Failure Modes in Capacitors When Tested under a Time-Varying Stress

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Steady step surge testing (SSST) is widely applied to screen out potential power-on failures in solid tantalum capacitors. The test simulates the power supply's on and off characteristics. Power-on failure has been the prevalent failure mechanism for solid tantalum capacitors for decoupling applications. On the other hand, the SSST can also be reviewed as an electrically destructive test under a time-varying stress. It consists of rapidly charging the capacitor with incremental voltage increases, through a low resistance in series, until the capacitor under test is electrically shorted.

Highly accelerated life testing (HALT) is usually a time-efficient method for determining the failure mechanism in capacitors; however, a destructive test under a time-varying stress like SSST is even more effective. It normally takes days to complete a HALT test, but it only takes minutes for a time-varying stress test to produce failures. The advantage of incorporating specific time-varying stress into a statistical model is significant in providing an alternative life test method for quickly revealing the failure modes in capacitors.

In this paper, a time-varying stress has been incorporated into the Weibull model to characterize the failure modes. The SSST circuit and transient conditions to correctly test the capacitors is discussed. Finally, the SSST was applied for testing polymer aluminum capacitors (PA capacitors), Ta capacitors, and multi-layer ceramic capacitors with both precious metal electrode (PME) and base-metal-electrodes (BME).

It appears that testing results are directly associated to the dielectric layer breakdown in PA and Ta capacitors and are independent on the capacitor values, the way the capacitors being built, and the manufactures. The testing results also reveal that ceramic capacitors exhibit breakdown voltages more than 20 times the rated voltage, and the breakdown voltages are inverse proportional to the dielectric layer thickness. The possibility of ceramic capacitors in front-end decoupling applications to block the surge noise from a power supply is also discussed.

To be presented by David (Donhang) Liu at Capacitors and Resistors Technology Symposium (CARTS) conference, Jacksonville, FL, March 28-31, 2011 and published on http://nepp.nasa.gov.