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RESEARCH NEWS

Double the cooling effect

Higher processor performance with microchannel cooler

One of the limiting factors for the computing power of processors is the operating temperature. As part of the CarriCool project under the aegis of IBM, Fraunhofer researchers have developed a new, effective cooling method: By integrating microchannels into the silicon interposer it is for the first time possible to cool high-performance processors from the underside as well. As a result, this innovation can achieve a significant increase in performance. Moreover, the scientists have integrated passive components for voltage regulators, photonic ICs and optical waveguides into the interposer.

When processors get too hot, they reduce their clock rate and operating voltage. In order to protect the CPU and motherboard from heat damage, the processors either reduce their computing speed or even shut off entirely. Heat, or rather, the cooling of the processors, has great influence on the performance of processors. Up until now, cooling elements have been used to avoid overheating, while, at the same time, fans are used to cool the heat-sensitive components from above. A research team around Dr. Wolfram Steller, Dr. Hermann Oppermann and Dr. Jessika Kleff from the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin and Dresden has now found a way to cool microchips from the top as well as from below using a liquid-based cooling system. This allows more effective cooling and therefore higher performance. For this purpose, microchannel structures with hermetically sealed vias are installed in the silicon interposer, which is located between the processor and the printed circuit board. The coolant is then pumped through the microchannels channeling off the heat from the processor.

Crisscrossing microchannels

Interposers are responsible for the electrical supply and cooling of the processor. They are like a layer between the circuit board and the chip and are enriched every 200 micrometers from top to bottom by electrical contacts to ensure the processor's power supply and data transmission. In order to be able to absorb heat and channeling it away from the processor, the scientists at Fraunhofer IZM installed microfluid channels cross-linking the vias, allowing coolant to be circulated.

The particular challenge was not only to integrate the small channels into the interposer, but also to hermetically seal them and thus to separate them from the electrical

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paths. The solution of the scientists: the interposer is made of two silicon plates. The horizontally extending cooling channels as well as the vertically extending channels for the electrical lines are incorporated in a complementary manner. In order to prevent contact between the water and the electrical vias, each individual contact is specially sealed.

"Up to now, the cooling structures are not very close to the computer core itself, which means the coolers are mostly applied from above," says Dr. Hermann Oppermann, group leader at Fraunhofer IZM. "The closer you get to the heat source, the better the temperature can be limited or the output increased. In high performance computing in particular, the data rates are continuously increasing. Therefore, it is important to have an effective cooling to ensure a higher clock rate. Previously used cooling systems were not so effective in this context. Now, with this new cooling system, the performance can be increased significantly."

More than just a cooling system

As if the cooling system were not enough, the Fraunhofer researchers additionally integrated voltage regulators for the power supply as well as optoelectronic components for data transmission into the interposer. While the voltage regulator supplies the processor with the appropriate operating voltage, the optoelectronics converts electrical signals from the processor into light signals. As a result, even large amounts of data can be transmitted with high signal quality – in contrast to copper lines in which the data losses increase with growing data rate. "By combining interposer, cooling, voltage regulators and optical interconnection technology, we have reached a new level of integration that allows smaller circuits with more power," says Oppermann. "This is an important step in high-performance computing, as we achieve higher clock speeds in the same amount of space."

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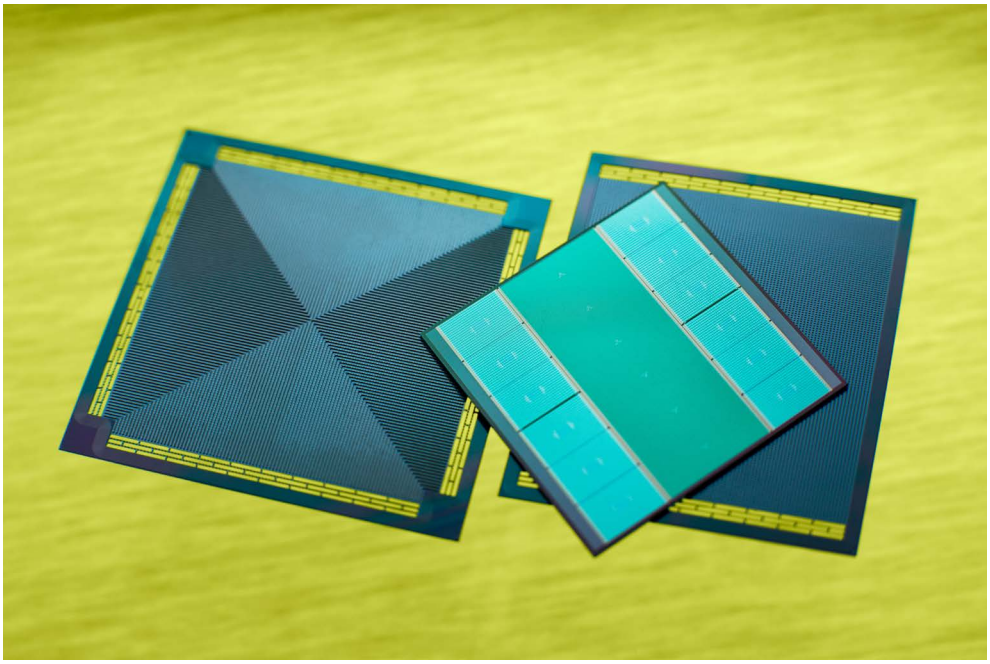

The integration of microchannels into the silicon interposer allows for the first time to cool a processor also from the bottom and thereby increase the computing power. © Fraunhofer IZM | Picture in color and printing quality: www.fraunhofer.de/en/press