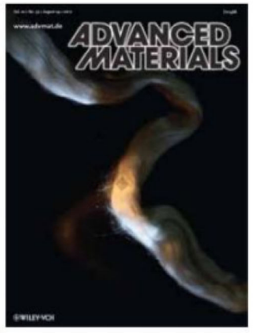
Mechanical Engineers Fashion Implantable Silk Biosensors



Featured on the inside front cover of the August 24 edition of Advanced Materials, *this image shows a metamaterial structure patterned directly onto a 2 cm × 2 cm freestanding silk film placed on a bed of natural silk threads.*

Photonics engineers use light to excite the bonds that connect atoms within molecules, causing them to vibrate at a specific resonant frequency. Using spectroscopy techniques to examine what light frequencies are absorbed by a material, they can determine what kind of bonds it contains, and thus identify the material. In recent years engineers have designed artificially structured materials—or metamaterials—that produce strong resonance frequency responses in the terahertz (10^{12} Hz) range—distinct responses that can "fingerprint" many biological and chemical agents.

Now a research team from Boston University and Tufts University has found a novel way to turn these electromagnetic metamaterials into implantable sensors and detectors made of tough but biodegradable silk. Incurring no harm on the human body and optically transparent, such devices may ultimately be used to identify toxins in the bloodstream or monitor drug delivery rates or tumor growth in real time.

Drawing on the expertise of Professors Xin Zhang (ME), Richard D. Averitt (Physics) and Fiorenzo G. Omenetto (Tufts Department of Biomedical Engineering), and Zhang's former graduate student Hu "Tiger" Tao (ME, PhD'10), the team has devised a new, simple method to spray electromagnetic metamaterials onto silk substrates, thus enabling them to be implanted in the body. The researchers described their achievement in the August 24 edition of *Advanced Materials*.

—Mark Dwortzan

Future of Engineering Symposium Explores Personalized "Intelligent" Medicine

On October 29 in the Photonics Center, Professor James Collins (BME), a leading expert in systems and synthetic biology, and George Savage (BME'81), a medical doctor and chief medical officer of the biotechnology firm Proteus Biomedical, addressed approximately 250 students, alumni and faculty at the College of Engineering's third annual Future of Engineering Symposium. The event focused on the potential impact of engineering, technology, innovation and public policy on health care.

"In the 19th century, medicine was highly personalized but also ineffective," Savage observed. "Now, we have swung to the other end of the spectrum, where medicine is highly effective but impersonal."

Savage discussed Proteus's system of small, ingestible event markers that are implanted in a patient's medications. An inexpensive, disposable monitor worn as a patch identifies each pill upon swallowing and tracks vital signs to detect and report adverse reactions.

Collins discussed emerging technologies ranging from targeted antibiotics to stem cell therapy as examples of the growing influence of synthetic and systems biology on personalized medicine.

"With these developments," Collins said, "doctors will be able to filter information through a network of human illnesses to determine a patient's disease state, specifically target that disease and predict exactly what treatments are needed."

—Kathrin Havrilla

Keynote speakers Dr. George Savage (BME'81) (left) and Professor James Collins (BME) engage the audience in a discussion about personalized health care. (Photo by Glen Kulbako)

First Ten Lutchen Fellows Share Research Highlights

Nine of this year's ten recipients of the Kenneth R. Lutchen Distinguished Fellowship Program (Chantal de Bakker, Amy Canham, Molly Keenan, Genevieve Plant, Joseph Greenspun, Craig LaBoda, Nicholas Luzod, Sean DeLeo and Samuel Hoffman) with Dean Lutchen. The tenth recipient, Benjamin Weinberg, was unavailable.

Last summer, ten College of Engineering juniors and seniors pursued innovative research projects supported by the new Kenneth R. Lutchen Distinguished Fellowships. Funded by annual donations of $100,000 from an anonymous alumnus of the College's Biomedical Engineering program, the program supports up to ten upper-level undergraduate research projects each summer. At a luncheon held in October, nine of the first ten Lutchen Fellows shared highlights of their projects with Dean Lutchen.

"I always felt it was very important to give undergraduates substantive, hands-on experiences outside the classroom," Lutchen said. "Classes are necessary, but we're also pushing the concept of the Societal Engineer—that engineering is a great foundation for people to have a significant impact on society."

A case in point is Amy Canham (EE'11), who spent part of last summer in Zambia investigating ways to collaborate with health professionals to design user-friendly medical technologies that address the particular needs of resource-limited countries. For four weeks, Canham worked closely with her advisor, Assistant Professor Muhammad Zaman (BME), and the Boston University Center for Global Health & Development, in an effort to improve public health in Zambia.

"I worked mostly with individuals designing training programs for using cell phones to transmit results from the lab where they are determined to the facility where they can be delivered to patients," said Canham, noting that cell-phone-based transmission of a child's blood sample data results to the facility can reduce the time it takes for health professionals to determine if that child is HIV-positive.

Samuel Hoffman (ME, EE'12) highlighted his efforts to optimize the design of a "polymorphic zoom" system that improves the optical performance of standard zoom lenses and could be used in unmanned aerial vehicles, security systems and microscopes. The system uses two electrically actuated "deformable" mirrors developed by Hoffman's advisor, Professor Thomas Bifano (ME), consisting of hundreds to thousands of optical surfaces controlled to nanoscale precision.

"In a conventional zoom, an optical lens is translated to achieve magnification or demagnification, typically using a motorized translational drive system," Hoffman explained. "In a polymorphic zoom, the focal lengths of two deformable mirrors are dynamically adjusted by changing the mirrors' shape. The result is a zoom system with unprecedented speed and inertial stability."

Chantal de Bakker (BME'12) summarized her contributions to the development of a noninvasive method that uses contrast agents to pinpoint cartilage formation in bone fractures that does not show up in CT scans.

"The ability to visualize cartilage could lead to the earlier identification of healing problems in complex fractures and also could be very useful in the analysis of fracture healing in animals used in biomedical research," said de Bakker, who collaborated with her advisor, Professor Elise Morgan (ME) on the project.

The Lutchen Distinguished Fellowship Program was designed to attract and retain top applicants to the College of Engineering. Each fellow must identify a research project and faculty mentor and maintain a minimum 3.0 grade point average. Entering freshmen who win a $10,000 fellowship can use it during the summer after their sophomore or junior year.

After hearing from last summer's fellows, Lutchen described their reports as articulate and passionate: "You really got into the essence of what you were trying to do, and I hope it has an influence on where you're going."

—Mark Dwortzan