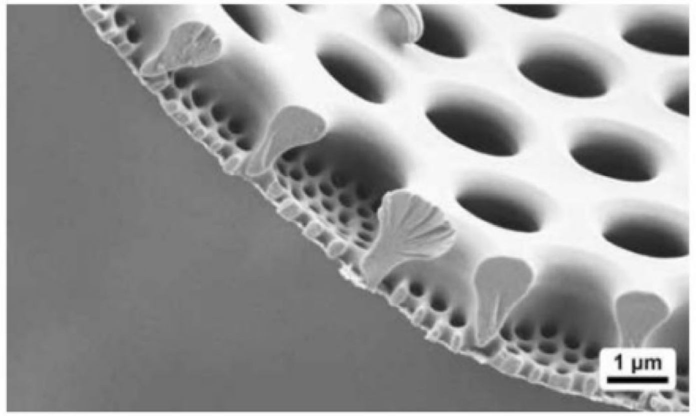
Naturally Inspired

ZHANG'S RESEARCH TAKES A PAGE FROM BIOLOGY TO BUILD MATERIALS



The porous, three-dimensional structure of the diatom frustules can be oriented on a large scale and used as a potential alternative for creating micro- and nanopattern surfaces, which have many practical applications in research. (Image courtesy of Zhang lab)

At first glance, diatoms seem to have little to do with engineering. However, they are the focus of a recently published study from Professor Xin Zhang's (ME, MSE) laboratory for microsystems technology.

"By drawing inspiration from different fields of science, we come up with unconventional approaches to study the materials, which allows us to learn more about them," said Zhang. "In this case, we learn from nature to build materials of our own."

The study, the cover story for *Extreme Mechanics Letters*, used the exoskeletons of diatoms (called frustules) to develop a stencil that can be easily produced and replicated in a certain range of sizes for use in research protocols. The porous, bowl-shaped, three-dimensional exoskeletons, made naturally of pure silica, lent themselves well to stencil making and served as a unique fabrication method.

"The ability to uniformly orient the frustules will be beneficial for enhancing their application to practical technologies, from sensors to solar cells," said Aobo Li (ME), a graduate student who worked on the study. "We were able to figure out how to orient them uniformly on a large scale, which allowed us to make micro- and nanostencils."

Current methods of creating nanopattern surfaces present a number of problems for researchers—they can be costly, time-consuming or it can be difficult to achieve scalability or control over the size of the stencil. Zhang's novel approach seeks to address these limitations by using the bio-structures of the diatoms as a potential alternative for fabricating micro- and nanopatterns.

"You can make chips, you can make computers, but if you humbly turn to nature, you see so many unique micro- and nanostructures that already exist," Zhang explained. "You can be inspired by these beautiful, available structures and can even build engineering components directly out of them. By looking to diatoms, we are trying to understand nature, and leverage these biological components for our specific engineering purposes."—**SARA CODY**

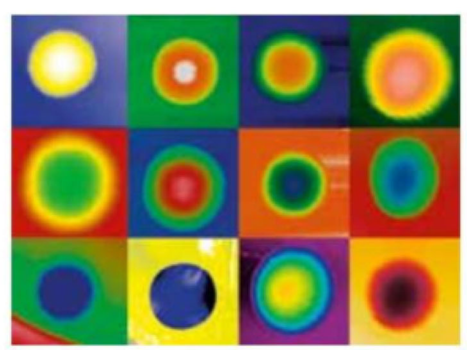
Nanopore Valves Enable High-Precision Gas Transport

A STUDY LED BY ASSISTANT PROFESSOR SCOTT Bunch (ME, MSE) has demonstrated the ability to measure and control the transport of gas through a single molecule-sized pore in graphene, a strong, flexible material made of one-atom-thick sheets of carbon atoms. By using gold nanoparticles to block and unblock such pores in a graphene membrane, Bunch and his research team have provided the first evidence of controlling the transport of gas through a molecule-sized opening in any existing membrane material.

"These nanopore molecular valves provide the unique ability to control a single-file flow of molecules, and may lead to important applications in nanoscale 3D printing, catalysis and sensor design," said Bunch.

Nanoscale 3D printing could be used to manufacture high-precision devices ranging from micro-needles to nano-robots. New applications in catalysis, the acceleration of chemical reactions, could yield new chemical compounds for scientific and commercial applications. The research may also improve the performance of graphene-based separation membranes, which can be used to purify gas, capture carbon from power plant carbon dioxide emissions and perform other applications.

Bunch and collaborators at Boston University, MIT, University of Colorado and National University of Singapore used two methods to create the nanopores in the graphene membranes. They either applied a voltage pulse with an atomic force microscope, or exposed the graphene to ultraviolet light. They also used an atomic force microscope to monitor the flow of hydrogen, nitrogen and other gases.



A composite of atomic force microscope images of pressurized graphene membranes. (Image courtesy of Bunch lab)

The research, which was funded by the National Science Foundation, is described in the online edition of *Nature Nanotechnology*.
—**MARK DWORTZAN**

Materials Day Focuses on Health Care

ONE HUNDRED AND TWENTY-SIX MATERIALS researchers from as near as Boston and as far away as California and Iran convened in the Photonics Center in September for the BU Materials Day Symposium, "Nanomaterials in Medicine: Improving Health Care Through Small Innovations."

The daylong event featured an array of speakers who addressed the promise and use of nanomaterials in drug delivery, biomedical imaging and fighting cancer and infectious diseases.

Dean Kenneth Lutchen welcomed the symposium participants and noted the wide-ranging, interdisciplinary strength of the College of Engineering's Materials Science & Engineering division. Materials research, he said, will play an important role in advancing society, particularly health care.

"The current challenges facing health care call for biomaterials solutions," he said. "It is an inherently complex, multi-scale problem you are trying to address."

Two College of Engineering faculty members affiliated with MSE—Professor Mark Grinstaff (Chemistry, BME) and Assistant Professor Allison Dennis (BME)—presented at the symposium.

Grinstaff's presentation focused on his lab's work in using drug-infused nanoparticles to treat mesothelioma, a highly fatal cancer associated with asbestos exposure. Mesothelioma progresses locally, Grinstaff noted, and the current chemotherapy treatments that infuse toxic drugs throughout the body for a relatively brief period have not been effective.

Grinstaff's approach has been to develop nanoparticles on the order of 100 nanometers that are infused with the chemotherapy drug paclitaxel. These particles are small enough to be admitted into a cancer cell, where the more acidic environment causes them to expand to 1,000 nanometers and begin releasing the drug. The cells are not able to quickly expel the particles, which can release paclitaxel into the cell—and only the cell—for up to two weeks.

His research has produced excellent results *in vivo*, Grinstaff noted, and he hopes that this approach may also benefit patients suffering from breast, lung and ovarian cancers.

Dennis' presentation focused on her work with quantum dots, which she described as semi-conductor nanocrystals with optical properties. Quantum dots have many applications in solid-state lighting and consumer electronics, as well as biomedical imaging.

She described how her lab has been working to manipulate the dots to change the color of light they emit and explained that dots

Professor Mark Grinstaff (Chemistry, BME) detailed his research in using nanoparticles to deliver chemotherapy at the Materials Day Symposium.

emitting multiple colors can be used to more effectively conduct tissue-depth imaging. Some of the dots are exceptionally bright, making their detection easier.

More recently, she has been working with the chemistry of quantum dots in order to find an alternative to the toxic element cadmium so the dots can be used more readily in biomedical applications.

Associate Professor Tyrone Porter (ME, MSE) organized the symposium and moderated the discussions that followed each presentation.

"Nanomaterials in medicine is such a timely subject as we have seen unprecedented activity in the design and production of biologically and medically relevant materials on the nanoscale," Porter said. "The symposium featured leaders in the field who are pushing the boundaries to generate novel constructs and platforms that ultimately will revolutionize how we image, diagnose, detect and treat disease."—**MICHAEL SEELE**

PHOTOGRAPH OF GRINSTAFF BY CYDNEY SCOTT

Student Team Makes Final Round in Air Force Satellite Competition

ANDESITE, a task force within Boston University's Small Satellite Program, has qualified to launch a self-designed satellite into orbit. The ANDESITE team is one of six that reached the final round of the US Air Force University Nanosat Program competition.

ANDESITE is a unique, interdisciplinary, University-wide collaboration consisting of 16 students in astronomy, electrical engineering, computer engineering and mechanical engineering, and two faculty advisors, Professor Joshua Semeter (ECE) and Associate Professor Ray Nagem (ME). ECE Research Engineer Aleks Zosuls also provides support and acts as a liaison with the Engineering Product Innovation Center.

The ANDESITE satellite is on the forefront of an international movement to advance our understanding of "space weather"—which arises from interactions between the Earth's plasma environment and the impinging solar wind—and its effects on society. These interactions can damage satellites, harm astronauts in space, render GPS information erratic and unreliable, disrupt ground-space communications and even cause electricity blackouts on Earth. In 2013, the White House raised inadequate space weather forecasting to the global agenda, citing the significant "threat to modern systems posed by space weather events" and "the potential for significant societal, economic, national security and health impacts."

The ANDESITE satellite is designed to deploy a network of magnetic sensors that will operate collectively as a space-based wireless mesh network that will study fine-scale variations in Earth's geomagnetic environment caused by space weather events. The ANDESITE satellite's scientific and technological innovations are on the leading edge of the burgeoning CubeSat movement.

The qualifying competition took place at the Kirtland Air Force Base in Albuquerque, New Mexico last year. According to Semeter, "It was a stressful experience for the students with an exciting outcome."

Now, the qualifiers must shift their focus from satellite fabrication to implementation. The University Nanosat Program will provide Air Force technical guidance and $110,000 to support each of the remaining six competitors.
—**GABRIELLA MCNEVIN**