

# PROJECT BRIEF

## Damage Mapping in Layered Devices

Researchers: Roi Meiom and Wade Lanning

### Objective:

In this program we will map the spatial distribution of processing- and service-induced damage in dielectric-conductor multilayer devices such as the one shown in Figure 1. The resulting correlations between the defects and device performance will be used in the future to develop more refined lifetime prediction and component "burn-in" strategies



Figure 1:  
A commercial multilayer ceramic capacitor (MLCC)

### Background

Processing- and service-induced stresses can drive the growth of cracks in both multilayer ceramic and electrolytic capacitors. If we can map these stresses and the associated damage, it should be easier to identify the root cause of the failure (i.e., the initiating flaw). Once these flaws and the driving forces for growth are known it is possible to:

1. take steps to mitigate the damage and/or residual stresses and
2. estimate component life and develop appropriate burn in acceleration strategies.

We have three tools at our disposal that can be used to map the stresses and damage in dielectric-conductor multilayer devices: nanoindentation, Raman spectroscopy, and electron backscatter diffraction (EBSD). Nanoindentation can be used to map the reduced elastic modulus and hardness distributions in materials, an example of such a map is shown in Figure 2.

We have performed studies on a variety of dielectric materials (mostly silicate glasses and PZT) in both flat and curved (fiber) configurations. Our ability to measure the local mechanical properties of a surface become particularly useful when combined with other state-of-the-art strain measurement tools.

In collaboration with our colleagues at NIST in Gaithersburg, MD (Dr. Robert Cook and his associates), we will use a high resolution Raman technique to map stresses in dielectric materials. They also have a very high resolution electron backscatter diffraction (EBSD) system that we will use map strains within the electrodes and other materials that are not Raman active.

When combined, these three techniques can be used to map damage and stresses in devices such as ceramic and electrolytic capacitors.

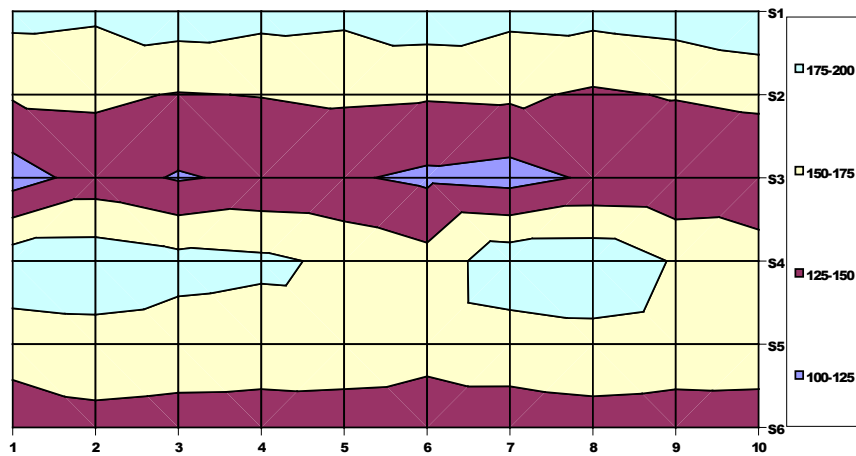


Figure 2:  
Spatial Distribution of the reduced elastic modulus (in GPa) for a ~450 nm thick Pt thin film

### Project Tasks

The three mapping techniques described above (nanoindentation, Raman spectroscopy and EBSD) will be applied to as-received and electromechanically stressed components and/or "model systems". The first system that will be evaluated is a MLCC based on BaTiO<sub>3</sub> with Ni electrodes and the second, a more complex, three dimensional Ta-based electrolytic capacitors. Once the maps of the initial and "stressed" conditions of the MLCC and electrolytic capacitor model system have been created, we will turn our attention to correlations with device performance. Our expectation is that these maps will reveal "hot spots" that will be associated with cracks or other defects.

The long term goal is to use the knowledge of defect size and stress distributions with established fracture mechanics models to estimate the critical conditions for device failure.