Tantalum Applications - Reply to General Question

Derating Polymer-Tantalum Capacitors

Tantalum History

The standard practice preached by almost all manufacturers of solid tantalum capacitors has included a recommendation that the devices be used in applications where the operational voltage would be no more than \(\frac{1}{2}\) of the rated. This 50% derating factor assures reasonable failure rates, especially for the power-on conditions experienced in most applications. The processing and materials involved with the T520, T530, or KO-CAP® capacitors involving a polymer cathode system are radically different from those of the traditional MnO\(_2\).

SSST Testing

We have recently begun to rely on SSST (Surge Step Stress Test) results as an indicator of susceptibility to power-on failures as we have seen many instances where the projected failure rates and experienced rates have been the same. (See Update – May 2000 – “Surge Step Stress Testing of Tantalum Capacitors.”) Figure 1 represents the mean data from sample batches run with MnO\(_2\) and polymer. This report covers batches tested from September of 1999 through March of 2000. The sample size varied between 80 and 200 pieces each. The first row lists the percentage of rated voltage where the 100-PPM failure rate level would be projected. The last three rows show the projected failure rates (PPM) for voltage applications of 50%, 80% and 90% of rated voltages.

The failure rate projection is 13 PPM for the MnO\(_2\) product at 50% V\(_r\), which is nearly equal to the polymer’s projected failure rate of 11 PPM at 80% V\(_r\). This correlation is again borne out when looking at the median values from the data collected, as in Figure 2. Here the projected failure rate of 9 PPM at 50% V\(_r\) for the MnO\(_2\) correlates well with the 5-PPM failure rate for the polymer. We are not sure why the failure rates jump so dramatically to the next highest stress level for the MnO\(_2\), as compared to the polymer at these chosen points, but again, this condition dramatically favors the polymer failure rates.

Stress-Induced Failures

We believe that there may be several reasons for this variation, as the dielectrics and anode materials are exactly the same in these devices. One theory suggests that the MnO\(_2\) material, as an inelastic or hard filler deposited in the channels within the device, may create faults in the dielectric as it is being processed. If a channel is seen as a necked-down constriction created with the tantalum particles as in Figure 3,
then the MnO₂ is deposited along the inner walls of this channel. The process of depositing the MnO₂ involves a dip in manganous nitrate solution close to room ambient temperatures, and a conversion from the solution to a solid material at about +270°C. This dip and conversion process is repeated several times to assure complete coating of the dielectric layer and continuous connection into the inner depths of the channels. As these materials are different (Ta, Ta₂O₅, and MnO₂), their coefficients of thermal expansion will vary, and mismatches will generate mechanical forces.

Of critical importance is the “wedge” area where the glassy Ta₂O₅ fills a crevice created where two tantalum particles come together. This in turn creates a “wedge” of dielectric, which is filled by the cathode material. Any forces created with the MnO₂ in this area may be enough to crack or fracture the dielectric. Considering the temperatures involved in the processing, this theory is very plausible.

The T520 or KO-CAP capacitor has the same constricted channel structures, but the fill is created with a polymer – a soft, elastic material. Any mismatches in expansion will cause an elastic displacement of the polymer out of the wedge site. Additionally, the polymer deposition process involves a temperature range from +25°C to +65°C, hardly enough to generate forces even if it were as hard and brittle as the MnO₂.

**Recommended Derating Factors**

We will keep the 50% derating factors as a recommended practice for the MnO₂ cathode system tantalums; but for the polymer-based cathode systems of the T520 and T530 series of the KO-CAP tantalum capacitors, we will recommend a 20% derating factor. This will allow the capacitors to be used at 80% of the rated voltage.