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'Nano-lightning' could cool future computers

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Mechanical engineers at Purdue University are developing a new type of cooling technology for computers that uses a sort of nano-lightning to create tiny wind currents.

The researchers have shown that the underlying concept for a 'micro-scale ion-driven airflow' device is sound and have recently filed for a patent.

'This is a groundbreaking idea,' said Suresh Garimella, a professor of mechanical engineering at Purdue who is working on the device with Timothy Fisher, an associate professor of mechanical engineering, Daniel J. Schlitz , who recently earned a doctoral degree from Purdue, and doctoral student Vishal Singhal.

Future computer chips will contain more circuitry and components, causing them to generate additional heat and requiring innovative cooling methods. Engineers are studying ways to improve cooling technologies, including systems that circulate liquids to draw heat from chips.

Using a liquid to cool electronic circuits, however, poses many challenges, and industry would rather develop new cooling methods that use air, Garimella said. 'The key attribute of this work is that it sticks with air cooling while possibly providing the same rate of cooling as a liquid,' he said.

The new technique makes use of a number of electrodes made from sets of 'nanotubes' of carbon with five nanometer wide tips. The electrodes can be charged negatively or positively. When one set of electrodes is charged negatively, electrons flow towards the positive electrodes and ionise the surrounding air as they do so.

The ionized air molecules cause currents like those created by the 'corona wind' phenomenon, which happens between electrodes at voltages higher than 10 kilovolts, or 10,000 volts.

'To create lightning you need tens of kilovolts, but we do it with 100 volts or less,' Garimella said. 'In simple terms, we are generating a kind of lightning on a nano-scale here.'

The researchers are able to create the ionizing effect with low voltage because the tips of the nanotubes are extremely narrow and the oppositely charged electrodes are spaced apart only about 10 microns.

Future cooling devices based on the design will have an 'ion-generation region,' where electrons are released, and a 'pumping region,' made up of another set of electrodes. Clouds of ions created when electrons react with air can then be attracted by the second region of electrodes and 'pumped' forward by changing the voltages at those electrodes to produce the cooling effect.

'By switching (the voltage at the electrodes) at the right frequency, the ion cloud is constantly moving forward,' Schlitz said. 'As the ions move forward, they make repeated collisions with neutral molecules, producing the breeze.'

The Purdue researchers have demonstrated that the pumping concept works with a region of electrodes made of many series, each series containing three electrodes. The first in the series is the most positively charged, followed by an electrode that has a less-positive charge and then a third electrode that is negative.

Switching the voltages from one electrode to the next causes the charges to move forward, which in turn moves the ion clouds.

'The switching itself is a well-known concept from physics, but we are the first to bring about ion pumping on a micro-scale like this,' said Garimella, who is director of Purdue's Cooling Technologies Research Center, a consortium of corporations, university and government laboratories working to overcome obstacles in developing new, compact cooling technologies.

More work must be done to perfect the technique and develop a prototype, the researchers said.

'Right now it's a laboratory-scale phenomenon,' Schlitz said.

Nevertheless, Schlitz and Singhal have created Thorrn Micro Technologies to commercialise the cooling system.

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