【Grant-in-Aid for Scientific Research (S)】

Development of phonon engineering through heat conduction measurements at microscopic area

Principal Investigator	Kyushu Institute of Technology, Faculty of Engineering, Professor MIYAZAKI Koji	Researcher Number:70315159
Project Information	Project Number : 22H04953 Keywords : Heat conduction, Phonon engineering,Thermoreflectance, Raman spectroscopy, Ab-initio calculation	Project Period (FY) : 2022-2026

Purpose and Background of the Research

●Outline of the Research

Thermal management at local hotspot is one of the key issues in developments of electronics, such as an electric vehicle, a cell phone etc. Heat conduction is diffusive energy transport from high temperature to low temperature, but the conventional model cannot be applied at microscopic area. Thermal transport is discussed to solve the issues mentioned above by lattice vibrations called phonons. The validity of phonon transport has not been directly confirmed yet due to the measurement difficulties. Here, we develop the thermal measurement technique to improve the spatial resolution for phonon transport discussions. The serious thermal issues will be solved when the multiscale thermal transport is well understood through the comparison between thermal measurements and multiscale numerical simulations.

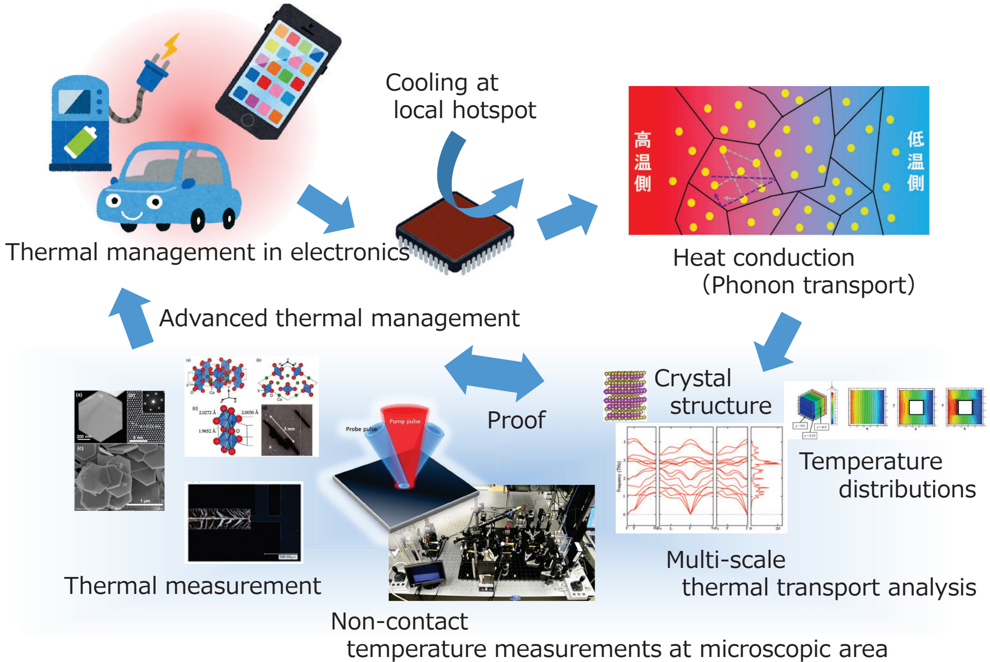


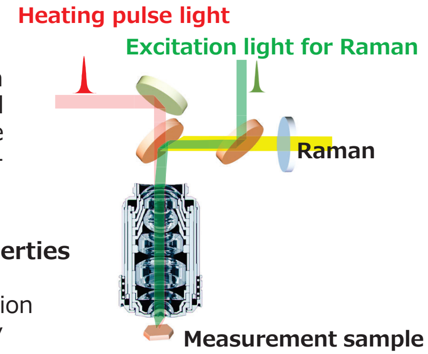
Figure 1. Research outline

●Method

Thermal energy is transported ballistically at microscopic area with artificial microstructures in the analytical model. Non-contact thermal measurement method is developed to confirm the validity of ballistic thermal transport model (Phonon model).

●Developments of thermal measurement

Measurement sample is heated by pulse light, and the temperature change is measured by Raman spectroscopy at microscopic area for thermal properties measurement. Tiny size sample thermal properties can be measured by the non-contact method.



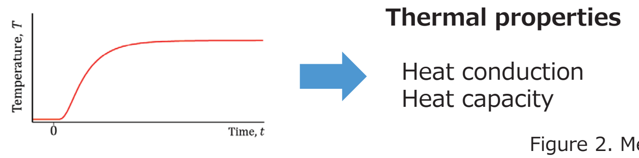


Figure 2. Measurement by Raman spectroscopy

Expected Research Achievements

●Non-contact thermal conductivity measurements

The thermal properties of tiny materials, such as nano-wire, nano-sheet etc. cannot be measured by a conventional measurement technique with small probe. The non-contact measurement method will be developed using light.

●Thermal conductivity of tiny samples

The thermal conductivity of nano-structured materials, such as nano-plate as shown in Figure 3. The measured thermal conductivity is compared with the predicted values by analytical model. The analytical model and measurement technique will be applicable to the practical thermal design through the validity confirmation.

●Analytical model discussions

The validity of the analytical model can be confirmed through the developments of thermal measurement method for temperature distribution at microscopic area. When the predicted temperature measurement from ballistic transport of phonons is confirmed through the measurement, the high impacts of multi-scale thermal transport model on thermal management in electronics will be promised.

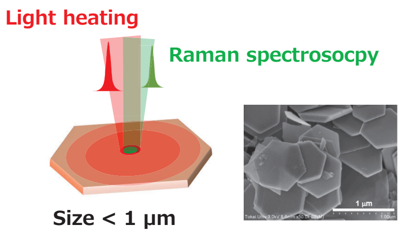


Figure 3. Thermal conductivity measurement at microscopic area

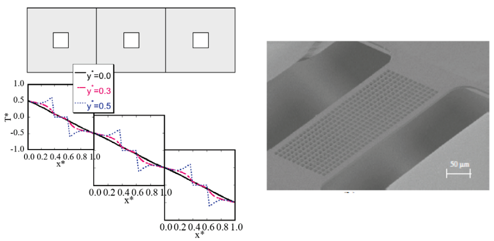


Figure 4 Comparison between analiyical model and measurement results

Homepage Address, etc.	Thermal device laboratory http://www.mech.kyutech.ac.jp/tdl/ Integrated research center for energy and environment advanced technology(i-ENERON) http://www.i-eneron.kyutech.ac.jp/