Research Highlights

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A New Way to Observe Heat Flows at Nanoscale

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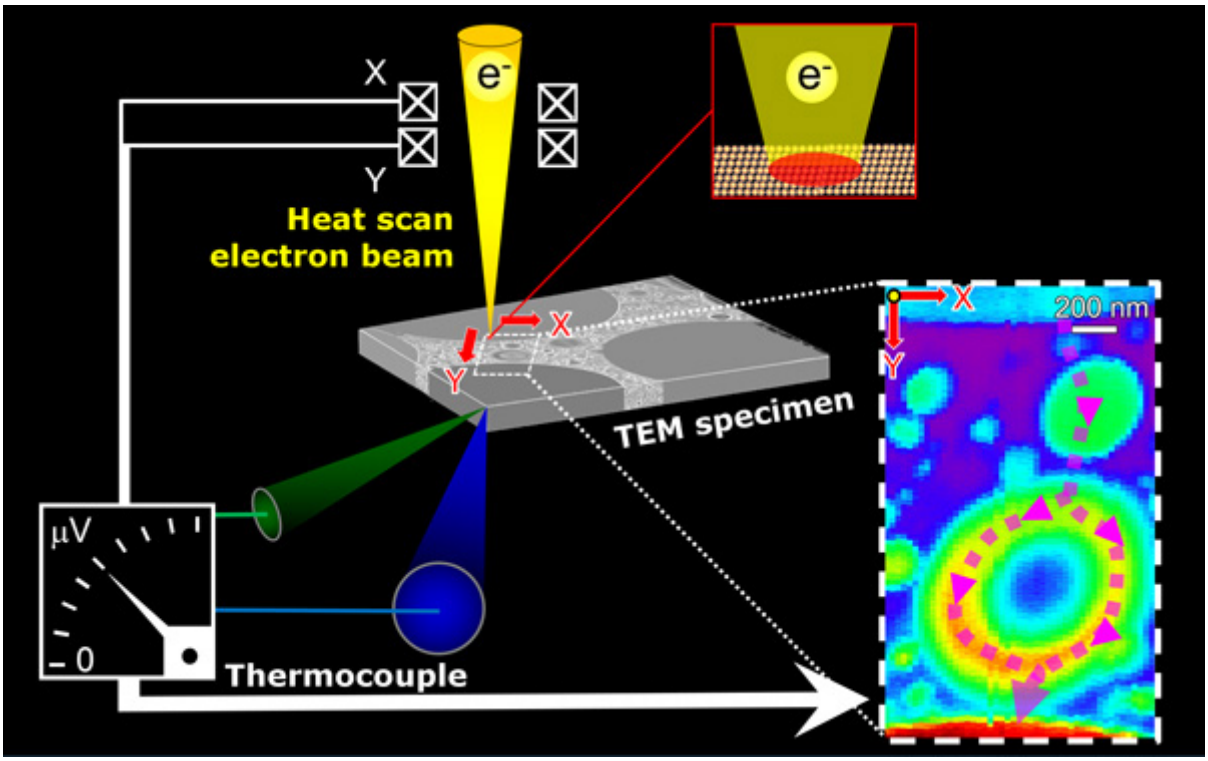
A team at MANA has devised a method for visualizing heat conduction pathways at nanoscale -- a development that could lead to progress in the energy efficiency of materials.



Generally, energy efficiency is mostly very low. Usually, only a third is actually used and the rest is lost as waste heat. Controlling energy flows in materials would greatly boost efficiency.

Methods for measuring temperature at nanoscale are available, but they cannot examine the relationships between nanostructure peculiarities, such as lattice defects and impurities.

The MANA team's technique characterizes heat flows at nanoscale and at the same time analyses specific locations in the sample, resulting in unprecedented temperature and spatial resolutions.

The team used a scanning transmission electron microscope (STEM) to observe the microstructure of a heat sink composite material consisting of alumina fillers embedded in a thermally insulating epoxy. They assembled a nanothermocouple and controlled nanoscale thermal conduction by alternating heat input by adjusting a scanning convergent electron beam, in combination with piezo-driven movements and precise positioning.

The method can be incorporated into nanoscale studies of heat flow in new materials for thermoelectric conversion, thermal diodes and heat sink composites.

It also allows analysis of heat-related phenomena, through tests inside the microscope. These can be combined with structural, mechanical, electrical, magnetic and optoelectronic investigations of materials at atomic scale.

The method will find applications not only in analyzing complex heat flows in heat sink materials, but also in making thermal transport measurements and revealing heat distribution in nanostructured objects.

The team plans to speed up the process and apply it to different target substances, such as electron beam-sensitive materials. The technique will help in the hunt for more energy-efficient materials.

This research was carried out by Naoyuki Kawamoto (Principal Researcher of Nanotubes Group, MANA, NIMS) and his collaborators.

Reference

"Visualizing nanoscale heat pathways"
Naoyuki Kawamoto, Yohei Kakefuda, Isamu Yamada, Jianjun Yuan, Kotone Hasegawa, Koji Kimoto, Toru Hara, Masanori Mitome, Yoshio Bando, Takao Mori and Dmitri Golberg
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