熱輸送のスペクトル学的理解と機能的制御
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Anufriev Roman

The University of Tokyo, Institute of Industrial Science
Project Associate Professor

Ray-Phononics for Advanced Heat Flux Management

§１．研究成果の概要

During his fiscal year, I focused my efforts on switching the project technology from silicon to silicon carbide and developing the fabrication process on the silicon carbide membranes. This process was complicated by the fact that silicon carbide is a more durable material than silicon and resists traditional plasma etching. However, the fabrication process has been adapted to produce nanoscale features on silicon carbide, and I could fabricate various silicon carbide nanostructures.

Next, I measured the obtained membranes, nanowires, and phononic crystals to better understand the nanoscale thermal properties of silicon carbide, which have remained mostly unknown. I demonstrated how the thermal conductivity scales down with the limiting dimension of the structure and be as low as 35 W/m·K in nanostructures with the limiting dimension of 30 nm, which contrasts with bulk values of more than 300 W/m·K. Moreover, I measured the phonon mean free path in silicon carbide membranes and found that it is substantially longer than that in silicon, which is beneficial for the project goals. These results have been published in NPG Asia Materials [1].

Finally, I finished the fabrication of the multiprobe time-domain thermoreflectance setup and development of the software. The first tests of the setup succeeded. Thus, in the last year of the project, I anticipate measuring the silicon carbide nanostructures using the multiprobe time-domain thermoreflectance setup.

【代表的な原著論文情報】

1) Anufriev et al. ″Nanoscale limit of the thermal conductivity in crystalline silicon carbide membranes, nanowires, and phononic crystals″, NPG Asia Materials vol.14, p. 35, 2022.