STORY AND PHOTOS BY ROSAIRE BUSHEY
MECHANICAL ENGINEERING

Heat flux sensor provides undergraduates with portable lab experience

Giving students excellent hands-on learning experiences doesn't necessarily mean laboratories filled with the latest high-tech hardware. Starting with the Spring 2017 semester, some mechanical engineering undergraduates are carrying their labs in their backpacks thanks to the work of two faculty members who turned a grant-inspired innovation into a unique learning tool for students.

Top - The entire kit fits in a case about twice the size of a deck of cards.

Above - Associate Professor Al Wicks worked with Professor Tom Diller to create the kit and adapt its inclusion into undergraduate course work this semester.

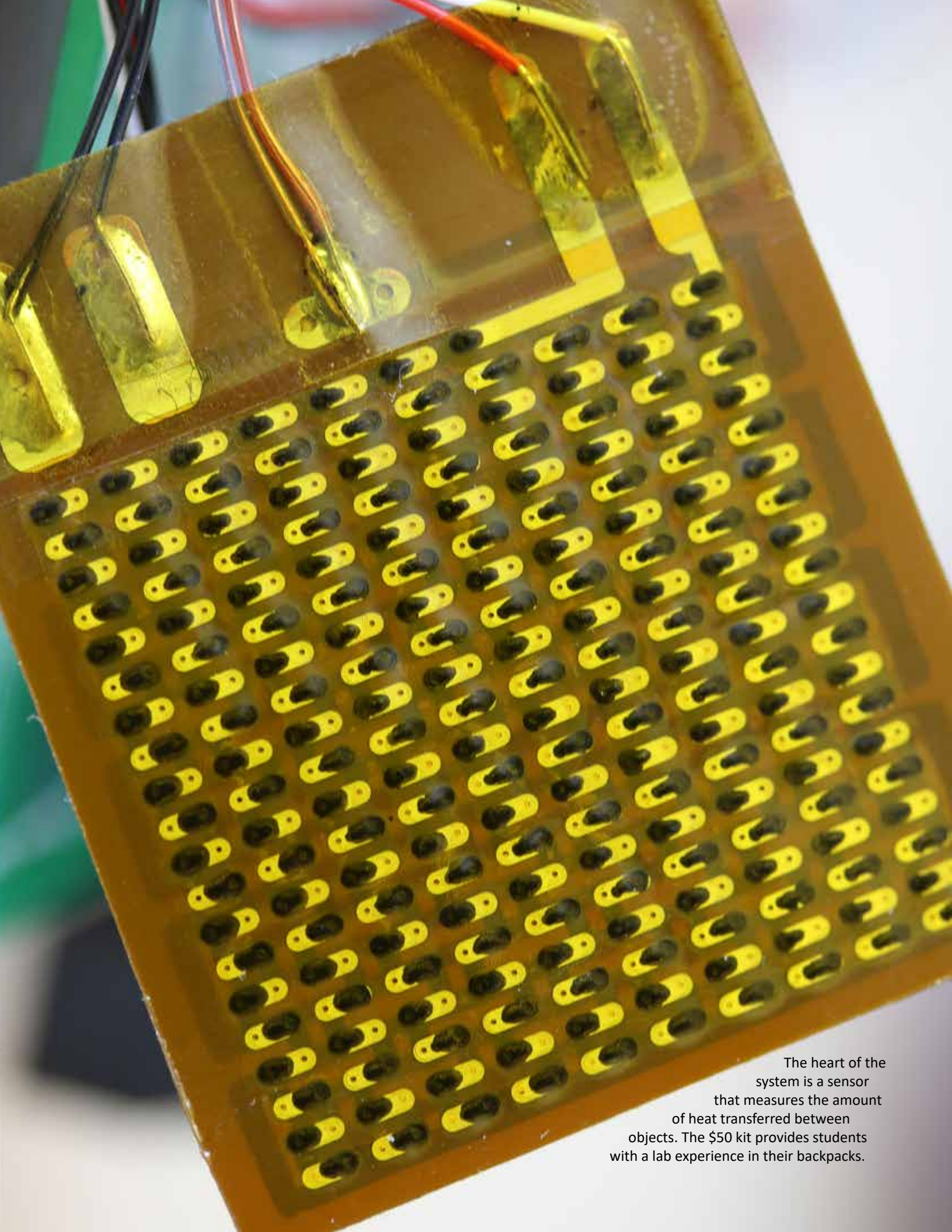
In 2015, two graduate students working with Professor Tom Diller on a National Science Foundation project for hands-on learning, formulated a method to manufacture heat flux sensors far more inexpensively than those being sold at the time. The students and Diller went on to form the company FluxTeq to commercialize the technology. The company is currently located in a lab at the Corporate Research Center. This spring Diller has started to use these products in his classes as part of a portable lab with the assistance of Associate Professor Al Wicks.

"We've been working for the last couple years on a way to provide students with more hands-on experiences," Wicks explained. "The concept is to allow students to have the capability of doing lab-type exercises without having a formal lab section."

With more than 400 undergraduates in current classes of mechanical engineering, there aren't enough 3-hour sections to handle the lab requirements such a student load would bring – to say nothing of faculty and graduate assistant staff to make it feasible. According to Wicks, heat flux-related labs haven't been part of the curriculum course requirements for nearly two decades.

The portable lab kit, which is only slightly larger than a deck of playing cards, allows students to do heat flux measurements, and provides a much more well-rounded educational experience for the students.

"We literally built a data acquisition system based on a micro-controller attached to a heat flux gauge," said Wicks. "There is a USB cable which can be plugged into a students' laptop and they can use this small, inexpensive system to make measurements. They are using state of the



The heart of the system is a sensor that measures the amount of heat transferred between objects. The $50 kit provides students with a lab experience in their backpacks.

Right - Professor Tom Diller and junior Riley Allison, connect the heat flux sensor kit as part of a demonstration.

art research tools and being exposed to data acquisition on systems based on a micro controller. That means they are starting to look at more sophisticated electronics and being introduced to ancillary activities that add to their educational experience. None of this was possible 10 years ago."

In January a group of about 75 students in one section of the required Heat and Mass Transfer course received their heat flux kits. The kits include a Texas Instruments TI432 micro controller with a TI "launch pad" board designed and built by ME graduate students that allows for measurements and data acquisition of the sensors. Texas Instruments donated 100 of the controllers for the initial run of sensors. For students like Riley Allison of Goochland, Virginia, a junior in mechanical engineering, the kit, despite its small size, was intimidating at first.

"I was like, 'oh, no! It goes back to our major where anytime we see wires or anything to do with coding we get scared," said Allison. "This has been a great way to slowly step into that realm of possibilities. We weren't given this kit to simply be a tool; we were shown how it works and what it is meant to do, which is great because so often you are given something and told to do a task without ever knowing how or why."

A heat flux sensor measures more than temperature – it measures the heat transfer between objects. With the kit, for instance, students can place their hand on a piece of metal (which is provided) and measure the heat transferred from the body to the metal. Doing the same test with another substrate, such as wood, would result in a drastically different result because of the heat transfer properties of the material. Students can also directly measure the heat transfer from their skin at a variety of locations around the body and determine, for instance, how many calories they are burning.

"Having the kits means students have to go out and do the work themselves with real hardware and analyze the data using industry-standard software," said Wicks. "The depth at which they dive into the software is really a positive experience because it gives students some real-world application to the software they might not otherwise get until they were graduate students."

"I've been on two co-op experiences and the MatLab software is always present," Allison said. "We are using the software with this heat flux kit to a much greater degree than I used it in those co-ops and it's been an awesome opportunity to see how everything ties together in a very important way.

Diller and Wicks agree they want to see students like Allison leave Virginia Tech as a problem solver. "As engineers we are trained to use the tools available to solve problems and problems aren't always defined," said Diller. "Students can't escape – if they need to code, they will learn how to code and solve the problem; if they need to understand electronics, they'll have to learn – not knowing isn't an excuse, it's an opportunity. The idea is that we are allowing the students to not be blocked by saying 'I can't do this,' or 'I don't know how'. They've had exposure to it now and that allows them to feel comfortable with the unknown and go off and explore."