Frontiers of Oxide Thermoelectric Materials for Power Generation Applications

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https://doi.org/10.5109/7323430

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp.28-29, 2024-10-17. International Exchange and Innovation Conference on Engineering & Sciences
バージョン：

Keynote Speaker

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Short Biography

Prof. Dr. Michitaka Ohtaki is Professor of Inorganic Materials Chemistry at Interdisciplinary Graduate School of Engineering Sciences (IGSES), Kyushu University. He holds BSc, MD, and PhD in Industrial (Applied) Chemistry from the University of Tokyo, Japan. Although he was conferred his PhD in Organic Polymer-Metal Complex Chemistry, he changed his field to Energy-related Inorganic Materials based on oxide ceramics when he joined Kyushu University in 1990. His current specific research interests are in oxide-based materials for thermoelectric energy conversion recuperating mid-to-high temperature waste heat, tailoring the thermal conductivity of inorganic materials by unconventional mechanisms, and self-assembly synthesis of low-dimensional quantum-confined inorganic nanomaterials and their electronic/optical/magnetic properties. He has supervised almost 80 graduate students (of which ~10 are PhDs) in these fields, and his graduate students all obtain good jobs in industry and academia. He has been funded for several research projects from government and industry. Among his accomplishments are the Academic Achievements Award of the Thermoelectrics Society of Japan (TSJ) in 2018, the CerSJ Award for Academic Achievements in Ceramic Science and Technology of the Ceramic Society of Japan (CerSJ) in 2019, and the Global Star Award of the American Ceramic Society (ACerS) in 2023. He has more than 200 peer-reviewed journal articles, more than 30 conference proceedings, 22 reviews, and 15 book chapters, and has been invited to more than 80 international conferences to deliver keynote and invited lectures. He has also been serving as Vice Dean of IGSES, Kyushu University, since 2023. He has been serving as the President of TSJ, and as an Executive Board member of the Division of Ceramics in Medicine, Biology and Biomimetics, as well as the Chair of the Kyushu Chapter, of CerSJ. He has also been serving as an Executive Board member of Kyushu Chapters of CerSJ and the Electrochemical Society of Japan.

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Abstract

Thermoelectric (TE) energy conversion generates electricity directly from a heat flux penetrating a solid device consisting of n- and p-type semiconductors. However, limitations in elemental abundance and poor thermal durability of conventional TE materials have prevented a wide commercialization of the TE power generation. Metal oxides are highly durable at high temperature in air, and are generally non-toxic, low cost with minimal environment impact. Boosted by the global environment issues and carbon dioxide mitigation problems, oxide TE materials are becoming more and more of vital importance for recuperation of decentralized waste heat energy for higher total energy efficiency. In this paper, nanostructure engineering in TE oxides will be depicted with focuses on thermal conductivity reduction by introducing complex microstructure, and by carefully choosing the crystal structure. The former approach is exemplified by multinary-doped ZnO with a spontaneously formed microstructure in sintered bodies, while the latter strategy is demonstrated by an ultra-low lattice thermal conductivity found in β-pyrochlore (defect pyrochlore) oxides with an oversized cage-like structure surrounding a small atom inside. Current issues of TE oxides will be discussed with a future prospect of the materials and applications.