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Edited by S.P. Beckman, H. Böttner, Y. Chopin, et al.

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**Nanoscale Thermoelectric Materials:  
Thermal and Electrical Transport,  
and Applications to Solid-State  
Cooling and Power Generation**

MATERIALS RESEARCH SOCIETY  
**SYMPOSIUM PROCEEDINGS VOLUME 1543**

**Nanoscale Thermoelectric Materials:  
Thermal and Electrical Transport,  
and Applications to Solid-State  
Cooling and Power Generation**

Symposia held April 1–5, 2013, San Francisco, California U.S.A.

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## PREFACE

At the Material Research Society Spring 2013 meeting, held in San Francisco April 1-5, 2013, three symposia were held that focused on thermal-to-electric energy conversion and thermal transport: Symposium H: Nanoscale Thermoelectrics—Materials and Transport Phenomena – II, Symposium I: Materials for Solid-State Refrigeration, and Symposium V: Nanoscale Heat Transport—From Fundamentals to Devices. Although each technical session was focused on a different aspect of this subject, the intellectual commensurability of these symposia warranted the publication of their proceedings in a single volume.

The sessions in symposium H covered the latest approaches and results in nanoscale thermoelectric materials and their devices for thermal-to-electric conversion, energy harvesting as well as for high-performance cooling and thermal management. Recent advances, including nanoscale materials to reduce lattice thermal conductivity without significantly affecting electronic transport, resonant states, delta-doping, topological insulators, energy filtering to control the flow of desirable heat-transporting carriers and organic/molecular structures were discussed. The sessions, which included several invited talks from leading experts, highlighted the fundamentals of nanoscale materials synthesis and first-principles calculations aimed at understanding the nanoscale physics of transport. The proceedings of the symposium is a collection of papers that highlight the multidisciplinary nature of the materials research, including measurement methods and characterization tools for thermal and electrical interfaces.

The sessions in symposium I covered the latest approaches in materials used for solid-state refrigeration technologies. The development of this symposium was in part driven by interests in technologies to replace the existing vapor-compression cycle devices, which are notoriously inefficient. It was also motivated by recent interest in technologies aimed at micro-scale refrigeration devices, e.g., cooling on a chip. In addition to presentations on thermoelectric solid-state technologies, which have experienced recent advances due to the development of nanostructured materials, presentations about new approaches were given including devices based on the magnetocaloric effect, the electrocaloric effect, and the elastocaloric effect. There are also common challenges to solid-state refrigeration that are shared by all phenomenological approaches; for example, the control and optimization of thermal conductivity at and around the operating region. These issues were also discussed in this session. By creating sessions that included researchers from diverse backgrounds we hoped to stimulate discussions across fields and provide a receptive forum for new concepts in refrigeration.

The sessions in symposium V covered the latest approaches in heat transport within nanostructured materials, nanoscale devices, and lithographically-defined nanostructures, where structural length scales overlap with intrinsic phonon and electron length scales, leading to the strong modification of thermal transport mechanisms. Topics of invited and contributed presentations included phonon barriers and superlattices, nanowires, graphene, carbon nanotubes and carbon nanotube composites, electron-phonon



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interactions, organic and hybrid materials, thermal radiation, microfluidics, and phase change materials. Emerging measurement and simulation techniques were highlighted, as well as applications to medical therapies, thermoelectric energy conversion, and energy storage. Profs. Ali Shakouri and Alan McGaughey, from Purdue University and Carnegie Mellon University respectively, gave well-attended tutorials on experimental and computational methods for studying nanoscale heat transport.

Scott P. Beckman  
Harald Böttner  
Yann Chalopin  
Christopher Dames  
P. Alex Greaney  
Patrick Hopkins  
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