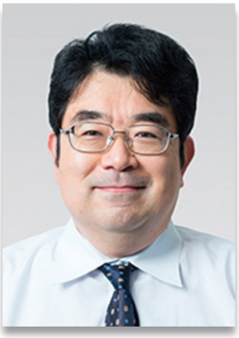
PLENARY SESSIONS



TAKAO MORI

Field Director, Research Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS)

Development of High-Performance Thermoelectric Materials & Modules for Power Generation and Cooling

Monday, May 18
8:40 – 9:15 a.m.

We have been utilizing novel routes such as magnetism, Anderson localization, etc. and advancing defect engineering, to develop new high performance thermoelectric materials. As a result, we have succeeded in developing materials and modules that surpass the half-century champion Bi_2Te_3-type. Electrode technologies for these new materials were also developed, with a novel concept of "active electrodes" leading to high stability and enhancement of the device performance than previously achieved. This strategy was also utilized for diffusion barrier materials. Effective methodology for designing high performance thermoelectric modules (TEGs) has also been developed and will be presented. The accurate evaluation of performance of actual devices is critical for the industrialization of the technology, and we have also laid out the best practices for evaluation of TEGs. I will also present advancements made in fabrication of various formats of TEGs: bulk, thin film, flexible. Peltier devices of novel materials have also been fabricated and tested. Processes suited to industrial and mass production are important, as are development of compatible thermal management technologies, which will be presented. The progress of thermoelectric applications will also be discussed.

About Takao Mori

Takao Mori received his Ph.D. from the University of Tokyo, Department of Physics. He is a Field Director at the National Institute for Materials Science (NIMS) and a Professor at the University of Tsukuba Graduate School, and elected Board Member and current President of the International Thermoelectric Society (ITS). Mori's research interests are to find ways to control structures and properties of inorganic materials. He is especially involved in development of thermoelectric materials and multidisciplinary enhancement principles, such as utilizing magnetism, to find new routes to achieve high control over band structures and electrical and thermal transport. Furthermore, he works on thermoelectric devices, modules and thermal management technology for applications. Mori is a Senior Editor of *Materials Today Physics*, Advisory Board Member of *JSSC*, J. *Materiomics*, *Joule*, and *Device.* He is also a Program Manager of the JST Mirai Large-scale Program.

PLENARY SESSIONS

KORNELIUS NIELSCH

Director, Institute for Metallic Materials (IMW), Leibniz Institute for Solid State Materials Research Dresden (IFW)

From Interface Modifications of Thermoelectric Materials towards Sustainable Modules

Monday, May 18
9:15 – 9:50 a.m.

In thermoelectric materials, phase boundaries are crucial for carrier and phonon transport. In ZnSb and Ag_2Se, metal ion migration under operational gradients triggers irreversible decomposition. Although β-Zn_4Sb_3 possesses high TE performance, it suffers from Zn-ion migration under thermal gradients. Through precise ZnO coating, we create continuous sub-nanometer barriers that immobilize interstitial Zn ions and inhibiting phase decomposition. The thermal stability of the ZnO coated sample persists through 40k thermal cycles, and the Seebeck coefficient mapping exhibits a uniform distribution along the temperature gradient. Furthermore, commercial thermoelectric modules have relied on Bi_2Te_3-based compounds because of their unparalleled thermoelectric properties at temperatures associated with low-grade heat (<550K). However, the scarcity of elemental Te greatly limits the applicability of such modules. We report on the performance of thermoelectric modules assembled from p-type MgAgSb and n-type $Mg_3(Sb,Bi)_2$. For a temperature difference of ~250K, a single-stage module displayed a conversion efficiency of ~8.5%, whereas a module using segmented n-type legs displayed a record efficiency of ~8.2% that is comparable to the state-of-the-art Bi_2Te_3-based thermoelectric modules. The extraordinary thermal stability of the thermoelectric modules based on MgSb alloys is achieved by coating the whole thermoelectric module with HfO_2 and SiO_2 by using atomic layer deposition.

About Kornelius Nielsch

Kornelius Nielsch has been Director of the Institute for Metallic Materials (IMW) at the Leibniz Institute for Solid State and Materials Research Dresden (IFW) since 2015, where he leads a research group working on sustainable thermoelectric materials and devices for thermoelectric cooling. Professor Nielsch received his diploma in physics from the University of Duisburg in 1997 and his Ph.D. in physics from Martin Luther University Halle-Wittenberg, Germany, in 2002. From 2002 to 2003, he was a postdoctoral fellow at MIT after which he took up the position of group leader at the Max Planck Institute for Microstructure Physics in Halle, Germany, in 2003. He then moved to the Institute of Applied Physics at the University of Hamburg, where he served as Professor of Experimental Physics from 2007 to 2015. From 2009 to 2015, he coordinated the Priority Program on Nanostructured Thermoelectrics, and he is currently coordinating the Marie Curie Doctoral Network on Mg-based alloys for thermoelectric cooling in collaboration with 15 partner institutions across Europe.

PLENARY SESSIONS

LUCAS LINDSAY

Research Scientist, Materials Science and Technology Division, Oak Ridge National Laboratory

Boron Arsenide for Heat Management: From Phonons to Devices

Monday, May 18
10:20 – 10:55 a.m.

Effective heat management is a defining constraint across technologies, from climate-scale systems to microelectronic hotspots. While thermoelectrics often target ultralow lattice thermal conductivity k, advanced thermal management demands materials with ultrahigh k, a substantially harder design target. Indeed, high k materials are critical for efficiently getting heat to and from thermoelectric modules and maintaining their optimal temperature differences. Here, I will present details behind the prediction, synthesis, and device-level integration of an emergent benchmark high-k semiconductor, Boron Arsenide (BAs), with a room temperature k on the order of 1000s W/m/K. I will highlight how intrinsic and extrinsic phonon-scattering mechanisms shape k in BAs, guiding integration pathways for thermal management, including design of interfacial properties and device-level hotspot mitigation. Finally, I will discuss future directions in wafer-scale synthesis, defect engineering, and reliability to frame a practical roadmap to transition BAs from exceptional material to mainstream thermal solutions.

About Lucas Lindsay

Lucas Lindsay received a B.S. degree in physics from the College of Charleston in 2004. He completed his Ph.D. work on theoretical thermal transport in carbon nanostructures at Boston College and earned his doctorate in 2010. He taught physics for two years at Christopher Newport University and then spent three years as a National Research Council Postdoctoral Fellow at the U.S. Naval Research Laboratory in Washington, D.C. He has been a research scientist in the Materials Science and Technology Division at Oak Ridge National Laboratory since 2014. He received the Department of Energy Early Career Award in 2019. His research focuses on the theoretical description of vibrational and transport properties of condensed matter.