Investigation on Heat Conduction on Phononic Crystal

フォノニック結晶の熱伝導解析

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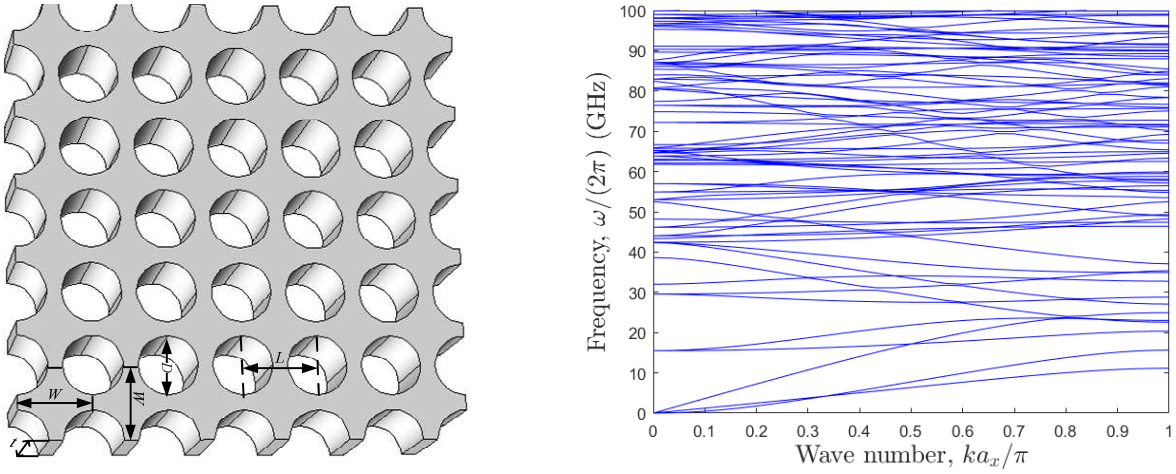
Phononic crystals (PnCs) are regarded as potential candidate of thermoelectric material because phononic structures can greatly reduce their thermal conductivity without altering the electrical property. Heat conduction in the PnCs is governed by both coherent (wave) phonon and incoherent (particle) phonon. In this work, in order to evaluate contributions of both coherent and incoherence phonons to heat conduction, we have employed the hybrid method [1] to calculate the thermal conductivity of a 2D periodic silicon PnCs (Fig. 1 (a)). As for the thermal conductivity of coherent phonon, we have performed lattice dynamics with phonon dispersion relation obtained from the Finite Element Method (FEM) and Klemens' model [2] for intrinsic phonon-phonon scattering. On the other hand, performing Monte Carlo ray-tracing method [3] with phonon transport property in bulk Si, we calculated the thermal conductivity of incoherent phonon involving boundary scattering effect due to PnCs structure. In the conference, we will present the thermal conductivity obtained by hybrid method and compare the contributions of phonon coherent and incoherent effects to thermal conductivity at a temperature range of 4 K to 300 K.



(a) (b)

Fig. 1. (a) Geometry dimension of 2D silicon phononic crystal (PnCs) with the width *W*, height *t*, and diameter of the cylindrical hole *D*. Distance of the center of the adjacent holes is *L*. (b) Phonon dispersion relations for the 2D silicon PnCs ([100] direction) calculated from FEM simulation.

Reference

[1] S. Alaie, et al., Nat. Commun. 6, 7228 (2015). [2] P. G. Klemens, Theory of the Thermal Conductivity of Solids (1958). [3] T. Hori, *et al.*, Appl. Phys. Lett. **106**, 171901 (2015).