Science : Discoveries

Cool Ideas for Overheated Chips

Mark K. Anderson 01.15.02

How do you cool a 200-watt light bulb the size of a postage stamp?

This is the essential problem that computer chip makers the world over now wrestle with as Moore's law runs headlong into the laws of thermodynamics. Many chips today already burn through more than a hundred watts of power -- cooled by heat sinks and exhaust fans, but only just barely.

Present cooling technology, in short, cannot sustain future hardware. And as the old fan-and-sink goes the way of MS-DOS, new cooling ideas and inventions will be needed to keep tomorrow's chips from frying to a crisp.

This week, hundreds of scientists and engineers gather in Santa Fe, New Mexico, to consider a host of such innovations -- including thin-film refrigerators, piezoelectric fans, thermoacoustic engines, and plain and simple liquid cooling.

Ali Shakouri of the University of California, Santa Cruz, argues that the trick is concentrating on a chip's hot spots.

Shakouri, who will speak on microscopic integrated circuit refrigerators at the Thermes 2002 conference Tuesday, has developed a micro-fridge the size of a grain of dust. It works by using electrons -- instead of freon in conventional refrigerators -- to carry thermal energy away from a chip's hot spot and dissipate it into the environment.

His group has succeeded in cooling chips by 5 degrees centigrade using this method.

But that number will have to at least be doubled before the Intels and Motorolas of the world consider Shakouri's solution. "To make a significant impact on design, chip makers need at least 10 to 20 degrees centigrade cooling," he said.

"We're now doing modeling to see how far fundamentally we can go. Theory tells us that with the material we have, we should be able to achieve 20 or 30 degrees of cooling."

Orest Symko of the University of Utah has a device he'll be touting at Thermes that he says can cool chips down by 10 to 20 degrees. Instead of using electrons to carry heat away, Symko's gadget uses sound.

"Thermoacoustic engines" have been studied since the 19th century, but Symko was the first to develop the old technique -- which involves transferring the heat to plates inside a pipe organ-like resonating chamber -- for microchip size scales.

Symko's group has two prototypes now in development, 4 centimeters and 1.5 millimeters in size. With the larger device, the sound is just at the edge of the audible; one colleague reports being able to hear the refrigerator "humming." The smaller one operates at 21 KHz, in the ultrasonic range.

Symko and his collaborators are also developing a method of recycling some of the sound back into electricity.

"At the conference, we're going to be talking about the proof of concept," Symko said. "Within the next six months, we're going to be in a position where we can come to potential customers and say, 'Here's what we have.'"

However, Ken Goodson of Stanford remains skeptical of the ultimate applicability for microchips of these thermoacoustic, thermoelectric and piezoelectric cooling systems. They all rely on a hot chip transferring its energy to air or electrons.

Such diffuse gases can shuttle some energy away, he said, "but I'm not sure it's going to haul out the 200 watts from a square centimeter."

When vast amounts of heat energy need to be transferred out of a small area -- such as a car engine -- breezes don't do the trick. Ask anyone who's ever driven with a dead radiator.

Rather, Goodson said, there's nothing that beats liquid cooling. The only reason computer engines aren't already cooled like car engines is because of the engineering challenge to keep coolant pumping through hoses the size of human hairs.

Preliminary tests of water-cooling computer chips performed 20 years ago, Goodson said, "hauled out a kilowatt from a square centimeter.

"The reason it wasn't applied is the industry didn't need it yet," he added.

But now, with the development of micro-machined pumps, Goodson says the future is liquid cooled.

"Now the IC (integrated circuit) industry is about to go over a cliff," he said. "So our project develops the pumping technology to make it work."

See Also:
Computer Optics Not an Illusion
It Works: Really Super Tiny Chips
NVidia's 3-D Vision Is Clear
Read more Technology news
Read more Technology news

Quick Links: Contact Us | Login/Register | Newsletter | RSS Feeds | Tech Jobs | Wired Mobile | FAQ | Sitemap

Corrections | Sitemap | FAQ | Contact Us | Wired Staff | Advertising | Press Center | Subscription Services | Newsletter | RSS Feeds

Condé Nast Web Sites:

Webmonkey | **Reddit** | **ArsTechnica** | **Details** | **Golf Digest** | **GQ** | **New Yorker**

Subscribe to a magazine: | Condé Nast web sites: | International Sites: