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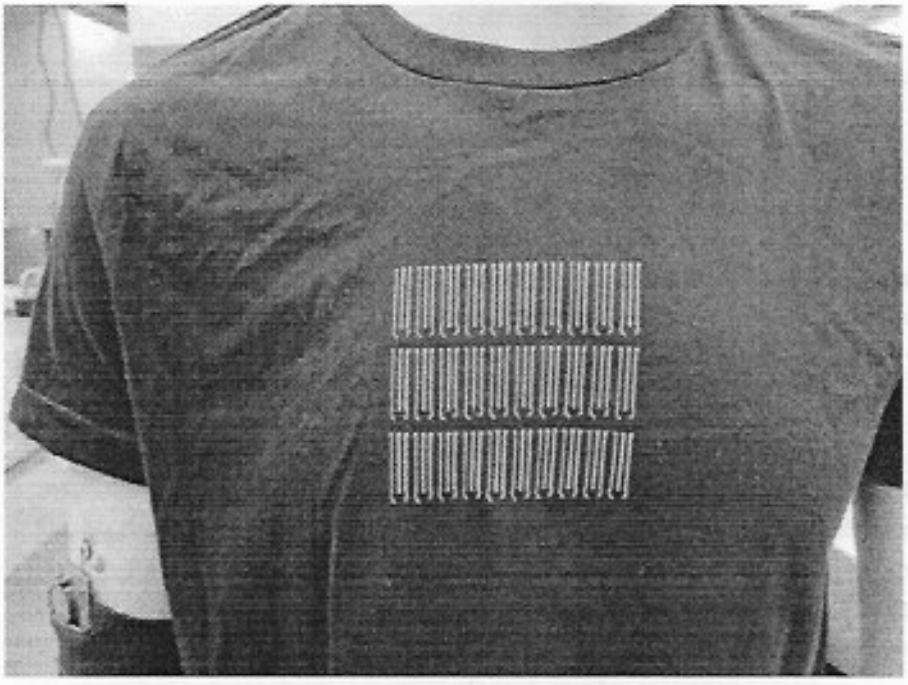
Nanoengineers win grant to make smart clothes for personalized cooling and heating

(*Nanowerk News*) Imagine a fabric that will keep your body at a comfortable temperature—regardless of how hot or cold it actually is. That's the goal of an engineering project at the University of California, San Diego, funded with a $2.6M grant from the U.S. Department of Energy's Advanced Research Projects Agency – Energy (ARPA-E). Wearing this smart fabric could potentially reduce heating and air conditioning bills for buildings and homes.

The project, named ATTACH (Adaptive Textiles Technology with Active Cooling and Heating), is led by Joseph Wang, distinguished professor of nanoengineering at UC San Diego.

By regulating the temperature around an individual person, rather than a large room, the smart fabric could potentially cut the energy use of buildings and homes by at least 15 percent, Wang noted.

"In cases where there are only one or two people in a large room, it's not cost-effective to heat or cool the entire room," said Wang. "If you can do it locally, like you can in a car by heating just the car seat instead of the entire car, then you can save a lot of energy."



Garment-based printable electrodes developed in the lab of Joseph Wang, distinguished professor of nanoengineering at UC San Diego, and lead principal investigator of ATTACH. (Image: Jacobs School of Engineering/UC San Diego)

The smart fabric will be designed to regulate the temperature of the wearer's skin—keeping it at 93° F—by adapting to temperature changes in the room. When the room gets cooler, the fabric will become thicker. When the room gets hotter, the fabric will become thinner. To accomplish this feat, the researchers will insert polymers that expand in the cold and shrink in the heat inside the smart fabric.

"Regardless if the surrounding temperature increases or decreases, the user will still feel the same without having to adjust the thermostat," said Wang.

"93° F is the average comfortable skin temperature for most people," added Renkun Chen, assistant professor of mechanical and aerospace engineering at UC San Diego, and one of the collaborators on this project.

Chen's contribution to ATTACH is to develop supplemental heating and cooling devices, called thermoelectrics, that are printable and will be incorporated into specific spots of the smart fabric. The thermoelectrics will regulate the temperature on "hot spots"—such as areas on the back and underneath the feet—that tend to get hotter than other parts of the body when a person is active.

"This is like a personalized air-conditioner and heater," said Chen.

Saving energy

"With the smart fabric, you won't need to heat the room as much in the winter, and you won't need to cool the room down as much in the summer. That means less energy is consumed. Plus, you will still feel comfortable within a wider temperature range," said Chen.

The researchers are also designing the smart fabric to power itself. The fabric will include rechargeable batteries, which will power the thermoelectrics, as well as biofuel cells that can harvest electrical power from human sweat. Plus, all of these parts—batteries, thermoelectrics and biofuel cells—will be printed using the technology developed in Wang's lab to make printable wearable devices. These parts will also be thin, stretchable and flexible to ensure that the smart fabric is not bulky or heavy.

"We are aiming to make the smart clothing look and feel as much like the clothes that people regularly wear. It will be washable, stretchable, bendable and lightweight. We also hope to make it look attractive and fashionable to wear," said Wang.

In terms of price, the team has not yet concluded how much the smart clothing will cost. This will depend on the scale of production, but the printing technology in Wang's lab will offer a low-cost method to produce the parts. Keeping the costs down is a major goal, the researchers said.

The research team

Professor Joseph Wang, Department of NanoEngineering

Wang, the lead principal investigator of ATTACH, has pioneered the development of wearable printable devices, such as electrochemical sensors and temporary tattoo-based biofuel cells. He is the chair of the nanoengineering department and the director for the Center for Wearable Sensors at UC San Diego. His extensive expertise in printable, stretchable and wearable devices will be used here to make the proposed flexible biofuel cells, batteries and thermoelectrics.

Assistant Professor Renkun Chen, Department of Mechanical and Aerospace Engineering

Chen specializes in heat transfer and thermoelectrics. His research group works on physics, materials and devices related to thermal energy transport, conversion and management. His specialty in these areas will be used to develop the thermal models and the thermoelectric devices.

Associate Professor Shirley Meng, Department of NanoEngineering

Meng's research focuses on energy storage and conversion, particularly on battery cell design and testing. At UC San Diego, she established the Laboratory for Energy Storage and Conversion and is the inaugural director for the Sustainable Power and Energy Center. Meng will develop the rechargeable batteries and will work on power integration throughout the smart fabric system.

Professor Sungho Jin, Department of Mechanical and Aerospace Engineering

Jin specializes in functional materials for applications in nanotechnology, magnetism, energy and biomedicine. He will design the self-responsive polymers that change in thickness based on changes in the surrounding temperature.

Dr. Joshua Windmiller, CEO of Electrozyme LLC

Windmiller, former Ph.D. student and postdoc in Wang's nanoengineering lab, is an expert in printed biosensors, bioelectronics and biofuel cells. He co-founded Electrozyme LLC, a startup

devoted to the development of novel biosensors for application in the personal wellness and healthcare domains. Electrozyme will serve as the industrial partner for ATTACH and will lead the efforts to test the smart fabric prototype and bring the technology into the market.

Source: *UC San Diego*

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