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Developing high temperature thermoelectric materials through control of atomic and grain structure

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Abstract

One need exists to develop thermoelectric (TE) materials which can function at high temperature, for applications utilizing waste heat, focused solar power, RTG, etc. We have been developing novel materials by focusing on particular features of the crystal structure. I will give an overview on this strategy, which has yielded promising borides, silicides, and oxides. Borides are stable compounds, typically with melting points above 2200 K, furthermore, possessing intrinsic low thermal conductivity. As a synthesis method we have discovered that C, N, Si, etc. can function as bridging sites and result in formation of novel crystal structures, such as the long awaited n-type counterpart to p-type boron carbide (one of the few commercialized TE materials). Control of the morphology has also been found to lead to large improvements in the thermoelectric properties. Recently, excellent control of p-n characteristics (+400 μVK^{-1} ~ -200 μVK^{-1}) were achieved in a system with a single crystal structure and same constituent elements. Silicon compounds with cage structures have revealed excellent high temperature TE properties coupled with unusual oxidation resistance in cooperation with Moscow State U. A series of indium-free TCOs has revealed low thermal conductivity through its homologous nature and mixing of the cation sites, and exhibited promising TE properties as an n-type oxide. Particular features in the crystal structure of these compounds have led to striking physical properties, and this will be presented.

Biography

Dr. Takao Mori's present research fields focus on Thermoelectrics, Magnetism, Solid State Physics, Inorganic Materials Science, and Material Synthesis. He is particularly interested in inorganic compounds with "network" structures; atomic clusters, cages, and nets. One particular focus is to develop thermoelectric materials viable for the first wide scale applications. He has published more than 10 book chapters, 200 papers, and 15 patents awarded and pending. He has edited a book with Prof. K. Koumoto on "Thermoelectric Nanomaterials" to be published in the Springer Series in Materials Science. From 2010 Dr. Mori has been a Visiting Professor at Hiroshima University and he is also Research Manager at the Center of Materials Research for Low Carbon Emission. He is also Lab Director of the TIA NanoGreen, Thermal Energy Conversion Lab, which is an Open Innovation Platform. He is a Board Member of the International Thermoelectric Society.