**GECKOS INSPIRE NEW ELECTRONIC PRINTING METHOD**

Geckos are masters of sticking to surfaces of all kinds—and easily unsticking themselves, too. Inspired by these lizards, a team of engineers has developed a reversible adhesion method for printing electronics on a variety of tricky surfaces such as clothes, plastic, and leather.

Researchers from Northwestern and the University of Illinois at Urbana-Champaign (UIUC) designed a square polymer stamp that allows them to vary its adhesion strength. The stamp can pick up an array of electronic devices from a silicon surface and move and print them on a curved surface. The research was published by the *Proceedings of the National Academy of Sciences* (PNAS).

“Our work proposes a very robust method to transfer and print electronics on complex surfaces,” said Yonggang Huang, Joseph Cummings Professor of Civil and Environmental Engineering and Mechanical Engineering at the McCormick School. Huang, co-corresponding author of the *PNAS* paper, led the theory and design work at Northwestern. John Rogers at UIUC led the experimental and fabrication work and is a co-corresponding author of the paper.

Key to the stamp are four pyramid-shaped tips on the bottom, one in each corner. They mimic the micro- and nanofilaments on the gecko’s foot, which the animal uses to control adhesion by increasing or decreasing contact area with a surface. Pressing the stamp against electronics causes the tips to collapse against the stamp’s body, maximizing the contact area between the stamp and the electronics and creating adhesion. The electronics are picked up, and, with the force removed, the soft tips snap back to their original shape. The electronics now are held in place by just the four tips—a small contact area. This allows the electronics to be easily transferred to a new surface. “Design of the pyramid tips is very important,” Huang said. “The tips have to be the right height. If the tips are too large, they can’t pick up the target. If the tips are too small, they won’t bounce back to their shape.”

The researchers found the changes in contact area allow the stamp’s adhesion strength to vary by 1,000 times. They also demonstrated their method can print layers of electronics, enabling the development of a variety of complex devices.

The National Science Foundation and the Department of Energy supported the work.

**McCOMICK SCHOLARSHIPS**

McComick students were extremely successful in receiving fellowships and scholarships in 2009–10. Several undergraduates received high-profile competitive scholarships, and 14 graduate students received National Science Foundation fellowships—the most ever for McCormick.

“These scholarships are extremely competitive,” says Stephen Carr, associate dean for undergraduate engineering. “Our students have been successful in pursuing and receiving national and international accolades that help them push their education and research to the top level.”

**Isabelle Ji**, a senior working toward a combined bachelor’s degree in environmental engineering and a master’s in chemical engineering, was awarded a Udall Scholarship, given to students committed to careers related to the environment, tribal public policy, or Native American health care. Ji is interested in a career in business strategies for sustainable development. On campus she leads education and outreach for Engineers for a Sustainable World.

Other McCormick students who earned scholarships and fellowships include the following:

- **Phillip Brunner**, a graduate student in materials science and engineering, and **Lisa Felberg** (chemical engineering ’11) received DAAD German Research grants.
- **Mark Ison**, a graduate student in electrical engineering and computer science, received the Congress-Bundestag Youth Exchange for Young Professionals and Erasmus Mundus scholarships.
- **John Sheppard** (biomedical engineering ’10) received an NIH-Oxford-Cambridge Scholarship, given to students toward a master of philosophy degree in physics.
- **Samantha Dale Strasser** (biomedical engineering, applied mathematics ’11) was one of four Northwestern students to receive a Barry M. Goldwater Scholarship, which encourages outstanding students to pursue careers in mathematics, the natural sciences, or engineering and to foster excellence in those fields. Strasser hopes to obtain her PhD in biomedical engineering.
- **Kelsey Stoerzinger** (materials science and engineering ’10) was awarded a Churchill Scholarship to pursue graduate studies at the University of Cambridge. The scholarship provides a year of support for a postgraduate degree in engineering, mathematics, or the sciences at Cambridge. Stoerzinger will be working toward a research-based master of philosophy degree in physics.
- **Aaron Young**, a graduate student in biomedical engineering, received the National Defense Science and Engineering Graduate fellowship.
- **Danielle Proffit**, a graduate student in materials science and engineering, was awarded a Udall Scholarship, given to students committed to careers related to the environment, tribal public policy, or Native American health care.
- **Stephen Carr**, associate dean for undergraduate engineering, received the National Defense Science and Engineering Graduate fellowship.
- **Gregory McGlynn** (computer science ’11) received the NASA Aeronautics Scholarship.
- **14 graduate students** received National Science Foundation research fellowships.
PROFESSORS RECEIVE $39 MILLION IN STIMULUS FUNDING
McCormick School professors are part of research projects that have received more than $39 million in funding from the American Recovery and Reinvestment Act. The act, passed by Congress in February 2009, allocated billions for scientific research. Professors in every department at McCormick have applied for and received awards that range from $50,000 to more than $19 million.

“The success of McCormick’s research awards is a consequence of our commitment to excellence in research and education,” said Julio M. Ottino, dean of McCormick. “Our professors are at the leading edge of science and technology in preparing students to address the most challenging global problems. We are poised to make a difference.”

The largest grant — $19 million — funds the new Non-Equilibrium Energy Research Center led by Bartosz Grzybowski, the Kenneth Burgess Professor of Physical Chemistry and Chemical Systems Engineering. Its focus is to synthesize, characterize, and understand new classes of materials under conditions far from equilibrium that are relevant to solar energy conversion, catalysis, and storage of electricity and hydrogen.

“Many of these awards are research projects that cross disciplines and schools,” says Rich Lueptow, senior associate dean for operations and research at McCormick. “This sort of effort is part of the culture at McCormick, and it is essential to the innovation our country needs in this economy.”

DETECTING COLON CANCER IN WOMEN
A team led by Vadim Backman, professor of biomedical engineering, found that combining novel optical technologies with a common colon cancer screening test may allow doctors to more accurately detect the presence of colon cancer, particularly in women. The study, done in partnership with colleagues at NorthShore University HealthSystem, combined a polarization-gating optical probe alongside traditional flexible sigmoidoscopy to measure the early increase in blood supply in rectal tissue as a marker for colon cancer. The results were published in the journal Cancer Prevention Research.

A flexible sigmoidoscopy examines the lower third of the colon for cancer. It’s quick and affordable, can be conducted by a primary care physician, and requires simpler bowel preparation than that of a colonoscopy. However, the test isn’t widely used for colon cancer screening because it examines only the lower third of the colon.

Women are more likely than men to have cancerous lesions in the proximal colon, a section of the colon not examined during flexible sigmoidoscopy. By itself that method detected only a third of colon cancers in women, according to previous studies.

The Northwestern researchers combined the flexible sigmoidoscopy with an optic probe that measures how light scatters through tissue and detects subtle changes in the tissue that can indicate the presence of cancer. The technology makes use of a biological phenomenon known as the “field effect,” a hypothesis that suggests the genetic and environmental milieu that results in a neoplastic lesion in one area of an organ should be detectable throughout the organ and even in neighboring tissue. The combined technique identified with 100 percent accuracy each person who had a neoplasia in the proximal colon. Researchers found that the early increase in blood supply was a particularly robust marker for proximal neoplasia in women.

This result provides hope that the technique could provide a mechanism to improve discrepancies in the accuracy of colon cancer screening between men and women.
NEW YORK FALLS SHORT IN HOMELAND SECURITY FUNDING

New budget allocation models developed by Sanjay Mehrotra, professor of industrial engineering and management sciences, suggest that New York City appears underfunded for protection against terrorist threats. The study also shows Chicago as underfunded, while Los Angeles appears overfunded.

Mehrotra and his team analyzed budgets for five fiscal years (2005–09) for 10 major US urban areas under a variety of terrorist-attack scenarios. The researchers found the funding received by New York in 2009 was around 30 percent of the total money allocated by the Department of Homeland Security to the 10 areas. According to the Northwestern models, the funding should have ranged between 33 and 49 percent. This would translate to a net increase of anywhere between $15 million and $92 million above the actual level of funding New York received in 2009.

A NEW HOME FOR THE CENTER FOR LEADERSHIP

The Center for Leadership at Northwestern has a new academic home at the McCormick School. McCormick will host the center’s academic offerings, serve as a springboard for the center’s connections with the University community, and provide faculty appointments to its leadership team.

“We’re excited to join McCormick because we think that leadership will complement the other offerings of the school,” says Adam Goodman, director of the Center for Leadership. “McCormick students will be called upon to be leaders in their careers, so it’s important for the school to introduce them to the concepts of effective leadership throughout their education.”

The Center for Leadership started in 1990 as the Undergraduate Leadership Program. For 20 years the program provided a popular interdisciplinary certificate program in leadership, and more than 2,500 students have participated in the program.

“The Center for Leadership is an excellent addition to the curricular and extracurricular activities offered to our students,” says Dean Julio M. Ottino. “Combined with other new initiatives at McCormick — such as the Segal Design Institute and the Farley Center for Entrepreneurship — we are building offerings to create whole-brained engineers. Our students emerge with deep technical knowledge, which is at the heart of engineering, but we must also instill leadership, entrepreneurship, and design skills into their thinking in order to prepare them to have maximum impact on the world.”

OIL, MAZES, AND CANCER

Bartosz Gryzbowski, the Kenneth Burgess Professor of Physical Chemistry and Chemical Systems Engineering, was interviewed on the BBC radio program Material World regarding his research that shows how droplets of oil can make their way through complex mazes. Gryzbowski created a system in which the droplets were powered by a combination of acid/base chemistry and surface-tension effects. When subject to a pH gradient within a maze, the droplets moved toward regions of low pH and found the shortest possible path through the maze. The technique could have implications in cancer therapy, as cancers are more acidic than the rest of the body. Researchers might design drugs to follow the pH gradient to cancer cells.

Published in January in the Journal of the American Chemical Society, the research has been featured in Science, Nature, and Popular Science, among other publications.

RATING AND RANKING AND SOCCER PLAYERS

Luis Amaral, a professor of chemical and biological engineering at Northwestern University, in collaboration with colleagues from Spain, used the data to quantify the performance of players by generalizing methods from social network analysis. Amaral and his team were able to objectively rank the performances of all the players in the 2008 European Cup tournament. Their results closely matched the consensus of sports reporters who covered the matches as well as the team of experts, coaches, and managers that chose players for the “best of” tournament teams.

To find a quantitative way to rank players, graduate student Josh Waitzman, coauthor of the paper, first wrote software to pull play-by-play statistical information from the 2008 European Cup website. This type of extensive statistical information is usually only gathered for important matches, Amaral says. Then Amaral and Jordi Duch, the paper’s first author and a faculty member at Universitat Rovira I Virgili in Spain, used the data to quantify the performance of players by generalizing methods from social network analysis. They mapped out the flow of the soccer ball between players in the network and shooting information and analyzed the results.

“We looked at the way in which the ball can travel and finish on a shot,” says Amaral, who also is a member of the Northwestern Institute on Complex Systems and an Early Career Scientist with the Howard Hughes Medical Institute. “The more ways a ball can travel and finish on a shot, the better that team is. And, the more times the ball goes through a given player to finish in a shot, the better that player performed.”

This research has been featured in several national media outlets, including MSNBC, the Washington Post, Scientific American, and Forbes.
PENS PROMISE LOW-COST RAPID NANOFABRICATION

A Northwestern research team has drawn 15,000 identical Chicago skylines with tiny beams of light using an innovative nanofabrication technology called beam-pen lithography. The team was led by Chad A. Mirkin, professor of biomedical engineering at McCormick, the George B. Rathmann Professor of Chemistry in the Weinberg College of Arts and Sciences, and director of Northwestern’s International Institute for Nanotechnology. Details of the method were published in the journal Nature Nanotechnology.

Researchers simultaneously patterned 15,000 replicas of the Chicago skyline over a few square centimeters of space using 15,000 tiny pens. Each skyline pattern was made up of 182 dots, with each dot approximately 500 nanometers in diameter — the diameter of each pen tip. The time of light exposure for each dot was 20 seconds, with the entire process taking about a half an hour. The method results in structures as small as 150 nanometers, though refinements of the pen architecture likely will increase resolution to below 100 nanometers. Conventional nanopatterning technologies, such as electron-beam lithography, can make similarly small structures but are inherently low throughput and cannot do large-area nanofabrication.

Beam-pen lithography could lead to the development of a sort of desktop printer for nanofabrication, giving individual researchers a great deal of control over their work. The method offers a means to rapidly and inexpensively make and prototype circuits, optoelectronics, and medical diagnostics and promises many other applications in the electronics, photonics, and life sciences industries.

NANOFIBER ‘NOODLE GEL’ PROMISES BETTER TISSUE REGENERATION

A Northwestern team is the first to demonstrate a method that delivers cells in the same alignment as the cells found in tissues, a technique that could jumpstart new growth and healing. The findings were published as the cover story in the July issue of the journal Nature Materials. The paper’s senior author was Samuel I. Stupp, Board of Trustees Professor of Materials Science and Engineering, Chemistry, and Medicine and director of the Institute for Bionanotechnology in Medicine.

The researchers produced centimeter-long, noodle-shaped strings of nanofibers containing living cells aligned in linear fashion. These gel-like strings are flexible, biodegradable, and can be made into different lengths and widths. They could be surgically placed on damaged tissue, where they would adhere naturally.

To create the noodle gel, Stupp and his team start with aggregates of specially designed peptide amphiphile molecules in water. Heating the solution causes the molecules to emerge as sheets suspended in water. When cooked, the sheets break into bundles of fibers, forming an unusual liquid crystal. The researchers then mix cells into the liquid crystal and, using a pipette, draw it by hand across a salt solution, causing the liquid crystal to gel immediately. The result is like a piece of cooked spaghetti composed of aligned nanofibers with huge populations of encapsulated cells.

Stupp is collaborating with other researchers on studies using the noodle gel for stem-cell delivery. One project focuses on the use of the aligned structures as highways to divert stem cells from parts of the brain where they are abundant to others where they might be needed to cure diseases, such as Parkinson’s.

Donald N. Frey, 86, professor of industrial engineering and management sciences, died in March. At McCormick he taught courses on innovation, entrepreneurship, and information systems; he also taught first-year engineers in the Engineering Design and Communication sequence — “to keep my foot in reality,” he said. Frey also mentored doctoral students.

Frey enjoyed a long and illustrious industrial career — with Ford Motor Company, General Cable Corporation, and Bell & Howell Company — before joining Northwestern in 1988. Along with others, he came up with the concept and design of the Ford Mustang, a car that became an American icon. Frey was an elected member of the National Academy of Engineering and received the National Medal of Technology from President George H. W. Bush in 1990.

In 2001 Frey established the annual Margaret and Muir Frey Prize at McCormick. Named for his late parents, the prize recognized design creativity in the best senior capstone projects — projects that are designed by a student or team of students and are related to known problems or credible new products or processes.