Self-Powered Vision
NC STATE’S ASSIST CENTER AIMS TO IMPROVE GLOBAL HEALTH OUTCOMES BY ELIMINATING SENSOR BATTERIES

By Gene Pinder

Health monitors harvesting energy from body heat. Stretchable nanowire electrodes embedded in garments. Wearable ozone sensors alerting asthma sufferers to adverse conditions.

These are some of the exciting research breakthroughs made by a National Science Foundation Engineering Research Center located on NC State’s Centennial Campus.

The Advanced Self-Powered Systems of Integrated Sensors and Technologies Center — better known as ASSIST — was launched in fall 2012 with a $20 million grant from NSF. Since then, the NC State-led consortium of academic institutions and private companies has worked to revolutionize health monitoring by giving sensors a whole new power source: the patient’s own body.

“Our mission is to improve global health outcomes by creating battery-free, self-powered, wearable systems for continuous health monitoring and long-term use,” explains Veena Misra, director of ASSIST. “The idea is for a wearable unit to collect continuous health data from sensors. At the same time, it’s being powered by the patient or user. It’s really breakthrough technology — and a lot of it is being developed at NC State.”

Freeing health monitors from relying on batteries sounds like a good idea, but it’s no easy feat. There are good reasons why health monitors use batteries: the power batteries generate is generally reliable and strong enough to drive the associated electronics, such as a pacemaker.

But batteries eventually die — even rechargeables. In a health care context, that makes battery-powered sensors poorly suited for long-term use and continuous monitoring.

Some research suggests that battery use may be one of the primary obstacles to patient compliance. In other words, patients may not use their monitors if they have to keep messing with batteries.

POWERED BY YOU
ASSIST researchers intend to change that paradigm by eliminating the battery completely.

“Humans have two ways to generate power using the body,” Misra notes. “One is heat, and the other is motion. But in order to harness that power efficiently, you have to have very advanced materials, and you need systems in place to capture that power.”

Take body heat, for instance. Small thermoelectric energy generators (TEGs) can be placed on the body to convert the temperature differential between the skin and the air into energy. But achieving maximum power and efficiency can be challenging, especially when a...
rigid TEG doesn’t conform to the contours of the skin.

In addition, a single TEG can’t deliver the desired power levels for the sensors and electronics of the future. As a result, ASSIST researchers have been working on stringing several TEGs together to achieve sufficient power, as well as making them more flexible. The team is exploring new “nanocomposites” of bismuth telluride that deliver higher power performance. NC State researchers have been particularly effective at developing these nanocomposites in grain form, further optimizing the material’s thermoelectric properties.

SAVING POWER

While some researchers are focusing on significantly improving the effectiveness of harvesting power from the body, other ASSIST teams are lowering the power demands of health sensors.

Wearable systems consume power in a number of ways, such as sending and receiving radio signals or by using the microchip embedded in a system. Researchers at the University of Virginia, an ASSIST partner institution, and the University of Michigan are developing high-functioning chips that use very little power — a critical requirement for a
self-powered wearable sensor.

Sensors, in fact, play a key role in the development of current and future health monitors. NC State researchers and others are developing more effective biochemical and organic compound sensors, such as ozone detectors, which could have significant applications in asthma treatment.

Imagine monitors that could use sensor data to detect environmental risk factors for an asthma attack and could warn a person, especially a young child, that an impending episode is likely.

BIG DATA

Misra says big data is at the core of the entire health-monitoring system.

“For all of these systems to have value, the data needs to be obtained from different sensors, then correlated and mined for trends,” she says. “That’s why we’re so focused on a systems approach. It all has to work together.”

That systems approach is multidisciplinary at its core. For example, a new wireless, wrist-worn platform of sensors optically measures movement of the blood in the body. The monitoring platform is solar-powered and contains supercapacitors—devices that can store energy in the form of an electrostatic field.

Another focus at ASSIST involves clothing. The center incorporates research from NC State’s College of Engineering and College of Textiles because ASSIST’s corporate members are particularly interested in integrating wearable platforms into apparel.

Instead of a wristwatch monitoring your heartbeat or body heat during a workout, imagine self-powered sensors embedded in your workout clothes that continuously monitor your activities. Or envision a hospital gown that has sensors in its fabric to continuously monitor a person’s vital signs as they recover from a devastating illness.

What does this research mean for the average person?

Misra expects people will make better decisions about their health because they’ll have access to more and better data. That, in turn, will make health care more effective and will eventually help drive down costs.

ASSIST member UNC REX Healthcare is acutely aware of the potential benefits of the center’s critical research.

Anita Watkins, director of Rex Strategic Innovations and chair of the ASSIST Industry Advisory Board, notes that technology developed by ASSIST will provide constant monitoring for hospital patients once they are discharged—a direction the health care system is already moving in.

In addition, the millennial generation expects health care to be digitized, with wearables as integral parts of overall health care. “They expect their visits will involve data from devices and that they will be active in their care decisions,” Watkins says. “They will be collecting data for their health care providers and transmitting that data back to improve health outcomes and overall wellness.”

Watkins is pleased that Rex Strategic Innovations became an ASSIST corporate partner. “ASSIST was one of our first partners when we started our initiative, and it’s been a great partnership,” she says. “We were looking for people and institutions that were forward thinking, and ASSIST matched our needs perfectly. We can look internally to generate innovative ideas for how to improve health care, but we also wanted to reach outside health care as well.”

Commercialization of the center’s research is a key outcome. It’s not enough that ASSIST will create new and exciting self-powered health monitors; the innovative technology also must stimulate the development and distribution of new commercial products and programs.

“Because our technologies are so advanced, we want industry to be able to pick them up and translate them into products that create jobs, stimulate the economy and create new market directions,” Misra adds. “That’s a critically important part of our work, and we’re very focused on it.”

While researchers work behind the scenes to bring new technology to light, the center also conducts an active educational outreach program, including preparing NC State students for careers in this burgeoning field.

ASSIST also holds summer programs for high school teachers to help strengthen interest in science, technology, engineering and mathematics by introducing students to a cross-disciplinary scientific environment.

“I think it’s really fulfilling to see how we’ve all come together,” Misra says. “We have really gelled as a center, and we’re all focused on achieving this self-powered vision.”