

## Multi-Layer Ceramic Capacitor Technology...Materials, Processes and Reliability Considerations

Ceramic capacitors are widely used in high reliability military and aerospace applications and recent qualifications of Capacitor BME technology within the Space community has delivered larger capacitance values in smaller sizes. This seminar introduces the technologies and materials used to manufacture ceramic capacitors and how these are adjusted and developed to meet a wide spectrum of applications needed from low voltage 4V parts to high voltage KV rated parts. The product design and materials selected are examined to better understand their influence on both the reliability metrics and the parametric performance of the capacitors in the final product application.

Space products are certified within ESCC (ESCC 3009), NASA (GSF) and Mil specifications to QPL standards and these require enhanced screening using CSAM and Burn IN processes. These are discussed in detail along with their influence on defect elimination and product reliability.

Detailed product data is discussed whereby over-voltage and over-temperature conditions have been used to evaluate B.M.E technology product capabilities. This data is used to calculate and extrapolate reliability performance. The QPL status of the MLCC BME products and planned future developments is also reviewed with plenty of time questions.

### Course Outline:

Ceramic Capacitors MLCC and BME Technology.

1. Capacitor introduction – Theoretical concept to practical design using the basic Capacitor equation to develop real life product manufacture models (30 mins)
  - Dielectric types NPO, X7R, X8R, X5R etc.
  - Basic performance parameters (Cap, DF, IR) - variation with Temperature and Voltage.
  - Other electrical parameters examples Z/ESR, VC, TC and measures VBD, Hot IR etc.
  - Real design examples – Effective plate area, Margins, Cover layers restrictions.
2. Capacitor Materials – Dielectric types, Electrodes and Terminations (BME vs PME) (30 mins)
  - Ceramic formulations and manufacture.
  - Ceramic PSD reduction for Higher CV development and the addition of rare earths
  - Electrode materials.
  - Termination materials - enhanced reliability with Flexible termination.

3. Capacitor Manufacture process (30 mins)
  - Fabrication. , Fire Ceramic, Termination, Electroplating, Testing, Packaging.
  - Quality system – reliability testing.
  - Commercial vs. Space grade High reliability products.
  - Process Flow for Space grade BME parts
  - Cycle time discussion.
  
4. Capacitor Defect types and screening techniques. (30 mins)
  - Customer Induced failure modes – mechanical, Thermal, etc.
  - Manufacturing related defects.
  - 100% Electrical testing methods – IR distribution Clip Test method.
  - 100% Burn IN.
  - CSAM Inspection.
  
5. BME Capacitor Design and evaluation for Space application. (30 mins )
  - Design models and theoretical V/um capability.
  - Overvoltage and Over temperature product evaluations.
  - Long term reliability testing evaluations and testing (2,000 / 4,000 / 10,000 hr.)
  - MTTF and reliability calculations.
  - Ripple Current, VC, and ESD performance.