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“Control of phonon transport by formation of Al_2O_3 interlayer in Al_2O_3-ZnO superlattice thin films”

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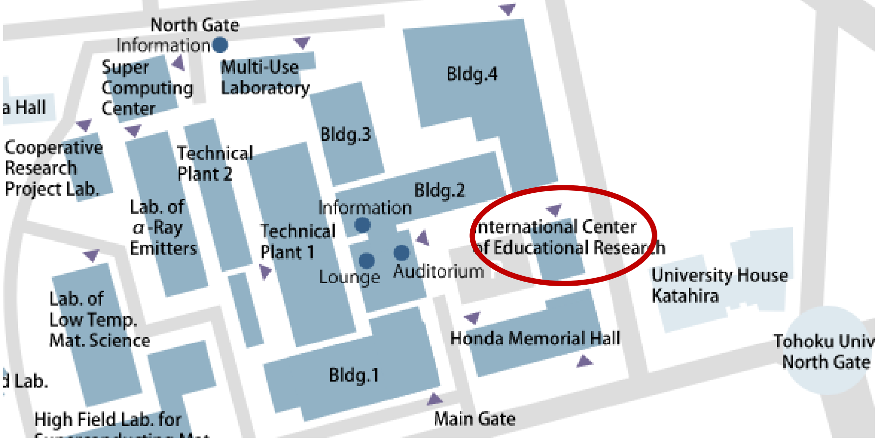
14:00～15:00

Venue:
IMR International Center of Educational Research, 2nd floor, seminar room 1, Katahira Campus
金属材料研究所国際教育研究棟2階セミナー室1



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Presentation will be conducted in English. Registration not required.

Control of phonon transport by formation of Al_2O_3 interlayer in Al_2O_3-ZnO superlattice thin films

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Abstract

Recently, significant progress has been made in increasing the figure-of-merit (ZT) of various nanostructured materials, including thin-film and quantum dot superlattice structures. Studies have focused on the size reduction and control of the surface or interface of nanostructured materials since these approaches enhance the thermopower and phonon scattering in quantum and superlattice structures. Currently, bismuth-tellurium-based semiconductor materials are widely employed for thermoelectric (TE) devices such as TE energy generators and coolers, in addition to other sensors, for use at temperature under 400 K. However, new and promising TE materials with enhanced TE performance, including doped zinc oxide (ZnO) multilayer or superlattice thin films, are also required for designing solid-state TE power generating devices with a maximum output power density and for investigating the physics of in-plane TE generators. In my talk, I will present an experimental observation and coherent phonon transport characteristics the Al_2O_3/ZnO (AO/ZnO) superlattice thin films, which were prepared by atomic layer deposition (ALD), and the evaluation of their both electrical and photon transport properties at the temperature range from 40 to 300 K. The measurement setup and technology for the in-plane thermoelectric (TE) properties of the thin films was also presented. All the in-plane TE properties, including Seebeck coefficient (S), electrical conductivity (σ), and thermal conductivity (κ) of the AO/ZnO superlattice (with a 0.82-nm-thick AO layer) and AO/ZnO film (with a 0.13-nm-thick AO layer) were evaluated in the temperature range from 40 to 300 K, and the measured S, σ, and κ were -62.4 and -17.5 μV/K, 113 and 847 $(\Omega\cdot cm)^{-1}$, and 0.96 and 1.04 W/m·K, respectively, at 300 K. Consequently, the in-plane TE ZT factor of AO/ZnO superlattice films was found to be ~0.014, which is approximately twice enhanced than that of AO/ZnO films (ZT of ~0.007) at 300 K. At the end of my talk, I will also present our on-going research works, including out-of-plane phonon transport and their energy generators of these materials. In this topic, we, for the first time, directly measured all cross-plane thermal electric properties, including thermal conductivity, electrical conductivity, and Seebeck coefficient, of the AO/ZnO superlattice films in the temperature range from 80 to 500 K using newly presenting technique using an integration of sandwiched superlattice films between two separate heaters as a heating source and electrodes with two Cu foils. From cross-plane TE measurement, 6-cycled AO/ZnO superlattice films show the best results among the samples. Our finding in ZT of ~0.45 at 500 K for AO/ZnO superlattice films present the best results among previously reported studies in the same field of the materials with high energy conversion efficiency of ~8.4%.