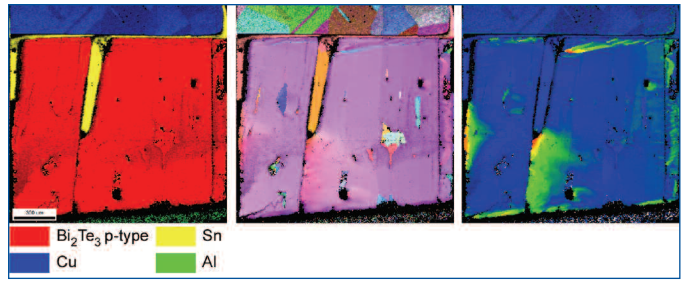
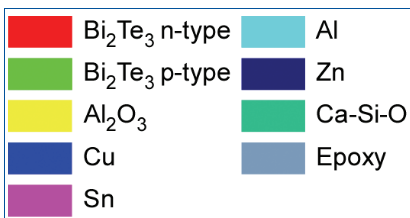
Thermoelectric (TE) Materials

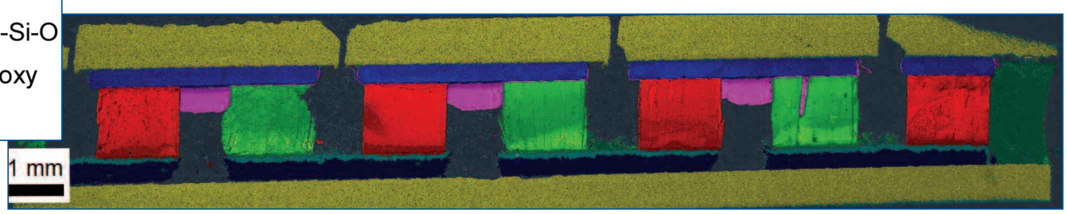
APPLICATION NOTE - EBSD

Thermoelectric (TE) materials convert thermal gradients to useful electrical power or use electrical energy to manipulate thermal energy in cooling and heating applications. TE behavior is a function of the thermal and electrical conductivity of a material, and these intrinsic properties are anisotropic, or dependent on crystallographic orientation. Electron Backscatter Diffraction (EBSD) is a Scanning Electron Microscope (SEM) based characterization tool for determining the orientation, grain boundary structure, and phase distribution comprising a material, and is therefore an ideal tool for analyzing and understanding thermoelectric materials and correlating their microstructure to the resultant performance.

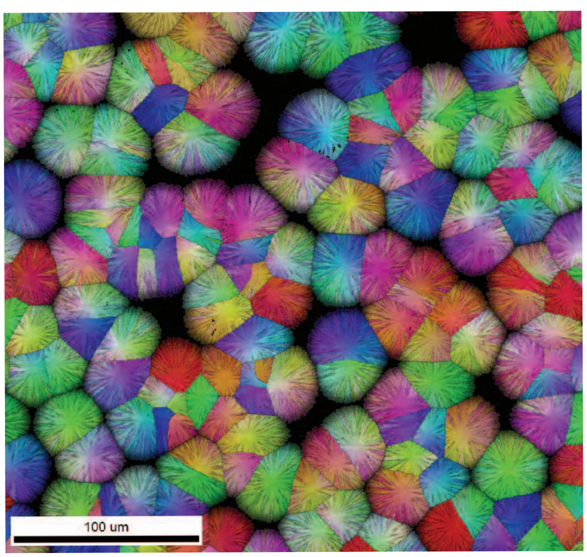


Phase map (left), Orientation map (center) and Orientation Deviation map (right) from single p-type Bi-Te device element. The phase map shows the presence of a tin phase within the TE element and the orientation spread map shows large orientation gradients present at the tin-Bi_2Te_3 interfaces. These strained regions will affect the thermal and electrical properties of the TE material.





Phase map combined with gray-scale EBSD image quality map generated from simultaneously collected EBSD-EDS data from cross-sectioned Bi-Te TE device showing the many phases that are present in a TE device. The microstructures of each of these phases, as well as the interfaces between the phases, contribute to the overall performance of the device and can be optimized for increased efficiency.



Orientation map of skutterudite TE material. The black regions are amorphous material which scatter phonons differently that the crystallized material, which will decrease thermal conductivity and enhance phonon glass electron crystal (PGEC) behavior for improved efficiency.

EBSD and Thermoelectrics

- Developing new applications of TE materials require higher efficiencies than current devices in order to be commercially viable
- Control of crystallographic texture and grain boundary structure is critical to TE efficiency
- EBSD is the ideal tool for fast and automated simultaneous measurements of both crystallographic orientations and grain boundary structure for TE material systems and correlating these measurements with TE performance
- EBSD can identify and help increase the fraction of twin boundaries and other coherent grain boundaries which can reduce thermal conductivity while maintaining electrical conductivity and improve TE performance
- Integrated EBSD-EDS analysis can be used to identify and map different phases within a device with sub-micron resolution
- EBSD is a key link for understanding and controlling TE microstructure and efficiency

Results with Confidence