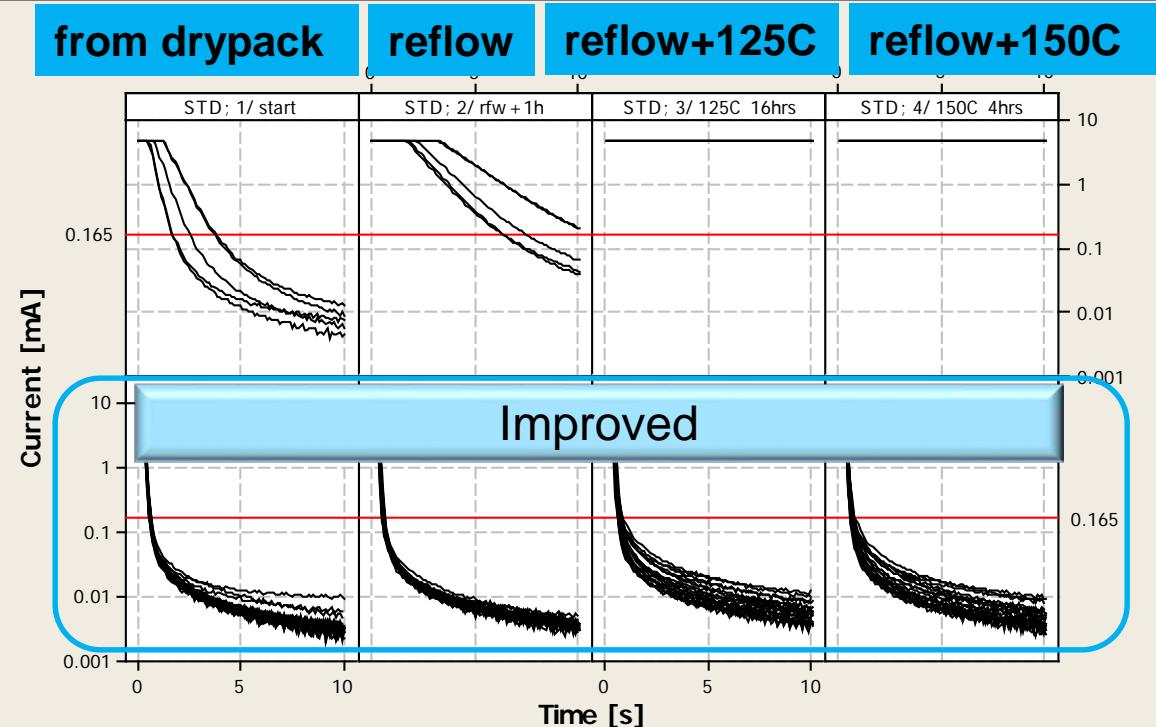


short time current measurement

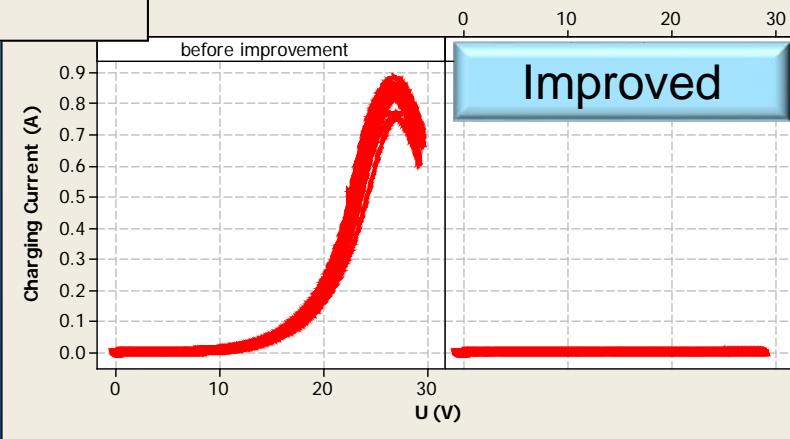


# Improvement of J-Cap™ Undertab

TCN X47 $\mu$ F/35V



TCNX476M035# - Charging current  
25°C drying (16 hrs); reflow & directly measured after cooling



# Conclusions

- dry tantalum capacitors with prepolymerized cathode suffer from increased charging currents and slow current decreasing after voltage application
- the effect is temperature dependent
- clear scientific explanation is not available yet
- AVX has developed specific technology that eliminates the transient current issues



Thank you.

