Lattice Dynamics in Energy and Information Technology Materials

In a society with growing energetic and information processing requirements, meeting these in a secure and sustainable way is a priority. Mitigating the energy lost in energetic transformation or storage and in information handling is one approach. For example, harnessing waste heat via thermoelectric devices holds some promise. For information technology, thermal management is a similar concern, as the desire for increasing processing speed or storage density calls for new materials.

Successful thermoelectric materials are found in a tight configuration spot where large electric conductivity and thermopower meet low thermal conductivity. Characterizing the lattice dynamics underlying the thermal conductivity in bulk and nano thermoelectric materials is a challenging task that inelastic scattering techniques such as inelastic neutron scattering and nuclear inelastic scattering can elegantly tackle. Phonon properties obtained in some bulk and nanostructured thermoelectrics, e.g. skutterudites, clathrates, and tellurides will be discussed.

Phase change materials utilized in rewritable DVDs require two primary characteristics: a large reflectivity contrast between the amorphous and crystalline state, and a low thermal conductivity that facilitates localized, fast, and low-power switching. Interestingly the lattice thermal conductivity in the amorphous and metastable crystalline state differs only by a factor two. Mössbauer spectral and nuclear inelastic scattering measurements provide direct experimental insights into the unique modifications in the lattice dynamics and electronic configuration upon crystallization.

The common theme that emerges from these two examples is the crucial importance of the chemical bond and its relation with the lattice dynamics for energy transport processes. Tuning bonds appears as a golden avenue for materials research.

Dr. Raphael Hermann has been a senior researcher in the dept. of materials science and technology at Oak Ridge National Laboratory since 2015. His research is directed towards characterization of vibrational properties of materials using neutron scattering, ultrasound, and Mössbauer spectroscopy. Previously, Dr. Hermann was research staff at Forschungszentrum Jülich, Germany, from 2006-2015, during which time he was a visiting professor at the University of Liege in Belgium from 2009-2015. He has been awarded the Helmholtz-University Early Career Fellowship (2007) and the "Prix des Amis de l'Université de Liège" for research on the guest dynamics in filled clathrates (2007). Dr. Hermann is a member of the American Physics Society, Acoustical Society of America, Materials Research Society, and AAAS, and has served as a prominent figure in the organization and coordination of many international collaboration programs.

Raphael P. Hermann
Materials Science and Technology Division
Oak Ridge National Laboratory
Tuesday, July 31, 2018
Ryan Hall, Rm. 4003, 11:00a.m.-12:00p.m.