Flexible device, Thermoelectric conversion

# Visualization of the temperature distribution on carbon nanotube bundles

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## Abstract

Despite the superior thermal conductivity of single carbon nanotubes, that of macroscopic assemblies are poor, mainly due to the presence of numerous intertube boundaries. Here, we report an in-situ nanoscale observation on the anisotropic thermal transport of a single bundle of carbon nanotubes to investigate the difference of thermal conductivity within and between carbon nanotubes. The experimental results indicate that even a small bundle shows colossal thermal anisotropy due to the intertube boundaries.

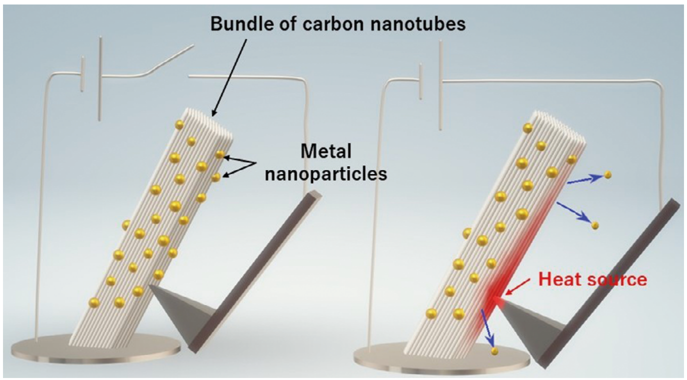


Fig. 1 Schematic illustration of the experiment

## Background & Results

Carbon nanotubes are popular nanomaterials known for their superior thermal properties. However, rope or film-based assemblies of carbon nanotubes show relatively low thermal conductions. One of the most critical causes may be the thermal transport at boundaries between carbon nanotubes. In this regard, several experimental studies have been conducted on macroscopic specimens which have revealed that the aligned nanotube films show significant thermal anisotropy pertaining to the alignment directions. However, in the macroscopic specimens, numerous nontrivial intertube boundaries occur and therefore the inherent difference in thermal conductivities between the intra- and inter- nanotubes remains unclear. In order to address this issue, we have focused on the thermal transport in nanotube bundles in which the nanotubes are self-organized into vertically close-packed structure (Fig. 1). Consequently, extremely high anisotropy of thermal conductivity along the directions parallel and perpendicular to the alignment of bundled carbon nanotubes was observed by in situ observation of the phase transition of metal nanoparticles decorating the bundle (Fig. 2). With the aid of finite element calculation, we demonstrated that the high anisotropy estimated in this study could cause the decrease of apparent thermal conductivity of the bundled carbon nanotubes.

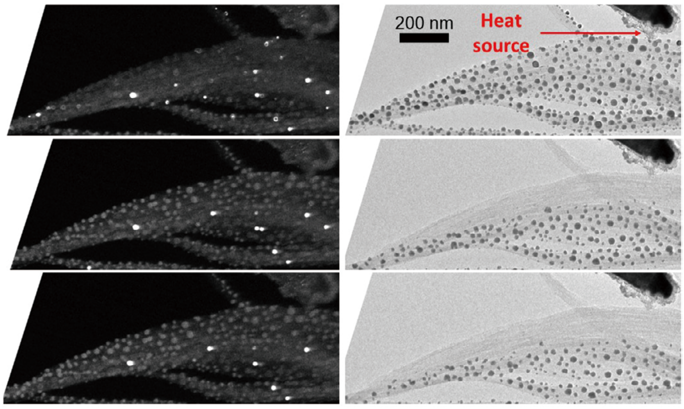


Fig. 2 Carbon nanotube bundle which is anisotropically heated

## Significance of the research and Future perspective

The reported results provides semi-quantitative benchmarks in the design of carbon-nanotube-based materials for directing the heat flow. Additionally, the methodology aids in visualizing the nanoscale thermal transport that is not restricted to carbon nanotubes.

Patent

Treatise Hamasaki, Hiromu; Takimoto, Seiya; Hirahara, Kaori. Visualization of thermal transport within and between carbon nanotubes. Nano Letters. 2021, 21 (7), p. 3134–3138, doi: 10.1021/acs.nanolett.1c00336
Hamasaki, Hiromu; Kawase, Takumi; Hirahara, Kaori. Anisotropic temperature distribution in carbon nanotube bundles determined using two types of phase transitions of nanoparticles. Physical Review Materials. 2022, 6, p. L023001-1–6, doi: 10.1103/PhysRevMaterials.6.L023001

URL

Keyword carbon nanotubes, thermal transport, transmission electron microscopy