POLYMER TANTALUM CAPACITORS WITH SUPPRESSED SENSITIVITY TO WATER CONTENT

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Outline

Tantalum/Niobium oxide Electrolytic Capacitors

- Liquid electrolyte
- MnO₂
- Polymer

Solid - MnO₂ / Ta anode electronic conduction
- High temperature
- Well-established reliability
- Failure mode
- Voltage limited
- 50% derating

Solid - Polymer / Ta anode electronic conduction
- High voltage
- Safe failure mode
- High temperature
- Temperature limited humidity & oxygen sensitive

Surge Currents

- Surge current at 25°C
- 30% higher energy needed

Temperature Cycling Currents

- Online measurement of current
- Voltage applied at 55°C; current high, then drops after temperature increase

Improvement of Hermetically Sealed Capacitors

- 22μF/100V hermetically sealed polymer
- Improved charging rate 120V/s

Transient (Anomalous) Currents

- Current decreases slowly when polymer cathode is used

- The phenomenon
  - Dry: no permanent dielectric damage
  - Wet: dry to the granules
  - More sensitive for pre-polymered cathode material
  - Not related to AVX product only

Anomalous Charging Currents

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

Temperature Cycling Currents

- Charging current and current at 30V

Improvement by Technology (DOE)

- Charging current (reflow + 1 hour) @ 20V (0.8xI₀)

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http://www.avx.com
Tantalum/Niobium oxide Electrolytic Capacitors

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

**Diagram**

- **Cathode System**
  - Outside
    - MnO2 or Poly
    - Carbon Coated
    - Silver Dipped
  - OR liquid electrolyte

- **Dielectric Layer**
  - Ta2O5 or Nb2O5
  - Middle

- **Anode (Ta or NbO)**
  - Inside

**Comparison Chart**

<table>
<thead>
<tr>
<th>Conventional</th>
<th>Conventional</th>
<th>Polymer</th>
<th>NbO - OxiCap</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2SO4 + special layers</td>
<td>MnO2</td>
<td>Polymer</td>
<td>MnO2</td>
</tr>
<tr>
<td>Ta2O5</td>
<td>Ta2O5</td>
<td>Ta2O5</td>
<td>Nb2O5</td>
</tr>
<tr>
<td>Ta</td>
<td>Ta</td>
<td>Ta</td>
<td>NbO</td>
</tr>
</tbody>
</table>
# Tantalum/Niobium oxide Electrolytic Capacitors

<table>
<thead>
<tr>
<th>Liquid electrolyte</th>
<th>MnO&lt;sub&gt;2&lt;/sub&gt;</th>
<th>Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WET / Ta anode</strong></td>
<td><strong>Solid - MnO&lt;sub&gt;2&lt;/sub&gt; / Ta anode</strong></td>
<td><strong>Solid – Polymer / Ta anode</strong></td>
</tr>
<tr>
<td>ionic conduction</td>
<td>electronic conduction</td>
<td>electronic conduction</td>
</tr>
<tr>
<td>hermetically sealed</td>
<td>+ high temperature</td>
<td>+ low ESR</td>
</tr>
<tr>
<td>+ surge robust</td>
<td>+ well established reliability</td>
<td>+ safe failure mode</td>
</tr>
<tr>
<td>+ high voltage</td>
<td>- derating</td>
<td>+ high voltage</td>
</tr>
<tr>
<td>+ high temperature</td>
<td>- failure mode</td>
<td>+ low derating</td>
</tr>
<tr>
<td>+ high capacitance</td>
<td>- ESR higher</td>
<td>- temperature limited</td>
</tr>
<tr>
<td>- temperature dependent</td>
<td>- medium voltage limited</td>
<td>- humidity &amp; oxygen sensitive</td>
</tr>
<tr>
<td>- frequency dependent</td>
<td></td>
<td>sensitive</td>
</tr>
<tr>
<td>- electrolyte leak possible</td>
<td></td>
<td>- specific issues</td>
</tr>
</tbody>
</table>

- low voltage/temp. limited
- ESR higher

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Transient (Anomalous) Currents

- 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

-55°C
150°C
125°C
105°C
85°C
196°C
25°C
Anomalous Charging Currents

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

surge current at 25°C

- 38.5V
- 80V

Significantly higher energy needed

total surge energy till 2.4ms

- MnO2
- dry polymer
- humid polymer

Theoretical capacitor E (0.007)
Temperature Cycling Currents

- 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

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
- after soldering
- hours at elevated temp.
- long time under vacuum
- dry hermetically sealed
Improvement by Technology (DOE)

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

TCJ Y336M025#

Parameter A
Parameter B
Parameter C

Charging Current (A)

dU/dt = 120 V/s

TCJ Y33µF/25V
Improved Technology Results

current drops fast for improved technology

**Graph:**
- **DRY:**
  - MnO2 (25°C, -55°C)
  - Polymer (25°C, -55°C)
- **HUMID:**
  - MnO2, polymer (25°C, -55°C)

**Legend:**
- Improved MnO2 and polymer performance in DRY and HUMID conditions.

**Technical Information:**
- TCJ D10µF/35V
- 25°C and -55°C testing conditions.
Improvement of Hermetically Sealed Capacitors

22μF/100V hermetically sealed polymer

charging rate 120V/s

short time current measurement
Improvement of J-Cap™ Undertab

**Table:**
- **from drypack**
- **reflow**
- **reflow+125°C**
- **reflow+150°C**

**Graphs:**
- Current [mA] vs. Time [s] for each category:
  - **STD:** 1/ start
  - **STD:** 2/ rfw+1h
  - **STD:** 3/ 125°C 16hrs
  - **STD:** 4/ 150°C 4hrs

**Reference Line:**
- Customer DCL limit @ 5 minutes

**Graph:**
- Improved performance

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

**Improved**
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.