New insights into how materials transfer heat could lead to improved electronics

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University of Toronto engineering researchers, working with colleagues from Carnegie Mellon University, have published new insights into how materials transfer heat, which could lead eventually to smaller, more powerful electronic devices.

Integrated circuits and other electronic parts have been shrinking in size and growing in complexity and power for decades. But as circuits get smaller, it becomes more difficult to dissipate waste heat. For further advances to be made in electronics, researchers and industry need to find ways of tracking heat transfer in products ranging from smart phones to computers to solar cells.

Dan Sellan and Professor Cristina Amon, of U of T's Mechanical and Industrial Engineering department, investigated a new tool to measure the thermal and vibrational properties of solids. Working with colleagues from Carnegie Mellon University, they studied materials in which heat is transferred by atomic vibrations in packets called phonons. Their results were recently published in *Nature Communications*.

"In an analogy to light, phonons come in a spectrum of colors, and we have developed a new tool to measure how different color phonons contribute to the thermal conductivity of solids," said Jonathan Malen, an assistant professor of Mechanical Engineering at CMU.

According to the researchers, the new tool will give both industry and academia a clearer picture of how an electronic device's ability to dissipate heat shrinks with its size, and how materials can be structured at the nanoscale to change their thermal conductivity.

For example, in the initial demonstration, the team showed that as silicon microprocessors continue to shrink, their operating temperatures will be further challenged by reduced thermal conductivity.

"Our modeling work provides an in-depth look at how individual phonons impact thermal conductivity," said Sellan, who undertook his research as a PhD Candidate in Professor Amon's lab. Currently an NSERC Postdoctoral Fellow at The University of Texas at Austin, Sellan is developing experimental techniques for thermal measurements.

Professor Amon, who is also Dean of the Faculty of Applied Science & Engineering at U of T, said Sellan's insights will allow researchers to design nanostructured thermoelectric materials with increased efficiency in converting waste heat to electrical energy. This work has exciting implications for the future of nano-scale thermal conductivity research."

More information: Paper: www.nature.com/ncomms/journal/ … full/ncomms2630.html

Provided by University of Toronto

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