Ultra-powerful Laser Makes Silicon Pump Liquid Uphill with No Added Energy

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(PhysOrg.com) -- Researchers at the University of Rochester's Institute of Optics have discovered a way to make liquid flow vertically upward along a silicon surface, overcoming the pull of gravity, without pumps or other mechanical devices.

In a paper in the journal Optics Express, professor Chunlei Guo and his assistant Anatoliy Vorobyev demonstrate that by carving intricate patterns in silicon with extremely short, high-powered laser bursts, they can get liquid to climb to the top of a silicon chip like it was being sucked through a straw.

Unlike a straw, though, there is no outside pressure pushing the liquid up; it rises on its own accord. By creating nanometer-scale structures in silicon, Guo greatly increases the attraction that water molecules feel toward it. The attraction, or hydrophile, of the silicon becomes so great, in fact, that it overcomes the strong bond that water molecules feel for other water molecules.

Thus, instead of sticking to each other, the water molecules climb over one another for a chance to be next to the silicon. (This might seem like getting energy for free, but even though the water rises, thus gaining potential energy, the chemical bonds holding the water to the silicon require a lower energy than the ones holding the water molecules to other water molecules.) The water rushes up the surface at speeds of 3.5 cm per second.

Yet the laser incisions are so precise and nondestructive that the surface feels smooth and unaltered to the touch.

In a paper a few months ago in the journal Applied Physics Letters, the same researchers proved that the phenomenon was possible with metal, but extending it to silicon could have some important implications. For instance, Guo said, this work could pave the way for novel cooling systems for computers that operate much more effectively, elegantly, and efficiently than currently available options.

"Heat is definitely the number one problem deterring the design of faster conventional processors," said Michael Scott, a professor of computer science at the University, who is not involved in this research.

Computer chips are essentially wafers of silicon covered with billions of microscopic transistors that communicate by sending electrical signals through metal wires that connect them. As technological innovations make it possible to pack astounding numbers of transistors on small pieces of silicon, computer processing speeds could increase substantially; however, the electrical current constantly surging through the chips creates a lot of heat, Scott said. If left unchecked, the heat can melt or otherwise destroy the chip components.

Most computers these days are cooled with fans. Essentially, the air around the circuit components absorbs the heat that is generated and the fan blows that hot air away from the components. The disadvantages of this method are that cold air cannot absorb very much heat before becoming hot, making fans ineffective for faster processors, and fans are noisy.

For these reasons, many companies have been eager to investigate the possibility of using liquid as a coolant instead of air. Liquids can absorb far more heat, and transmit heat much more effectively than air. So far, designers have not created liquid cooling systems that are cost-effective and energy efficient enough to become widely used in economical personal computers. Although Guo's discovery has not yet been incorporated into a prototype, he thinks that silicon that can pump its own coolant has the potential to contribute greatly to the design of future cooling systems.

Provided by University of Rochester

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