Grains, Domains and Solid Solutions: Extrinsic Effects on Phonon Thermal Transport in Oxides and Techniques to Characterize Them

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This tutorial will provide a survey of various extrinsic phonon scattering mechanisms and their impact on the thermal transport properties of several oxide material systems. The thermal properties of a material can have a profound impact on its operational performance in a given application. As an example, passive and active components alike may suffer both performance degradation and reliability issues as a result of both acute and/or sustained operation at temperatures outside their intended operational range.

This presentation will cover several phonon scattering mechanisms in a variety of materials to shed light on how nano-structuring affects the thermal conductivity of a material. Various mechanisms include scattering at incoherent interfaces, such as grain boundaries in nano-grained $SrTiO_3$ and $BaTiO_3$, scattering at coherent interfaces such as weakly bonded layers in $Sr_2Nb_2O_7$ and ferroelastic domain boundaries in $BiFeO_3$, and scattering due to point defects such as impurities/dopants in solid-solution alloys such as PZT. In addition, this tutorial will elaborate on several of the characterization techniques used to measure the thermal transport properties on the nano-scale, including opto-thermal techniques such as time domain thermoreflectance (TDTR) and frequency-domain thermoreflectance (FDTR), as well as electro-thermal techniques such 3-omega. The overarching goal is that the attendees will be able to leave with an improved understanding of phonon thermal transport and apply the concepts presented here in their own research on various ferroelectric materials.