Effect of Defect Dynamics on Reliability of X7R Multilayer Ceramic Capacitors

Pedram Yousefian
Penn State
pyousefian@psu.edu

Base metal electrode (BME) multilayer ceramic capacitors (MLCC) are widely used in aerospace, medical, military, and communication applications, requiring a high level of reliability. Thus, determining the lifetime reliability of MLCCs is critical to provide more reliable components and no weak links to the electrified infrastructure. The burn-in test is a screening procedure used to eliminate components with higher probability of infant mortality failures. During this process, components are exposed to high temperatures and voltages relative to their design. The effect of the burn-in test on the dynamics of oxygen vacancies were studied using thermal stimulated depolarization current (TSDC), impedance spectroscopy, and in-situ high-accelerated lifetime testing (HALT). The TSDC results unveiled that the burn-in test caused intragranular and transgranular migration of oxygen vacancies, which will not be relaxed afterwards. These electromigrations can be in the form of dissociation from locally associated defect complexes, pile up of vacancies at a grain boundary, and transgranular migration. Mean time to failure (MTTF) data gathered from in-situ HALT demonstrated that burn-in tests were not only ineffective at detecting infant mortality failures, but also had a negative impact on the reliability of BME MLCCs. Moreover, we demonstrated that the annealing process is insufficient for MLCCs recovery. The tracking of MTTF with various models, as well as future challenges to shape changes in the population distribution around these MTTF differences with variables such as electric field, temperature, and time will be discussed.