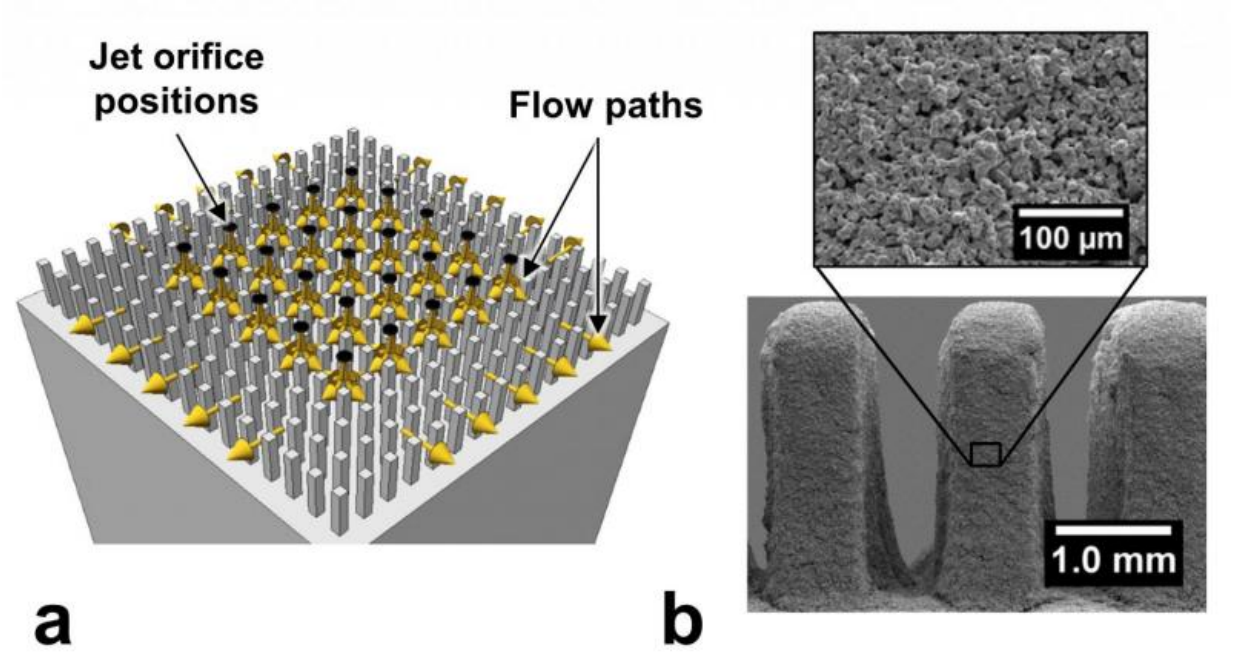
Research team develops new cooling technology for hybrid and electric vehicles

September 13 2016, by Emil Venere



A team of researchers from Purdue University and the Toyota Research Institute of North America developing a new cooling technology for hybrid and electric vehicles is a finalist for the 2016 R&D 100 award.

The technology has evolved from work originating in the Purdue-based National Science Foundation Cooling Technologies Research Center.

The center, formed in 1999, is a consortium of corporations, government laboratories and the university working to overcome heat-generation problems in electronic systems by developing new compact cooling technologies.

"We have worked with 45 companies that have been members of the center in the area of efficient high-performance cooling and miniaturization of cooling technologies," said Suresh V. Garimella, who founded the center and is Purdue's executive vice president for research and partnerships and the Goodson Distinguished Professor of Mechanical Engineering. "I think the most satisfying outcome from the work in our center has been the fantastic undergraduate and graduate students who have had enriching experiences by working closely with our member companies."

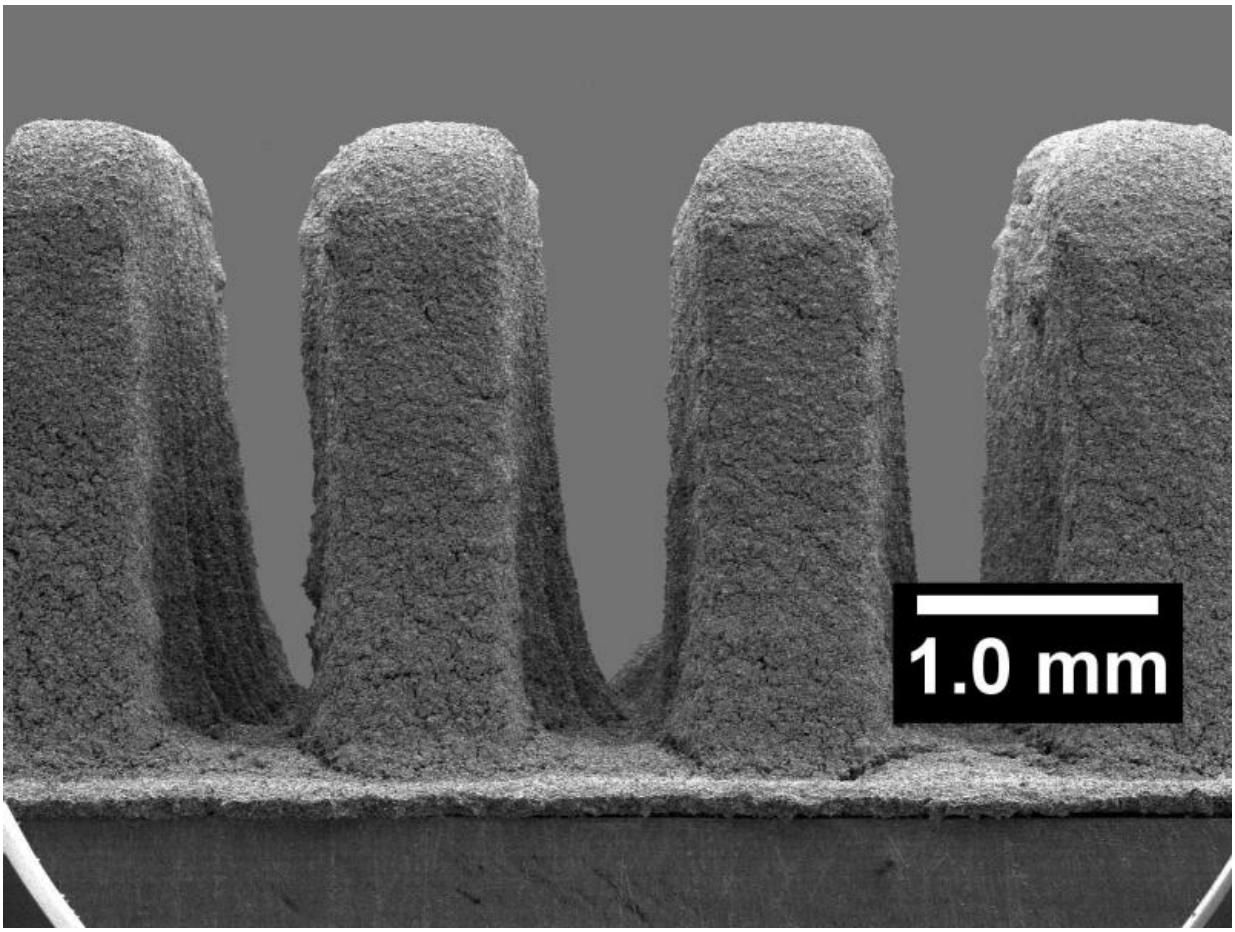
Toyota, a member of the center, approached Purdue researchers around five years ago, seeking ways to further improve efficiency and performance of cooling electronics in hybrid-electric and electric vehicles. A doctoral student, Matthew Rau, took on the project to study "jet impingement technology" for his Ph.D. thesis.

"Matt spent a summer at Toyota's Electronics Research Department in Ann Arbor, Michigan, transferring technology from what we learned in the lab, as part of this multiyear project," Garimella said. "It was a very close collaboration, and the reason it was successful was that Toyota put a lot of effort into this research themselves, performing computer modeling and setting up experiments in a more realistic setting at Toyota than a university alone is able to do."

Rau, who received a doctorate in mechanical engineering in 2016, is now serving a prestigious National Research Council postdoctoral fellowship at the U.S. Naval Research Laboratory in Washington, D.C.

The new cooling technology is called a "high performance two-phase cold-plate design for automotive power electronics cooling." In cold-plate systems, a coolant flows through a metal plate that is attached to a device that needs to be cooled. Allowing the coolant liquid to boil on the surface of the plate provides greater cooling and also helps maintain a uniform temperature across the surface of the power semiconductor device. The technology under development uses "jet impingement" to enhance cooling by flowing the coolant in a perpendicular direction, producing jets that wash across a hot surface and improving heat transfer.

The cooling system is about 5 centimeters by 5 centimeters, or roughly 2 inches by 2 inches. It has been found to cool power devices operating at a rate of a thousand watts per centimeter squared, or the equivalent of the heat generated by 10 100-watt light bulbs crammed into the space of a square centimeter.



Fins before testing. Credit: Purdue University

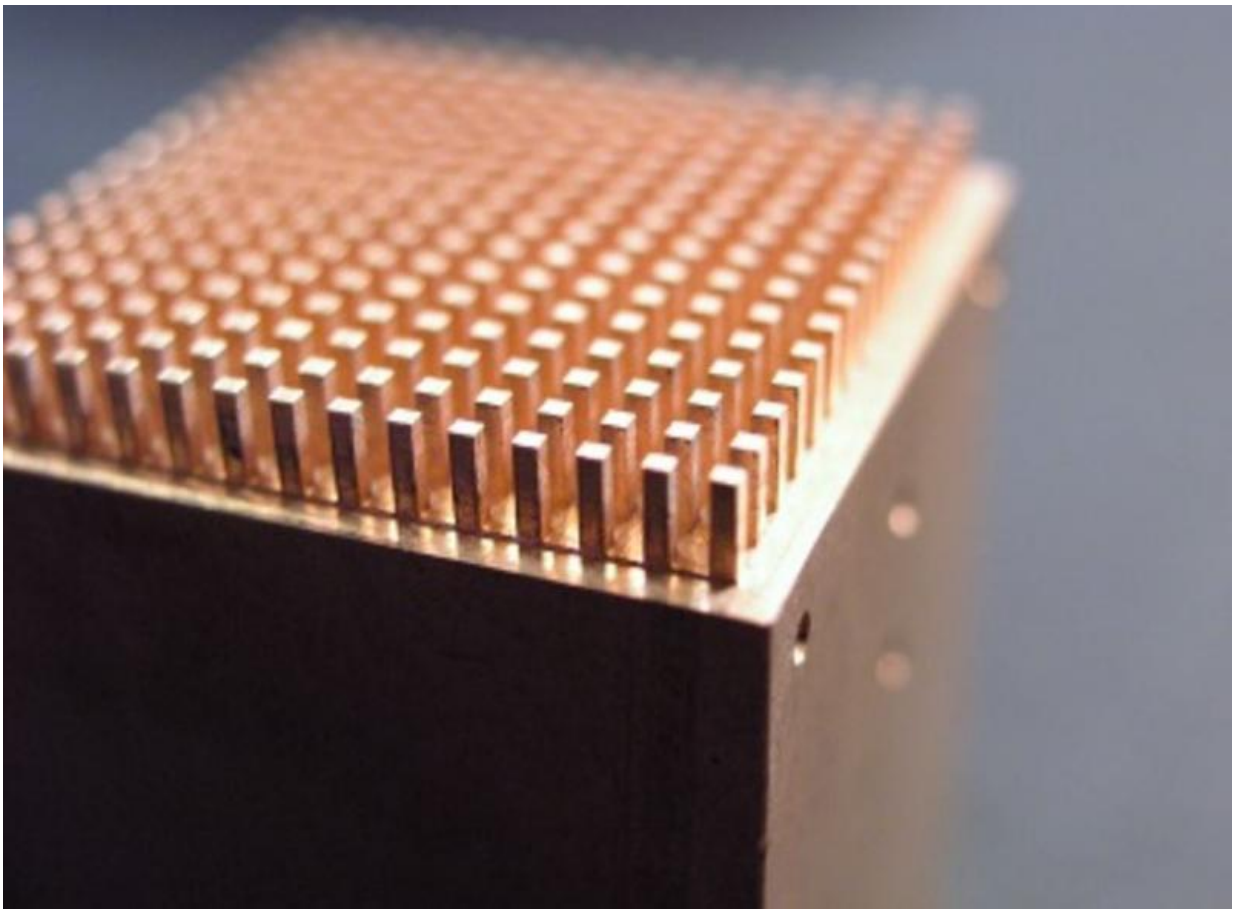
"This is a big number," Garimella said. "Today a smart phone might dissipate 5 watts, a laptop 30 watts, and most work stations not more than 100 watts. But, overall, our main contribution here was bringing our 25 years of knowledge in impinging jets and boiling on surfaces to design something very special."

To improve performance, the researchers modified the cold plate's surface by incorporating porous copper coatings and tiny pin-like fins. Also key to the design is a manifold that is optimized to more evenly

distribute the coolant through many tiny nozzles. Two patents have been issued, and Toyota has filed a third patent application related to the cooling technology. Toyota researchers Eric Dede and Shailesh Joshi also are named in the patents and the R&D 100 application.

In 2011, the cooling-research center received the NSF Industry/University Cooperative Research Center Association's Alexander Schwarzkopf Prize for Technological Innovation. Earlier, Indiana's 21st Century Research and Technology Fund provided $3.8 million to help commercialize an advanced cooling system for hybrid and electric cars.

The R&D 100 Awards, given annually to the top 100 innovations recognized by R&D Magazine, have been called the "Oscars of invention." The innovation is listed under the Mechanical/Materials category.



Credit: Purdue University

"Being selected as a finalist for the R&D 100 award is one more testimonial to the close collaborations we have developed over the years with companies," Garimella said.

More than 60 undergraduate students and about 100 graduate students have performed research through the center.

"They come out of Purdue with training in fundamental research projects, but also with applications in the real world, so they are sought after by companies," Garimella said.

The center also has involved about 15 Purdue faculty members from a variety of fields, from electrical engineering to chemistry.

Provided by Purdue University