JULIANNA ABEL AND DAVID PUI ARE THE U OF M'S LEAD RESEARCHERS FOR A NATIONWIDE "SMART FABRICS" INITIATIVE. (PHOTO BY WILLIAM CLARK)

COVER STORY

Weaving a smarter future

AS PART OF A NEW INITIATIVE, UNIVERSITY OF MINNESOTA RESEARCHERS WILL ADVANCE INNOVATIONS IN FIBERS AND FABRICS

BY EVE DANIELS

Since the dawn of the Digital Revolution, everyday objects have become smarter and smarter. In most American cities today, smartphones, smart cars, and smart buildings are ubiquitous. Now, thanks to a new multi-million-dollar partnership, there's a good chance that our clothing and other textiles will get smarter, too.

Announced this past April, the Advanced Functional Fabrics of America (AFFOA) initiative brings together expertise from the University of Minnesota and dozens of other academic and industry partners. The goal is to drive innovation in the emerging field of "smart fabrics."

Contrary to how they might sound, smart fabrics aren't just for Iron Man. The AFFOA partners are focused on real-world applications that improve lives.

"They can be any type of textile structure that incorporates technology in a novel way," explains Julianna Abel, Benjamin Mayhugh Assistant Professor of mechanical engineering at the U of M and one of the lead researchers for the new partnership. "The idea is to use real fabrics, which

then have fiber technology woven throughout the structure that can carry and pull information from the wearer."

Student work from Professor Julianna Abel's class

PHOTOGRAPHY BY WILLIAM CLARK

Also known as functional or connected fabrics, smart fabrics will be able to "see, hear, sense, communicate, store and convert energy, regulate temperature, monitor health, and change color," according to the AFFOA.

The initiative will receive $75 million in federal funding out of a total $317 million through cost sharing among the Department of Defense, industrial partners, venture capitalists, and the Commonwealth of Massachusetts.

The first round of proposals is due in November, with a target launch date of December. While the specific projects are yet to be determined, they are likely to shape the next generation of textile manufacturing.

"AFFOA is placing a lot of emphasis on manufacturing to bring products quickly to the marketplace," says David Pui, who is L.M. Fingerson/TSI Chair in Mechanical Engineering, Distinguished McKnight University Professor, and a lead researcher on the project. "Ultimately, this will help establish a new industry with improved manufacturing capabilities."

From apparel to aviation

The AFFOA partnership encompasses 31 universities, 16 industry members, 72 manufacturing entities, and 26 startup incubators across 28 states. Among the industry partners are major brands such as Dupont, Warwick Mills, NextFlex, Steelcase, and Corning.

The U of M was chosen as an AFFOA collaborator due largely to the success of the Center for Filtration Research, which Pui directs. Nearly 20 companies are funding research in the center, and several of them will be involved in the advanced fabrics project.

Boeing Commercial Airplanes, based in Seattle, is one of those companies. Boeing hopes to work with Pui and Abel on developing fabrics with nano-activated carbon fibers (ACF), which have moisture-control properties and can absorb a variety of gases.

"If these ACF fabrics are made into an airplane seat, they could take out odors and also are flame resistant and noise absorbent to make the cabin quieter," says Pui.

"This will help the flying public and crew in the areas of aircraft cabin environment, mitigation of potential disease infection in cabins, and the design and certification of fire and smoke protection systems," says Chao-Hsin Lin, technical fellow with Boeing's Environmental Control Systems.

EXPANDING HORIZONS

Philanthropy hasn't just supported faculty positions for David Pui and Julianna Abel. It's also broadened their horizons. As L.M. Fingerson/TSI Chair in Mechanical Engineering, Pui has been able to continually expand his research focus. "The endowed position has allowed me to explore research outside of my normal activities," says Pui, a member of the National Academy of Engineering. He draws on his expertise in aerosol science and nanoparticle engineering to evaluate the properties of smart fabrics.

Needless to say, the future of fabrics goes well beyond our wardrobes. “We think of textiles as clothing, but they’re so much more than that,” says Abel. “There are countless other applications where a textile is a great form factor.”

Along with airplane seats, airplane wings might benefit from smart fabrics one day. Currently, Abel is trying to create textile structures that could be used for aircraft wings that change shape in flight. “You could potentially complete an endurance mission or a strike mission with the same aircraft,” she says.

Fabric innovations could also save lives. “Military uniforms made with high-tech materials could make them invisible to night vision so they could be used in rescue missions without detection,” notes Pui.

Within the medical industry, smart fabrics have infinite potential. “We could possibly act on or provide information back to the body, instead of just sensing it,” says Abel.

Medical applications could include noninvasive health monitors, rehabilitation equipment, and even products for new parents. “Imagine something that babies wear to monitor their temperature,” says Pui, “or even their wet diapers.”

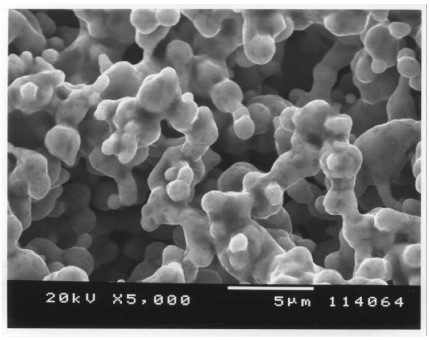
Abel joined the U of M in 2014 as Benjamin Mayhugh Assistant Professor of mechanical engineering as part of a MnDRIVE-funded cluster hire in robotics, sensors, and advanced manufacturing. The MnDRIVE funding provided not only some of the equipment for her lab, but also valuable connections to industry.

“MnDRIVE is directly tied to the local economy, so through that initiative, I’ve been able to meet with people from many different companies in Minnesota,” says Abel. “It’s helping to build a pipeline, so we can transition the technologies we develop into products that will help the whole state.”

She’s also grateful for her endowed professorship, which has allowed her to purchase equipment and materials and support a graduate-student researcher.

Team effort

If weaving high-tech sensors into fabric were easy, we'd all be wearing smart jeans and lounging on smart sofas. But a lot more research needs to happen before functional fabrics hit the market.



Professor David Pui's laboratory has evaluated various nonwoven fabrics to find out which ones are best at filtering atmospheric particulate pollutants and removing cleanroom contaminants to enable the clean manufacturing of semiconductor chips. Pictured here: electron micrograph of sintered nickel metal.

IMAGE COURTESY OF DAVID PUI

"Sometimes these novel materials are stiff or brittle, so we have to make adjustments to them," says Abel. "Fabrics need to have drapability, and you want to maintain that feature when you integrate technology."

Another challenge is to distribute information as widely as possible. Unlike the Apple Watch or Fitbit, which are limited to a single point source, the goal is to distribute sensors across the body and multiple pressure points.

Despite the challenges, Abel is well-equipped for the future of fabrics. Her lab is the only one on campus where you'll find sewing machines, knitting machines, and bobbin winders alongside environmental test chambers, ovens for shape setting, and state-of-the-art electronics.

By coincidence or kismet, the advanced fabrics project formed shortly after Abel started her faculty position in 2014. "It was perfect timing," she says. "I had been

doing this work at the local level, but this is a much larger scale. We need everyone working together to make products that are better than anything we could create on our own."

Eve Daniels is a Minneapolis-based writer, editor, and video producer.

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