Scientists Develop First Chip-Scale Thermoelectric Cooler

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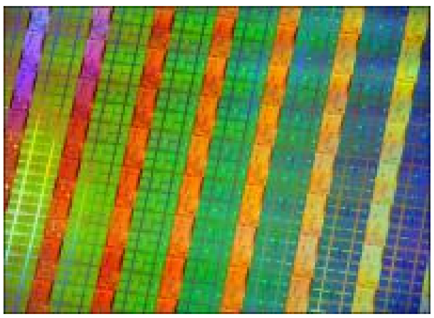

(PhysOrg.com) -- As computer chips become more powerful, they also become hotter. Nearly all the power that flows into a chip comes out of it as waste heat, and that heat hurts the performance of the chip.

Methods for cooling transistors have always been an important part of the semiconductor industry, but recently researchers have been coming up with more clever strategies for keeping computer chips cool. One such strategy is the use of a chip-scale thermoelectric cooler, which has been demonstrated for the first time by a collaboration of researchers from Intel, Arizona State University in Tempe, RTI International, and Nextreme Thermal Solutions.

In a recent study published in *Nature Nanotechnology*, the researchers presented the thermoelectric "chiller" embedded in a chip package that pumps heat out of the chip when current flows through it. The chiller could lower the temperature of a small hot spot on a large chip by nearly 15°C - exceeding the significant 10°C goal that was described in an analysis by researchers at the University of Maryland five years ago.

One key to the device's performance was that the researchers focused on cooling only the hottest spots on a chip, which has previously been shown to be a more energy-efficient strategy than trying to cool the entire chip. Another key is that the researchers fabricated the device out of nanoscale layers of material, which has previously been shown to increase efficiency.

The thermoelectric cooler consists of a superlattice structure made of bismuth, tellurium, antimony, and selenium. The structure pumps heat from the back side of the chip to a conventional heat spreader on the front side, which uses convection to transfer the heat and cool the chip.

In experiments, the researchers created a hot spot on the chip (with a heat flux of about 1300 W/cm^2, which is much higher than usually found on a microprocessor). Even before powering the thermoelectric superlattice structure, the chiller could decrease the temperature of the hot spot by about 6°C. After powering the thermoelectric cooler, the temperature of the hot spot cooled by nearly 15°C.

The researchers explained that the thermoelectric technique could provide cooling solutions for computers in future data centers, in which cooling hot spots on processors will be critical for good performance. Transistors run faster when they're cooler, and also last longer because extreme temperature changes cause mechanical stress on computer chips that can destroy them. Thermoelectric strategies might also help cool the chips in portable devices, such as multitasking smart phones, which run data-intensive processing.

As co-author Ravi Prasher of Intel explained, packaging a nanoscale device within a macroscale system is a significant achievement. However, the team still needs to do more work before commercializing the device.

More information: Chowdhury, Ihtesham, et al. "On-chip cooling by superlattice-based thin-film thermoelectrics." *Nature Nanotechnology*. Published online: 25 January 2009 | doi:10.1038/nnano.2008.417.

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