*Tailoring Thermal Transport*

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Everyone knows that electronic devices can overheat and fail. This is becoming more of an issue as the devices used in our daily lives, from cell phones to laptops, get smaller—the influence of the size-scale effect becomes increasingly important. The ability to extract heat rapidly and efficiently is critical for electronic and optoelectronic devices. Arvind Narayanaswamy is one of the leading researchers studying energy transport in nanoscale structures and devices.

Shrinking a device's size greatly impacts its ability to transport energy, due to classical as well as quantum size effects. Fourier's law of heat conduction, which describes heat transfer well at macroscopic scales, breaks down at nanoscales. So does Planck's theory of radiation, when objects get much closer than a few microns. Recently, researchers, including Narayanaswamy, have discovered that the enhancement in thermal radiative transfer at nanoscale gaps can be utilized to increase the power density of thermophotovoltaic energy conversion devices.

Narayanaswamy's team is addressing two broad areas of thermal transport: nanoscale effects on thermal radiative transfer and thermal transport in nanoscale polymeric materials. His work in radiative transfer focuses on understanding photon transport between nanostructures, and he has shown that by choosing appropriate materials, it is possible to overcome the limit on radiative transfer imposed by Planck's law by a significant amount. While this phenomenon may seem esoteric—most often, heat transfer in nanoscale devices is by thermal conduction—it could have an important impact on hard-disk drive technologies. Narayanaswamy is working with industrial collaborators to ensure that nanoscale thermal radiation does not have a deleterious effect on the performance of magnetic recording devices.

While nanoscale effects on thermal transport in solid-state materials have been well investigated, their influence in polymeric materials is less clear. Polymers are used everywhere, from credit cards and plastic bottles to organic optoelectronic materials. Thermal transport in polymers becomes especially important since they are poor conductors of heat; any means of improving heat conduction through polymers will improve device performance. Narayanaswamy's work focuses on understanding thermal transport in polymeric nanowires synthesized in his lab by different techniques. An important component of his research is technique development to enable measurement of heat transport through single nanowires.

"Our work on nanoscale thermal radiation is very exciting," said Narayanaswamy. "While it will be some time before we can translate our research into applications, the tools we've already developed are helping us start examining thermal transport in polymers. Our discoveries will have immediate engineering implications, especially in electronics cooling."

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