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wisconsin engineer

NOVEMBER 2008 VOLUME 113, NUMBER 1

No More Needles

Thanks to hydrogel p.10

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wisconsin engineer

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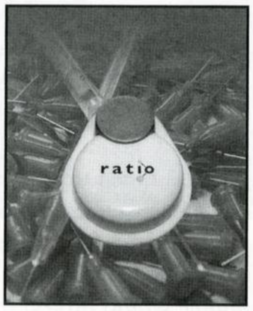

Cover photo by Ross Tillman & Preston Judkins

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Financial crisis forces reality check

By Jaynie Sammons

In the past four and a half years, I have comfortably resided within the collegiate bubble. While the rest of the country grappled with ridiculous gas prices, meager social security checks, and unfathomable health care premiums, I was relatively oblivious. In fact, there were times when my greatest fear was whether or not I would finish my statistics homework before next weekend's football game. Naturally, when I first caught wind of this so-called "economic crisis," I assumed that my bubble would protect me.

Wrong. Reality struck me on two fronts:

1. We tend to forget that friends and family members are living outside the college safe-haven. So while we may not be the ones with diminishing 25-year investments into a 401(K), our parents are, and they're getting a little nervous. Up until this semester, I had not once considered my parents' financial situation to be anything but stable, so it was incredibly unsettling to call home and hear my mom talk about losing money from her retirement fund—something we assume to be a relatively safe investment.

2. Since this will be my last semester on campus, I spent a significant portion of my time searching for post-graduation jobs. However, due to the economic instability, the number of companies that are hiring this semester has suddenly decreased. Businesses are reevaluating their future plans and some have determined that their need for new hires can wait until the economy becomes (or at least appears to be) slightly more stable. While we may have had a record number of employers at the Fall 2008 engineering career fair, an e-mail sent out in mid-October by the UW-Madison ECS office indicates that, in light of the economic downturn, companies' plans to hire have decreased approximately 7.2% from their August estimates (this data was collected by NACE in a Job Outlook survey of 126 employers). This means that the number of new hires for the class of 2009 will be about the same as last year, when it was initially projected to increase.

Although our nation's current financial uncertainty is a bit unnerving, the fact that we're dealing with it as college students rather than as middle-aged adults may actually be to our benefit. Unlike our parents, since we aren't looking to retire within the next 10 to 15 years, we don't need that sense of security that a retirement fund typically offers.

However, that doesn't mean we shouldn't be making smart financial decisions while we're still young. The U.S. got into this mess because our greed got the best of us, and, contrary to what some might think, we are not indestructible. So unless we start making a conscious effort to limit our spending and live within our means, it is possible that more of us will start to experience the financial plaguing that has begun to spread across the nation.

Many are optimistic, though. With any luck, the next few months will reveal a complete economic turnaround, and we will all be breathing sighs of relief and exclaiming, "See? I told you it wouldn't last long." But even if this is the case, by no means should we go back to our old habits of excessive spending. As citizens of the United States, I would hope that we care enough about our nation's future to find a way to regulate ourselves, regardless of the example that our government has set for us. For me, this means creating a financial plan in preparation for when I graduate in the next month, since it will undoubtedly be tempting to spend money once I have a larger paycheck.

It goes without saying that my bubble has thinned significantly over the course of the semester. And although it will officially burst this December when I walk in the commencement ceremony, I have come to terms with my fate. I have accepted the fact that I will be living frugally during the first few years of my life in the "real world," and fully understand that smart decisions now will result in financial security later. I can only hope that my life lessons will help my peers to realize that our nation's financial uncertainty affects everyone, and that the more prepared we are now, the easier it will be to adjust to life outside our bubble. WE

Jaynie Sammons

COLLEGE OF ENGINEERING
UNIVERSITY OF WISCONSIN-MADISON

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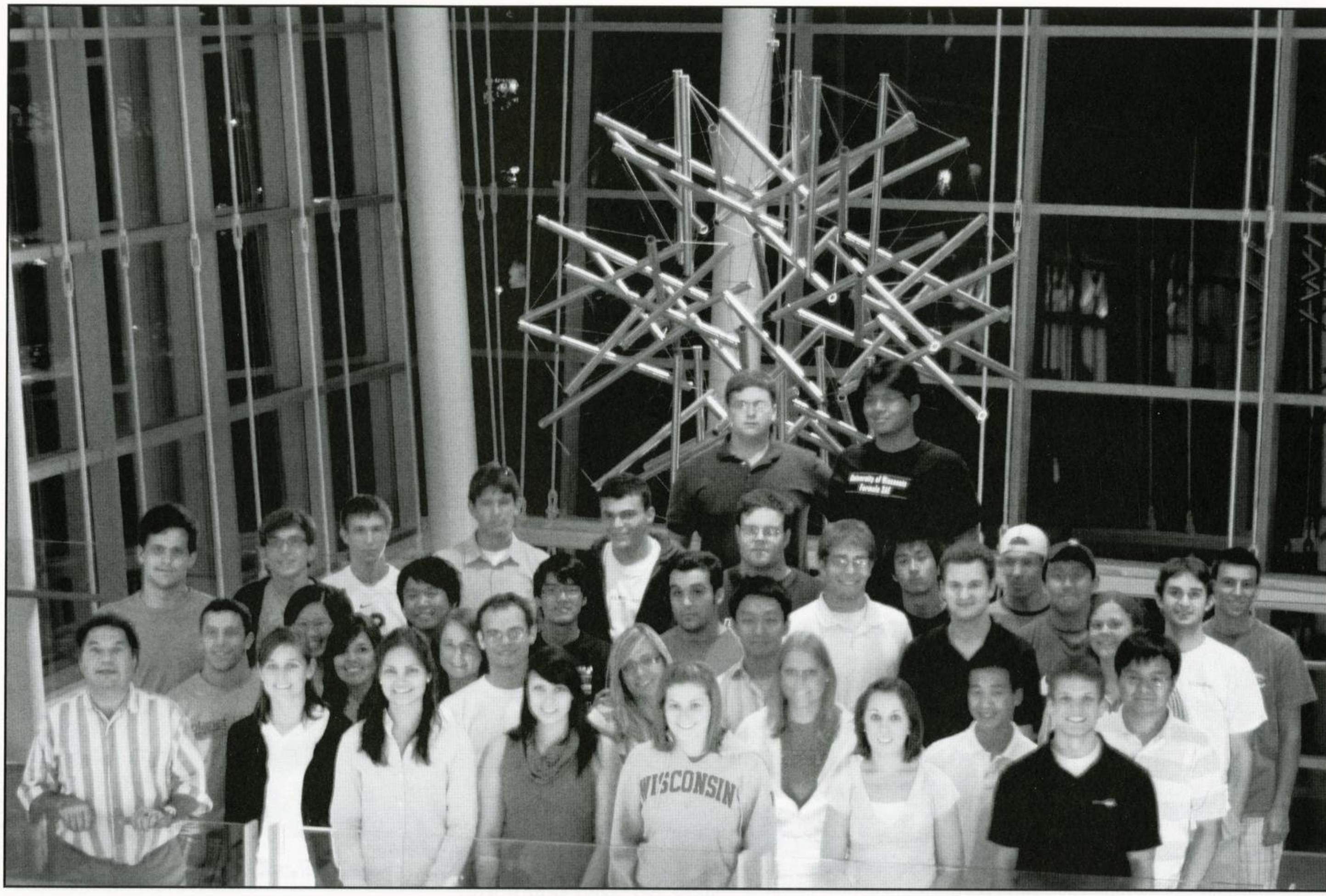


Photo by Anna Mielke

Discovering The Future

Photo by Evan Owens

By Carrie Boecher and Mike Sargent

It's a beautiful afternoon in October, and I'm sitting in Union South, staring out the window. Across the street, cranes swing about, bulldozers push debris to the sides, and Bobcats climb over the bumpy terrain. These machines, along with approximately 60 workers, are constructing the new Wisconsin Institutes for Discovery, a multidisciplinary research complex that is slated to open in late 2010. Funded by the state of Wisconsin, the Wisconsin Alumni Research Foundation and a generous gift from UW-Madison alumni John and Tashia Morgridge, the Institutes will operate in a unique format that puts public and private researchers side by side. According to George Austin, the building project manager, this configuration will ultimately benefit the Institutes.

While the Institutes discoveries in science, engineering and medicine will certainly be innovative, the facility itself will be revolutionary in its construction, design and function. In contrast to many of the older buildings on campus, every aspect of the Wisconsin Institutes for Discovery has been taken into account in order to maintain it's position as a forerunner in multiple areas of research for many years to come.

"One of the fundamental elements going forward is to have a one hundred year building. We want the building to be relevant to the science that will be conducted there for a very long period of time," Austin says.

"Having the ability to have both public and private [researchers] together in the facility will increase the power of it in terms of attracting the best and brightest researchers and it would provide a more nimble situation in terms of how research could be done"

-George Austin

Compare this to the building in which I'm currently working, Union South, which will be razed in January 2009. Built in 1971, the union's cold architecture and poor design no longer accommodate the needs of the campus.

At the Wisconsin Institutes, however, architects and builders are looking forward. For instance, floor and ceiling heights are designed to allow for potential expansion. Extra space in the ceiling allows for new wires, pipes and other services to be added in over time. The labs themselves will also be extremely flexible. Not only does this allow many types of research teams to use the same labs in the present, but it will also accommodate changes in future research and technology.

In addition to the building being designed to last, it is also being designed to reduce its impact on the environment. To measure this, builders are comparing its consumption of resources to that of similar buildings on campus. One goal for the facility is to use 50 percent less energy and water than a building like the Biochemistry addition, which, at only ten years old, is a fairly young structure. Since laboratories tend to use more energy and water than typical buildings, designers and builders are looking for unique ways to reduce and reuse these resources.

In one of the many creative solutions, for instance, the water used for purification in wet laboratories will be captured and sent to toilets and urinals in the building.

"Meeting the goal requires that we consciously think through the opportunities that could save us energy or water"

-George Austin

This pledge for environmental responsibility is partially due to the Morgridges who specifically requested that the building be as sustainable as possible—including its construction. At the outset of the project, the goal was to recycle 80 percent of demolition and construction debris. For demolition debris, the actual number was an impressive 98 percent. The majority of these materials were used again as building materials, such as bricks and wall boards, and others, like fixtures, were taken to be reused by non-profit groups.

Overall, the founders of the Institutes for Discovery want the facility to act as a bridge between the research being performed and the community. One of the most important tools in achieving this connection will be the ground floor of the building, called the Town Center. In this space, researchers, professors, students and the general public will be able to mingle around a coffee bar and cafeteria, listen to seminars in the central forum and have personal discussions in one of the many breakout rooms that are scattered throughout the floor. These interactions will hopefully make the Institutes for Discovery two of the top research facilities in the country.

"We encourage people to use the ground floor as a pathway as well as a destination," Austin says. "[We] want to utilize that space in relation to the science occurring in the building and ultimately to create opportunities under the Wisconsin Idea."WE

Photo by Wa'el Abel Samad

The Wisconsin Institutes for Discovery will be located on the central campus, at the 1300 block of University Avenue between Campus Drive and University Avenue.

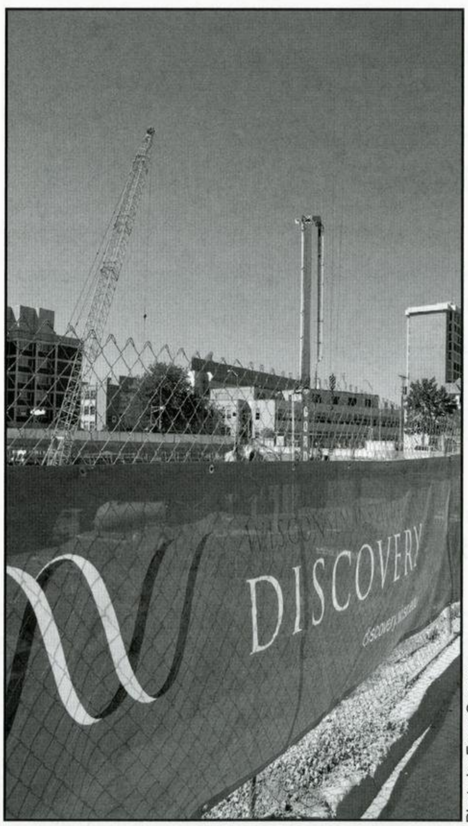


Photo by Evan Owens

Sustainability is a top priority in the design and construction of the facility.

Author bio: Carrie Boecher is a junior majoring in civil and environmental engineering. This is her second semester with the magazine.

Author bio: Mike Sargent is junior majoring in civil engineering. This is his second semester with the magazine.

Say good-bye to your rabbit ears

Going Digital

By Bonnie Atkinson

Has your favorite television show ever disappeared in a snow storm right in the middle of a good part? Have you ever found yourself sitting in awkward positions in your living room because you didn't want to interfere with the television signal? Well, those days will soon be over. The switch from analog to digital television (DTV) is fast approaching.

DTV began in the 1990s when broadcasters and television manufacturers looked for ways to offer high definition television. The Advanced Television System Committee (ATSC) formed and decided digital transmission was the answer. Broadcasters asked for a second channel for their digital transmission in addition to their analog channel. On February 17, 2009 all analog channels will be turned off and returned to the Federal Communications Commission to be used for other services. Some of the reclaimed spectrum will be auctioned off to generate revenue for the US Treasury. Other parts of the reclaimed spectrum will be used for public services including police, fire and ambulance.

Image from the Wikimedia foundation

If you currently have "rabbit ears" on your television set you will need to buy a DTV converter box by February 17, 2009.

Some students feel the government is scamming Americans with the switch—like Lianne Streng, a senior in chemical engineering, who wonders what is wrong with analog and why we are being forced to buy converter boxes.

The answer is space. In the 1990s, Congress considered the benefits of transitioning from analog to digital and acknowledged the crowding on the broadcast spectrum. To understand what that means, picture a radio that has a hundred stations between 95.1 and 95.3. On a radio like this, it would be difficult to tune in to the station of your choice, and if you wanted to start a radio station at 95.2, it would be very hard to find a space to broadcast without all the other stations drowning you out.

The switch to DTV will free up valuable space on the broadcast spectrum. With analog television, you receive an analog composite video signal and a separate sound signal. A digital channel carries a 19.39-megabit-per-second (Mbps) stream of digital data that your digital TV receives and decodes. A broadcaster can send a single program at 19.39 Mbps, or they could divide the channel into several different streams, called subchannels. For example, they could send four subchannels of 4.85 Mbps each. On top of that, each subchannel can potentially carry a different program. This means stations will be able to multicast—that is, broadcast multiple channels of free programming all at once.

David Devereaux-Weber, a network consultant at the DoIT center who specializes in television, says, "as a result [of multi-casting], in the space occupied by one analog channel in standard definition, you can send eleven digital channels in standard definition."

What does this mean for UW-Madison students? If you are a student living in the dorms, UW-Madison already has been transmitting high definition signals over the residential television network since September 2008. Because all dorms provide cable, students in residence halls do not need to purchase a converter box. Students living in houses or apartments will not be affected if they are currently subscribing to cable or satellite.

However, if you are a student with basic television, you will need to buy a converter box in order to continue watching your favorite programs. To help with the transition, a federal subsidy program will provide two coupons by mail, each worth $40 off the cost of a converter box, to households that request them. Converter boxes vary in cost, from $40 to $60. Since various types of converter boxes are available, you have the option of shopping around.

"The February 2009 deadline is when analog over-the-air transmitters are going to be turned off, but that doesn't necessarily mean that you won't be able to use your analog television anymore. If you are connected to cable TV or satellite, those entities are not required to stop transmitting in analog form, so cable subscribers and satellite subscribers won't notice a lot of change," Devereaux-Weber says.

Not only will DTV influence our entertainment, but it will also improve our means of observing the world around us. In 2005, Devereaux-Weber participated in the exploration of hydrothermal vents on the ocean floor called black smokers. The technology that was used on this study was an underwater vehicle named Jason (you may have seen some video from this aquatic robot during the movie Titanic). Rather than having to extract ocean creatures and observe them later, the scientists were able to observe the creatures in their natural habitat thanks to the bandwidth provided by the digital broadcasting spectrum.

Moving into the digital world doesn't just mean getting a crystal-clear view of Dr. Phil's mustache. The transition to DTV is a stepping stone to a new way of broadcasting and viewing information.


Photo by Tim Lam

David Devereaux-Weber explains the superior quality digital images.

Author bio: Bonnie is a second-year journalism major. This is her first semester with the magazine.

Are you Gelling?

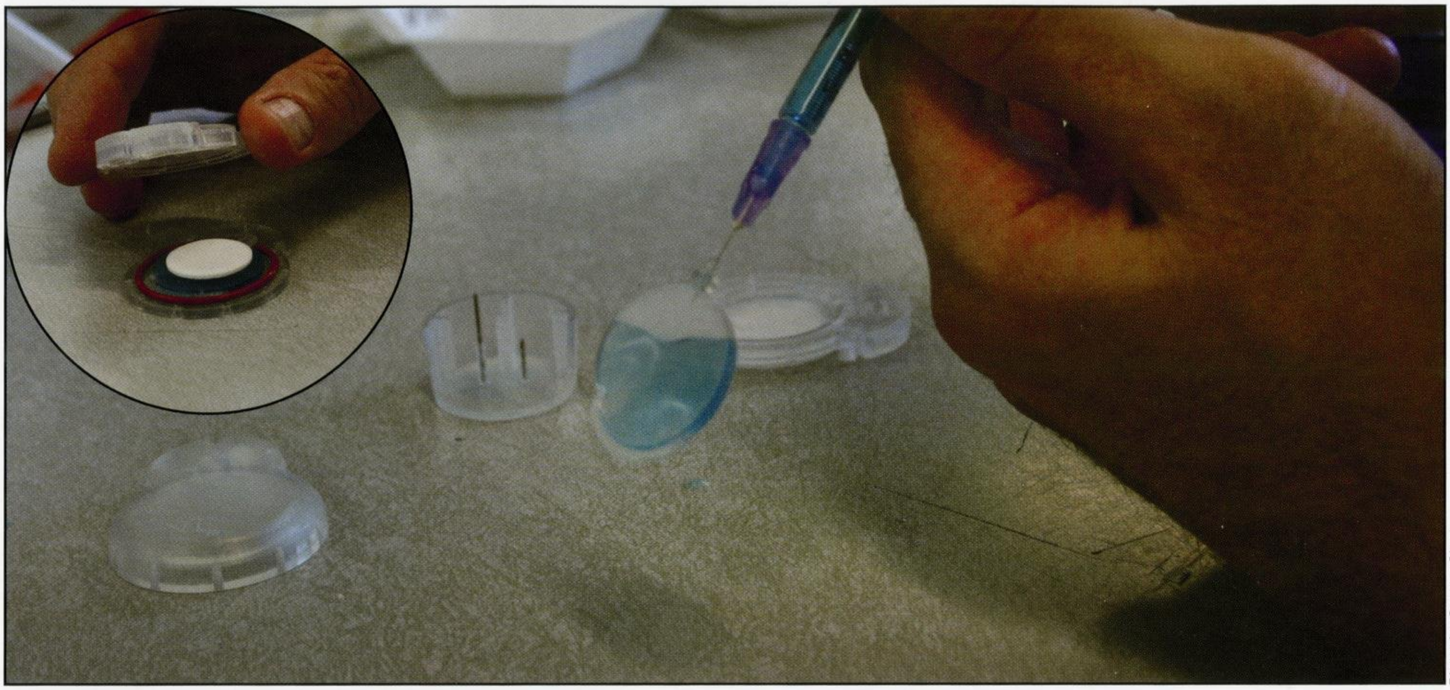


Photo by Steven Shutt

By Emilie Siverling

Right now, the only comforts available to ease the pain of vaccines are Disney character band-aids and lollipops. But, in the coming years, we may see a revolutionary method of drug delivery—a method that utilizes the properties of polymer hydrogels and microneedles to administer medication painlessly.

Professor Beebe and a Wisconsin School of Business student, Tony Escacega, also founded Ratio Incorporated in 2005--a small start-up company that focuses on drug delivery. Ratio is responsible for producing the hydrogel-based pump (the core technology of the drug delivery device).

One of the 2008 UW-Madison Coulter Translational Research Partnerships is a project design a non-electric, pain-free drug delivery device. This partnership pairs David Beebe, a professor in the biomedical engineering department, with Carol Diamond, a pediatrician at the UW-Madison hospital, with the goal of researching the drug delivery device both from an academic and medicinal standpoint. Ben Moga, a graduate student in biomedical engineering, is also participating in the project and is in charge of the laboratory research with guidance from Beebe.

History of the design

The project started five years ago when David Eddington, a former student of Beebe, published a PhD thesis on the swelling of polymer hydrogels to be able to control a drug delivery device. Since then, the team of biomedical engineering professor, pediatrician and student have worked to design a device that best utilizes this swelling to deliver a liquid pharmaceutical. The first step was creating a crude prototype that has already gone through test trials in animals. These trials helped determine the best design geometries and were used to prove that the basic design actually delivered the pharmaceuticals.

"This device will allow the wearer to receive a transdermal (across the skin) infusion of liquid medication"

-Ben Moga

The current design "is a pump that is worn like a patch," Moga says. "When you think of pumps, you think of things like insulin; put it on, press a button [and receive an] electronic infusion for so many hours. When you think of a patch, you think of a nicotine patch or birth control. We're going for low profile, except we're actually doing a bolus injection of liquid pharmaceutical." This device will allow the wearer to receive a transdermal (across the skin) infusion of liquid medication over a period of time, but its operation will be as simple as sticking it on the body and pressing a button—no electricity required.

How the drug delivery system works

The scientific discovery behind the non-electric device is the polymer hydrogel. When injected with water, this hydrogel reacts and expands at a certain rate that can be changed by altering the chemistry of the hydrogel. The hydrogel is placed next to a foil-based material storing the drug, known as a drug bladder, and the hydrogel's expansion pushes the liquid pharmaceutical out of the drug bladder and into the patient. Between the hydrogel and the swelling bladder, which stores the water necessary for hydrogel expansion, is a middle insert that serves two functions, according to Moga. "It gives a wall for the hydrogel to push on, and we've also designed it so that water basically floods [the hydrogel]; that way, our rate is controlled by the hydrogel itself because it always has access to water."

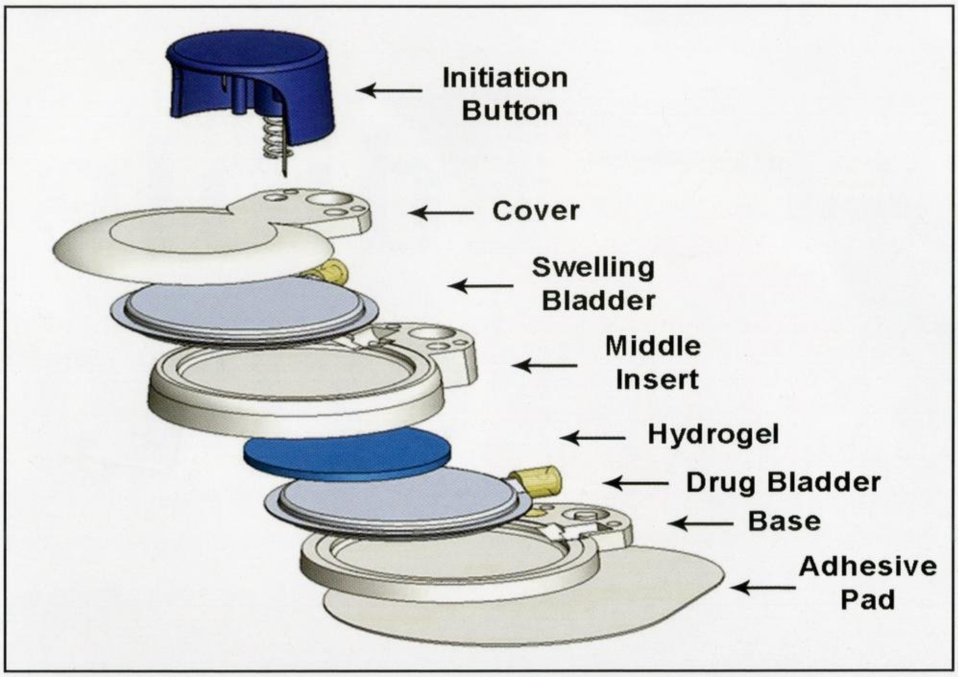


Illustration by Ben Moga

The device's simple exterior masks complex interworkings that facilitate drug delivery.

The only thing needed to initiate hydrogel expansion is the push of the button, which simply opens the connection between the hydrogel and the swelling bladder. This button would also activate the drug transport system, an array of microneedles. These microneedles are plastic and only 300 micrometers long. Because they're so tiny, they don't cause pain when they puncture the skin. However, they also cannot withstand the same pressures that hypodermic needles, the type normally associated with drug delivery shots like vaccinations, are able to. Further research needs to be done to characterize the microneedles and determine whether their properties are sufficient to penetrate the skin and deliver the drug. "There has been a lot of work done on microneedles already, [which have] guided the designs I've made of the microneedles," Moga says. "It's not something we're horribly worried about but it's something I'm entirely mindful of moving forward."

The future of the drug delivery system

Over the next nine months the team will continue to conduct research in the engineering laboratory and through animal trials, mostly focused on the unique challenges presented by the microneedles. Once the drug delivery design has been proven effective, it will be submitted to the FDA for approval. Depending on how the FDA classifies it, the product could be approved as soon as two years from now. However, it is more likely that clinical trials will take longer than a year and the design would be FDA-approved in four to six years. Following approval, the device will need to be prepared for mass production. Although this may take a little time, it will make the device cheaper and ultimately smaller due to automated manufacturing.

The final device will be able to deliver liquid pharmaceuticals of sizes ranging from 250 microliters to five milliliters over a time period of a few minutes to eight hours, depending on the size of the delivery dose and the length of sustained injection time needed. Although the drug delivery system was initially designed for injections of drugs combating hemophilia, they could also deliver other liquid drugs like certain pain medications and vaccines. Imagine the global increase in disease containment if vaccines were available in cheap, single-use patches!

Eventually, the drug delivery device may be able to do multi-drug injections or even deliver narcotics safely. "Because there is a problem with addicts breaking in devices and getting the drug…we can either get more controlled dosing strictly out of prescription when they're distributing it, or we can somehow engineer it so that it knows it's on the skin; that's the only way it'll work, or it's impossible to get the drug out without destroying itself," Moga says.

When Moga, Beebe and Diamond finish their research on the non-electric drug delivery system, they will have changed the medical industry for the better. Not only will their system be cheap and painless, but it will also be easy for both medical professionals and patients to use, thus reducing the hassle of modern needle injections.

Until then, be sure to enjoy your well-deserved lollipop from the doctor's office. WE

Author bio: Emilie Siverling is a senior majoring in materials science and engineering. This is her fifth semester writing for the magazine.

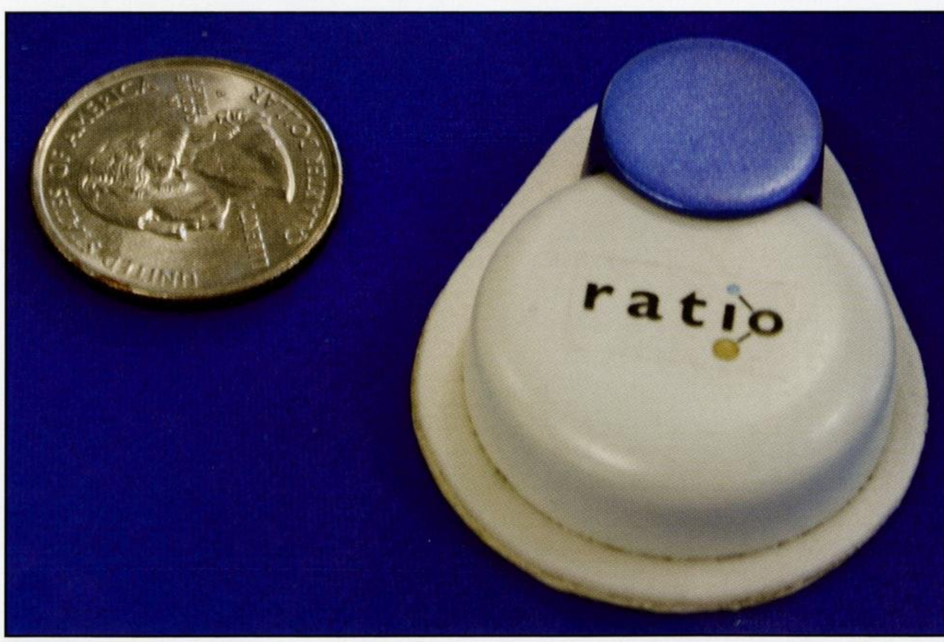


Photo by Rachel Dau-Schmidt

The device's diminutive size incorporates a painless drug delivery system, which is capable of delivering medication typically only deliverable via hypodermic needles.

Edible Engineering

Photo by Ross Tillman

By Carrie Boecher

On a warm fall day, Kelsey Banaszynski and Andy Renaud lead me through the corridors of Babcock Hall, pointing out the enormous posters that line the otherwise bare walls. The posters shout the names of products they are displaying—"Kudamushi," "Handicotti," "Healthy sTart"—and are covered in graphs, flow charts and colorful photographs of the products.

These posters present the final projects from past years of the UW-Madison Food Product Development Team, a campus organization that competes nationally by inventing and producing new and innovative food products. For instance, the "Healthy sTart" consists of a bowl made from granola and filled with yogurt and fruit—a perfect on-the-go snack that's nutritious. The UW-Madison team won top honors with this product at the 2005 competition hosted by the Institute of Food Technology Student Association, one of the biggest product development contests of the year.

Product development is only one component of the Food Science Club at UW-Madison. The group of about 45 undergraduate students works to increase their knowledge in the area of food science, apply what they learn in classes to the real world, learn about future job prospects and just have some fun.

"The Food Science Club is a great way for all of us in the major to connect and get to know each other," Banaszynski, the current president of the club, says. "It also allows us to utilize our skills from classes to come together in competition."

In addition to product development, Food Science Club members compete in dairy judging, where students assess various dairy products for inconsistencies, and college bowl, a sort of quiz bowl. College bowl questions cover a variety of topics within food science, and can range from, "Which bacteria help in Swiss cheese production?" to "What is the spongy white tissue in an orange called?"

The competition that relies most on design and engineering is the Product Development Team. Each year, there are numerous product development competitions hosted around the country by a variety of organizations. Some of the competitions in which the UW-Madison team has participated in the past include those held by the Almond Board of California, NASA and the aforementioned Institute of Food Technology Student Association. These competitions usually take place in late spring and early summer, but the team starts preparing as early as September. The first step, of course, is coming up with the right product. So how exactly does the team settle on an idea?

"We start by brainstorming," Renaud, the current chair of the Product Development Team, says. "We think: what do we want to make, and what markets do we want to fill?"

"A lot of times we'll look at the new trends on the market. For example, passion fruit is a really big flavor right now, so we might try to incorporate that into the product," Banaszynski says.

Another factor that influences the team's product is the contest guidelines. The contest sponsored by the Almond Board of California, for instance, requires that the products feature—not surprisingly—an almond base. Other competitions might have rules for the number of calories or the amount of a certain nutrient in the product.

After the team settles on an idea for a particular competition, the experimentation begins. For months, the team meets in the food lab, preparing batch after batch of the proposed product. Using their food science knowledge, members tweak the recipes a little bit at a time until they are just right.

"The Food Science Club is a great way for all of us in the major to connect and get to know each other...It also allows us to utilize our skills from classes to come together in competition."

-Kelsey Banaszynski

"[The process] requires a lot of trial and error," Banaszynski says. "It's like when you're younger and you bake cookies; if they're too wet, you try adding more flour."

"All ingredients have functionality," Renaud says. "As food scientists, it's our job to know exactly what each of those ingredients does."

Besides preparing the perfect product, the team has to come up with a comprehensive plan for its production. They must include the nutritional content of the food, a model for efficient and safe production of the item on a large scale and processing steps for the product. They also conduct sensory tests, in which test subjects try the product and rate it in areas such as flavor and texture. All of this information must be compiled into a written report and submitted months before the actual competition, usually in February. It's a lot of work, but when it comes to the competition, it pays to be thorough.

"We get judged on how well we think of the product," Renaud says. "We can't just say, 'Let's make something.' We have to think about how we're going to make it, how we're going to market it and what consumer group we're targeting."

According to Renaud and Banaszynski, teams are also judged on the innovation of their products, as well as the ability of the products to fill voids in the market. For instance, some products are marketed as ready-to-eat in order to meet the growing demands of a busy population, while others are designed to be heart-healthy to appeal to older customers.

So exactly what kinds of new foods have been invented over the years? The last big winner for the team was "Kudamushi" in 2006. "Kudamushi" is marketed as a "dessert sushi,"

Photo by Ross Tillman

Club officers Kelsey Banaszynski and Andy Renaud pose in front of the first prize Healthy sTart display.

though it really isn't sushi at all. It consists of jasmine rice wrapped in a piece of fruit leather and garnished with a bit of jelly in the center. It can be frozen and thawed as necessary, giving it a long shelf life. Another product is "Handicotti," a handheld pasta filled with marinara and ricotta cheese. This product was designed as a quick, on-the-go meal. In addition to preparing the food itself, the team had to design the perfect pouch in which to hold the pasta.

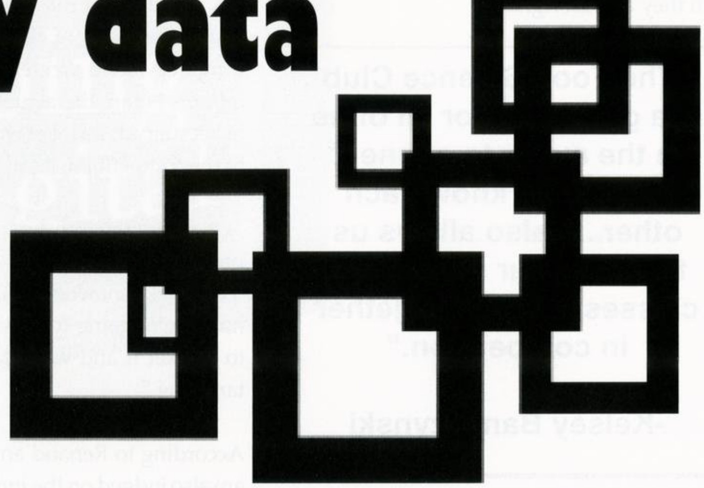
After all the brainstorming, planning and preparation, the team finally gets to the actual competition. There, they compete against other college teams, the majority of whom are from the Midwest. Judges are mostly looking for the innovation of the products, as well as the effort and planning that went into its development, but it doesn't hurt if it has a good flavor. After all, like Renaud says, "Nobody's going to want to eat it if it doesn't taste good." WE

Author bio: Carrie Boecher is a junior majoring in civil and environmental engineering. This is her third story for the magazine.

Photo by Ross Tillman

Mixers are one of many tools used by the Product Development Team when designing new foods for competition.

The building blocks of high density data storage



By Matthew Stauffer

The density of humans on Earth is approximately 35 people per square mile. In the hard drive industry, the goal is to pack as much information into a small space, with the density of information being upwards of one terabit (10^{12}) per square inch—far too close together for comfortable living, but necessary for small technological devices.

UW-Madison chemical and biological engineering professors Paul Nealey and Juan de Pablo are among the researchers working on technology for polymer molecules to self-assemble into patterns and organize their neighbors with bits of information for application in the hard drive industry.

Hard drives, found in most electronic devices that store media, including digital video and audio recorders, video game consoles, laptops and desktop computers are read and written using magnetic information encoded in a pattern on a rotating solid disc. As data becomes increasingly complex, the amount of data that devices need to store and access in order to function also increases. This, combined with the need to constantly make devices smaller, leads to an increase in data storage density.

One of the front-running technological advances that aims to increase data storage density is called bit-patterned media. Bit-patterned media works to effectively partition the information, which is physically represented by deposited bits of magnetic material, into segments analogous to pixels on a computer screen.

With bit-patterned media, there is a patterning, or lithographic step, involved in the production process. Lithography, used for writing integrated circuits, uses a combination of mask templates and photo-reactive chemicals to write patterns.

Traditionally the hard drive industry has not used lithography techniques because the size constraints of the technique do not meet the high-resolution demands of data storage devices. In order to increase the data storage capabilities, the hard drive industry needs to pattern smaller dimensions and denser features than is currently available from the most advanced lithographic techniques.

"The needs of the hard drive industry already exceed the capabilities of the microelectronics industry…and you can't rely on the infrastructure of the microelectronics industry to provide an answer for the hard drive industry," Nealey says.

This is hard to imagine because most people think that the integrated circuits in the microelectronics industry are leaders of the field in terms of highest density and smallest features when it comes to new products. However, the density of features in the hard drive industry far exceeds that of integrated circuits.

The technology of the integrated circuits industry is being used in a new process, which combines the lithographic tools of integrated circuit fabrication with the materials assembly of block copolymers.

"You can't rely on the infrastructure of the microelectronics industry to provide an answer for the hard drive industry."

-Professor Nealey

"It turns out that we have these incredibly wonderful self-assembling materials called block copolymers, which really like to make these very periodic, very regular patterns. And they make these patterns at the density and the size of the features that would be applicable to the hard drive industry," Nealey says. These block copolymer materials spontaneously self-assemble into structures that are approximately the correct size, regularity and spacing that are useful for mass data storage in a hard drive.

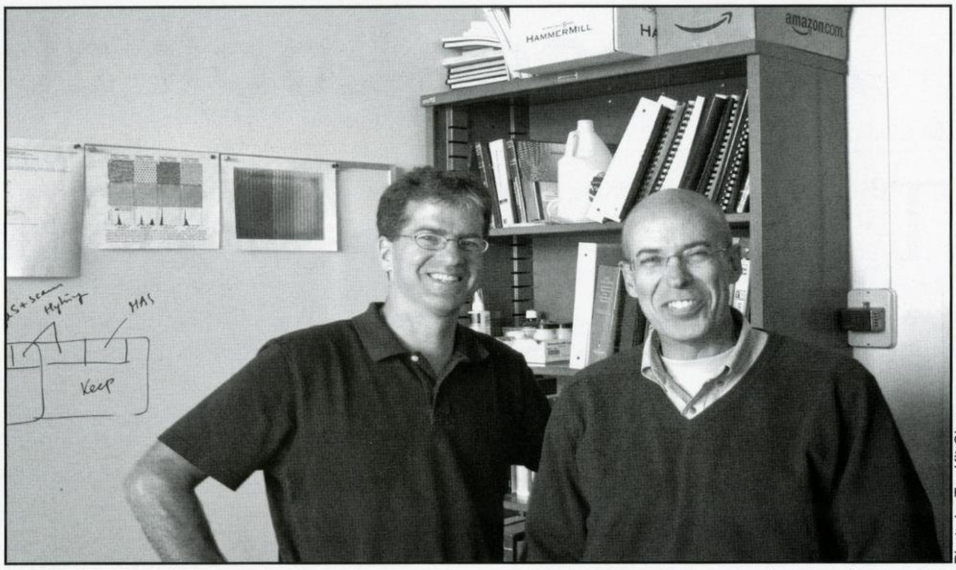


Photo by Tsz Kit Chan

Professors Nealey and de Pablo have been working for ten years on the fundamental technology that has led to the application of block copolymers for data storage.

"The question is how we get these materials to spontaneously organize into those [nanometer-sized] assemblies over a macroscopic-length scale," Nealey says. The standard size of a hard disk in most PC's is 2.5 inches in diameter. The configuration of the individual bits of magnetic surface material needs to orient absolutely perfectly in order to function in a data storage device. This is a significant aspect of the bit-patterned media's use of block copolymers, as engineers must rely on the self-assembling feature of the material to function predictably and perfectly at the sub-micron level over a relatively long range.

"What professor de Pablo and I have been doing is developing methodologies for inducing these self-assembling materials to spontaneously order like they want to, only with degrees of perfection and the arrangements that are necessary for this intended manufacturing process," Nealey says. This is not an easy task considering the large number of molecules involved at the resolution needed to satisfy advancing industry standards.

"There are more spots on a single disc than there are people in the world, and each one has to be standing in their right place," Nealey says. "They have to be absolutely perfect in concentric circles because they spin. You can't tolerate a missing or misplaced spot in a 15 nanometer domain."

The polymer materials self-assemble in regular patterns over relatively long ranges compared to the size of a molecule, on the order of microns, but there are grains in the material, which effectively are defects that are not tolerated for this application. Nealey and de Pablo are working to control the crystal structure to form a single crystal following the path of concentric circles. There is an induced strain in the material when bending a straight line, so the researchers are using a method known as directed assembly to induce the stresses necessary to cause that bending strain. Directed assembly provides input information to the self-assembling material, essentially telling it how to assemble in a way that is more perfect and directed in the orientation that is necessary for the application.

Nealey and de Pablo are using advanced lithography tools from the microelectronics industry in combination with the self-assembling materials to achieve extremely high-resolution data storage density. The lithography tools are used to make chemical patterns to establish long-range order for the directed assembly process. The block copolymers assemble themselves on those chemical patterns and then interpolate the small spaces between the lithography tools that cannot pattern. This combination of processes is capable of achieving very precise short-range order with a density that surpasses the capabilities of lithography alone. The combination also achieves the long-range macroscopic alignment that is necessary for device fabrication.

One important aspect of this fabrication technique is called density multiplication. Density multiplication implies that manufacturers will only need to pattern the material of every fourth spot on the substrate. The other spots in the array will pattern themselves according to the inherent nature of the self-assembling block copolymers. This has the potential to greatly reduce the time and cost of fabrication.

There are different strategies and approaches being pursued to increase the capacity and the density of data storage devices. If bit-patterned media becomes the method that is adopted as the new industrial standard, there is a good chance that the block copolymer materials will be used. According to Nealy and de Pablo, this will happen very soon as market trends continuously demand more information to be stored on smaller devices.

The block copolymer team, comprised of UW-Madison and Hitachi Global Storage Technology research staff, published this work in Science magazine in August 2008. In the paper they demonstrate a storage density of one terabit (10^{12}) of information per square inch. The current industry standard is about one third of that. Recent trends show the capacities tend to double every year. This leads Nealey and de Pablo to believe that this technology will reach consumers in about three years.

"As with most advances, these things don't happen over night. They come about through a fundamental understanding of the materials and the parameters that govern how the materials behave," Nealey says, acknowledging the work that has taken over a decade to develop.

"We have had this vision for some time that using these materials in this kind of way might have these kinds of applications and that we might be able to meet the constraints of manufacturing like the perfection, the order and the dimension," Nealey says. "Now we have shown it to a degree that is being accepted by industry." WE

Author bio: Matt Stauffer is a 5th year senior in the Materials Science Engineering department. He is happy to be back in Wisconsin after a good stint of random travels.

A Closer Look at Science

By Cody Wenzel

The Materials Science Building at UW-Madison has a variety of impressive labs used to test and analyze different materials. Some of these labs are inconspicuous, like one in the basement, which is simply a room filled with nothing but air conditioning units, a single monitor and a series of large cabinets. However, within those cabinets, there is a high-end supercomputer with the power to simulate materials by processing down to each individual atom.

Izabela Szlufarska, a professor in the materials science department, is one of the founders of this lab. Originally from Poland, Szlufarska came to The United States nine years ago to seek her PhD in theoretical condensed matter physics in 1999. After graduating from the University of Tennessee, she took a road trip, packing up all her belongings in her car and heading to Los Angeles. With no set plan for the trip, each morning was an adventure as she got out her map, deciding where to go next.

"In research you are an explorer as well… many times, you go where no one has gone before," Szlufarska says. It was her drive towards adventure that brought her to the United States and into her area of research. She says research is her way of seeking adventure and always doing new and exciting things with her life.

In her early years, Szlufarska was a math-oriented girl with a passion for learning how things work. In Poland, she was one of few girls who attended a specialized high school with extended programs in math, physics and computer science. "Unfortunately I did not have a very fun experience in high school because it was so demanding and competitive," Szlufarska says.

According to Szlufarska, her college years in Poland were similar. She was one of very few women in physics—but that didn't keep her from getting her MD.

Today, Szlufarska is at the cutting-edge of computational material simulations. Her group employs molecular dynamic simulations, which work at the most fundamental level by processing a material as a large grouping of atoms connected through basic forces. With this kind of simulation it can be determined how to best design a material at the atomic level so that it will yield optimized properties for needed applications.

One specific area Szlufarska is researching is nano-mechanics. Her work with friction, adhesion and wear at the nanoscale has lead to her Air Force Young Investigator Program award.

"My proudest moments being here are when I see my students succeed in what they do at UW-Madison and after they graduate."

-Professor Szlufarska

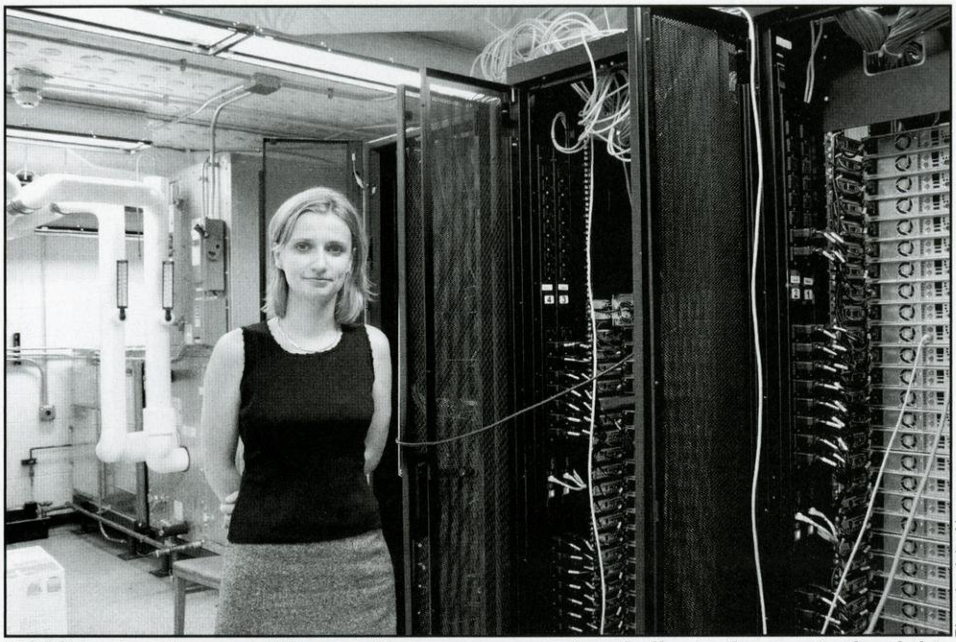
At the nanoscale, surface forces can play a dominant role, meaning they are important for any engineering design where two surfaces are in contact. An example of application are micro electromechanical systems (MEMS) devices. These tiny engines have potential in various fields, but their performance is limited by the adhesion between them. MEMS are currently made of silicon where large adhesion and friction forces cause these devices to fail very quickly. This is where a computer simulation can be very useful, because it allows scientists to determine what fundamental physical and chemical processes are involved in sliding. Understanding and quantifying these processes would allow for predicting the coefficient of friction and performance of materials. Currently, even if all material properties were known, the frictional response could not be predicted. The computer simulations have led her to a recent breakthrough where, together with her student Yifei Mo, Szlufarska proposed laws of friction at the nanoscale and showed how they relate to the chemistry of contacting surfaces.

Szlufarska's results explain controversies that have haunted friction experiments at the nanoscale. However, this is only beginning. "I think it will still be years before there is a more reliable and unified theory for friction, but we will continue working in this direction," Szlufarska says.

Another area of research getting attention and the CAREER award from the National Science Foundation is Szlufarska's work dealing with biosensors. This project is in collaboration with Robert Hamers from the UW-Madison chemistry department. The idea behind a biosensor is that first a very small structure is taken within a particular measurable resonance. When a target molecule attaches itself to that structure, the resonance frequency changes. Currently, Szlufarska is working on a theory to detect the structure of the target molecule as it attaches to the biosensor based on the specific change in resonance. Although similar technology exists at the macroscale, theories do not hold on smaller scales and this is the first time someone is looking at this problem. If successful, this technology would have a broad range of medical and defense

Photo by John Hageman

Professor Izabela Szlufarska does most of her research in the Materials Science & Engineering Building every day.



MS&E is planning on adding another supercomputer similar to the one to the right of Professor Szlufarska. The multiple rack mounted processors are combined and used to simulate complex atomic behavior of materials at the nanoscale.

applications, such as detecting chemical agents in real time.

Materials science is a very interdisciplinary field with ties to physics, chemistry, biology, metallurgy and engineering. One of the main reasons Szlufarska came to work at UW-Madison was because there aren't stiff boundaries between departments. This has allowed Szlufarska to easily collaborate with professors from outside the materials science department.

Now in her fourth year of teaching at UW-Madison, Szlufarska says she is finally getting some free time again. An active person, she frequently enjoys rollerblading on the bike paths and has recently taken up salsa dancing.

Her passion outside of work is working to bridge the gap between science and faith. She spends her free time looking at where conflicts lie and how the two views of the world interact. She participates in a Christian faculty fellowship on campus to talk about these issues and invites speakers to discuss the topic further.

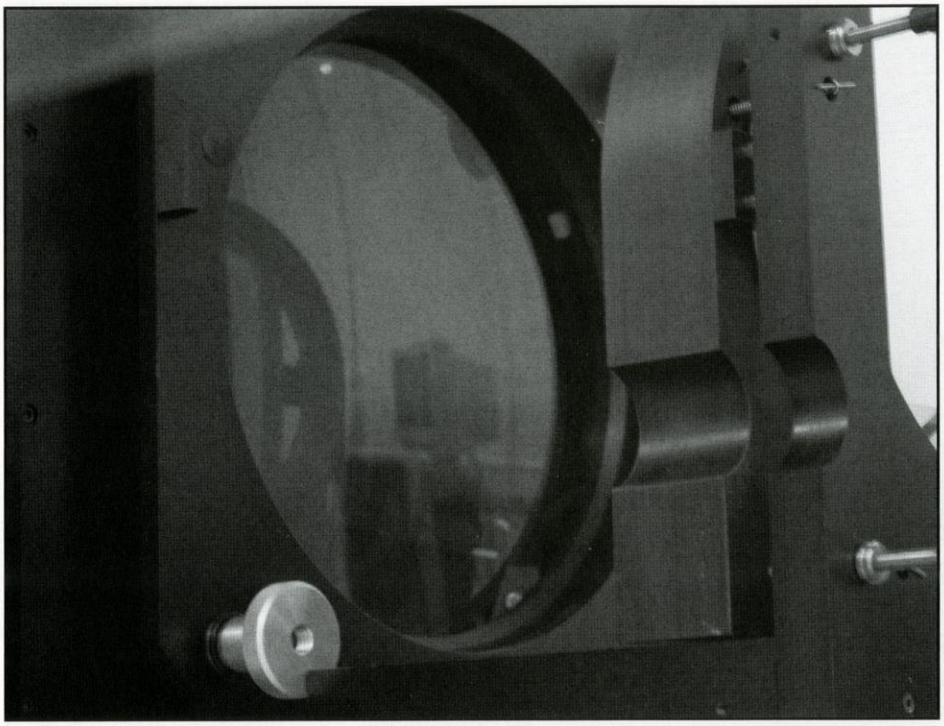
As far as where her motivation came from, Szlufarska believes she has her parents to thank. Although neither of them attended college, her father was always interested in science and engineering. He got her reading books at a young age and would show her how things work around the house, such as their car engine. "My parents always believed in me and told me that the sky is the limit. They told me to have big dreams and that it doesn't matter what people tell me along the way," Szlufarska says.

Although she is currently teaching two courses (one undergraduate and one graduate), Szlufarska loves interacting with students one-on-one more than teaching classes. "My proudest moments being here are when I see my students succeed in what they do at UW-Madison and after they graduate," she says.

"I think that overall Izabela is a very good mentor. She's very nice and extremely supportive to her students. She's very considerate and always thinking on the side of students. She has been encouraging me when I came across problems in my PhD study and other aspects of life. And no matter how busy is she, she's always been helpful," Yifei Mo, a graduate student in Szlufarska's lab, says.

Szlufarska encourages students to find a mentor who can give them advice and encouragement along the way. "All of us have had doubts at times on whether or not we have what it takes, but doubts are a normal part of taking a risk and living your life fully." we

Author bio: Cody Wenzel is a transfer student from UW-La Crosse. He is a junior majoring in chemical engineering. He is an active member in Concrete Canoe and AIChe. This is his first semester with the magazine.



SEE MY NEW TECH

The Computational Mechanics Center received a donation of a new instrument enabling research into smaller computer chips

By Roxanne Wienkes

SEMATECH, an international semiconductor research consortium, and UW-Madison have been teaming up for over decade to study advancements in technology. This year, SEMATECH graciously donated a Zygo phase-shifting interferometer to UW-Madison's Computational Mechanics Center.

The phase-shifting interferometer is a device commonly used to measure optical components. With the goal of making computer chips smaller and faster, the Computational Mechanics Center has made a home for the instrument and begun research.

SEMATECH's senior staff member Chris Van Peski chose to move the interferometer from Austin, Texas to UW-Madison to better serve the industry as a whole. Van Peski was previously using the device for the same type of research, but in light of his recent retirement passed the torch to Roxann Engelstad's lab.

Jacob Zeuske, a UW-Madison mechanical engineering graduate student, plays a large role in the experimentation with the interferometer. He is one of two people with access to the high-tech machine—the other being Engelstad, the head of the department. Zeuske is using the interferometer to explore extreme ultraviolet lithography (EUVL) technology so that the process can be perfected to produce computer chips that are a fraction of the size, 100 times faster and can hold 1000 times as much memory.

The VeriFire MST interferometer, is the model of the device donated by SEMATECH and is manufactured by Zygo. It uses a wavelength shifting laser and data acquisition techniques to enable simultaneous measurements of both the front and back surface of transparent optics. "Basically what we are doing is measuring gaps between two surfaces," Zeuske says. Currently, the lab is taking measurements of the flatness of the circular glass plates (known as substrates) for SEMATECH,

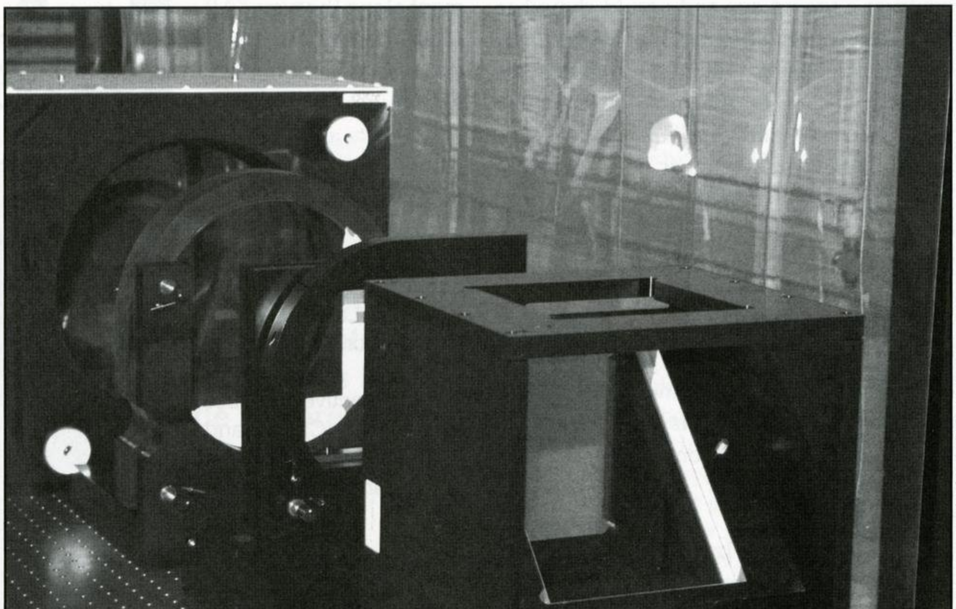


Photo here and at top by Mario DiBenedetto

A close-up shot of the instrument set up to measure the flatness of the square substrate, the oblique piece of glass at the lower right.

and the data from these measurements is used as the input to models which simulate EUVL processes.

"You can never achieve perfect flatness, but if we know what we have, we can correct for it."

-Jacob Zeuske

Essentially, lithography is a method of transferring a pattern from one surface to another. The Computational Mechanics Center is concerned with the mechanical aspects of EUVL; the lab is using the interferometer to measure the glass plates and predict any deformation in the glass substrates that may happen while being patterned.

In the future, when the technology is in use, a circuit pattern will be deposited into a layer of the glass plate and then reflected onto the silicon wafer. While the pattern is being put into the glass, it is possible that some bowing may occur,. This means that in addition to any pre-existing non-flatness, there will be some irregularities in the substrate. "It's really important that the glass is flat when you do this; if it's not flat, the pattern you put on it will be distorted," Zeuske says. When working on nanometer scale, accuracy is very important so it is imperative to know what is going to be reflected. The glass can be flattened by using an electrostatic chuck to create an electrostatic force that pulls the glass into a flatter shape. "You can never achieve perfect flatness, but if we know what we have, we can correct for it," Zeuske says. The lab is experimenting to see if the non-flatness measured by the interferometry system can be corrected by altering the initial pattern in the substrate.

Prior to the donation of the interferometer, UW-Madison collaborated with SEMATECH on various other projects. In 1997, SEMATECH funded a $2 million research project lead by Engelstad at UW-Madison. At that time, the semiconductor manufacturing process needed to be revamped and the mechanical engineering department simulated four new approaches for the consortium of semi-conductor manufacturers. The EUVL, which is what UW-Madison's new interferometer uses, was one of the methods modeled in 1997.

With this donation, the Computational Mechanics Center is on the forefront of leading technology in this field. Currently there is a limit on how small computer chips can be made. However, "It is hoped that it [EUVL] will allow the patterning of much smaller features. It holds the potential for achieving nanometer scale features," says Zeuske, which could lead to many new possibilities. WE

Photo by Mario DiBenedetto

Jacob Zeuske, a researcher, describes the inferometer which is located in the basement of the Mechanical Engineering Building.

Author bio: Roxanne is a junior studying environmental engineering. This is her first semester with the writing staff.

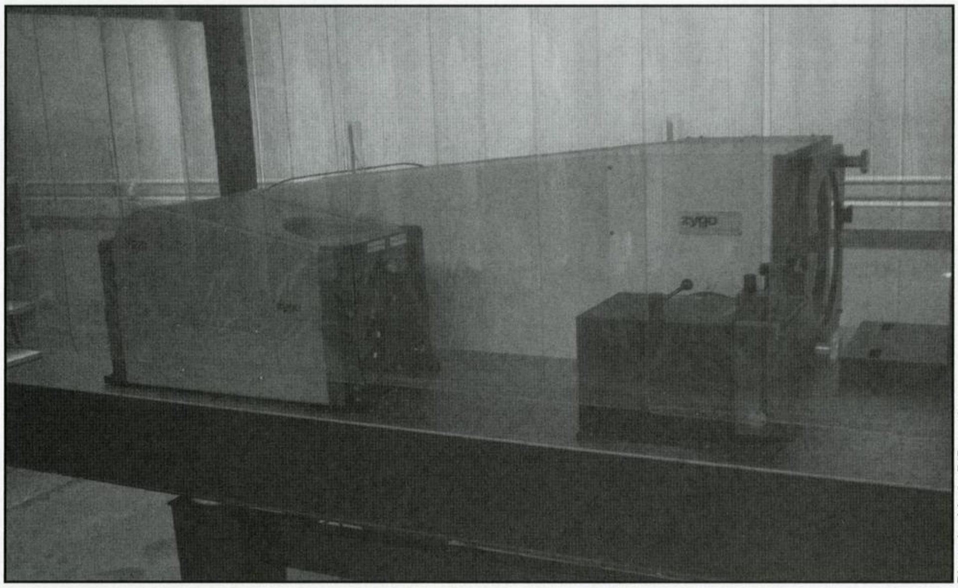


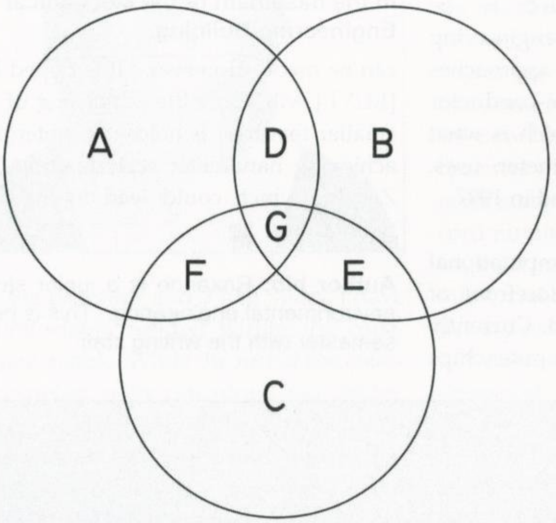
Photo by Mario DiBenedetto

The phase shifting laser, on the left, emits the illuminating laser beam at various wavelengths, acting as the light source for the instrument.

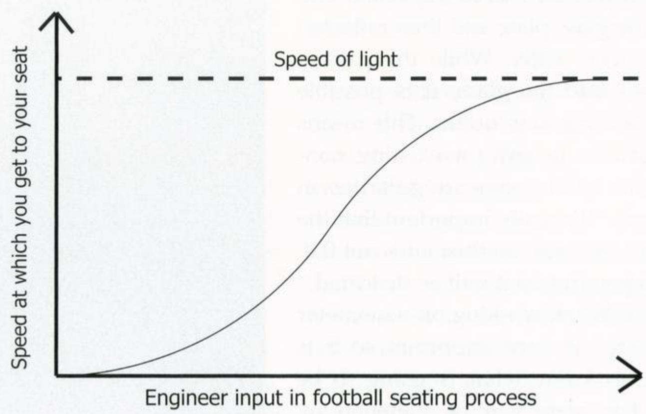
Just one more

The finest in eclectic humor

An Engineer's outlook of life



A. Inability to do simple arithmetic
B. Goal of outsmarting the professor
C. Love of the game Snake
D. Political pundit
E. Does crosswords in the front row
F. Professional Pictionary player
G. Target market for the TI-89



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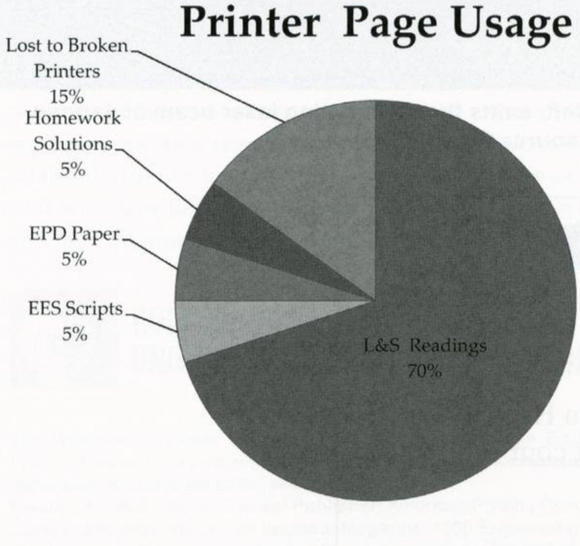

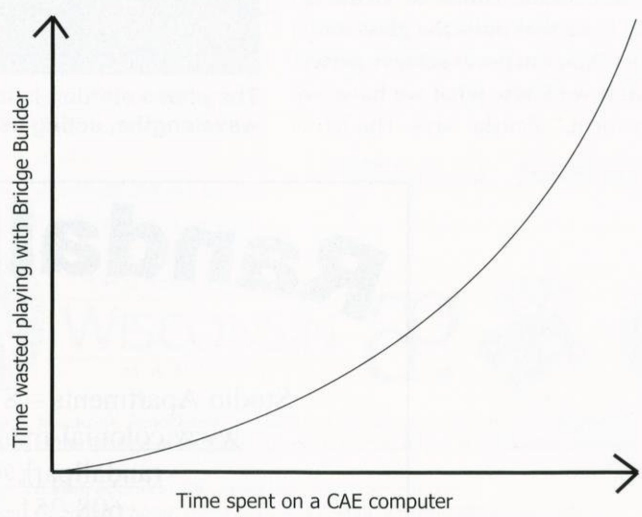

The 2008 election

Photos by Nelson Chan

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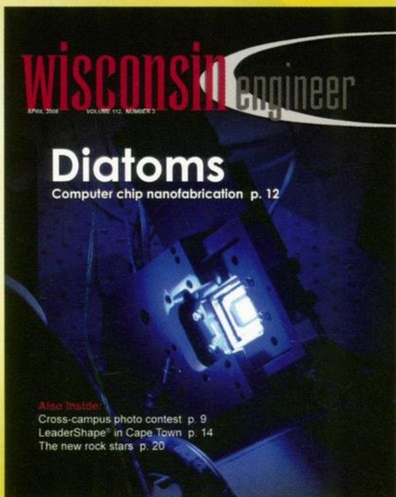

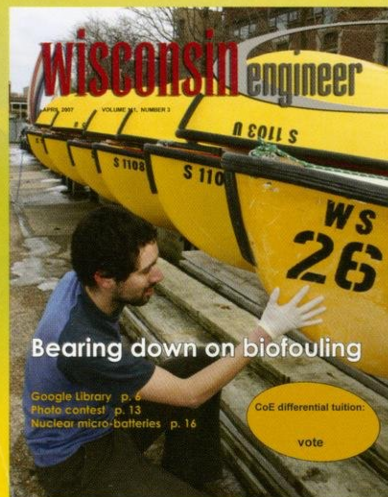

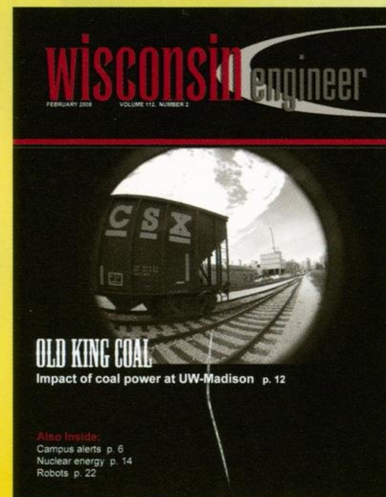

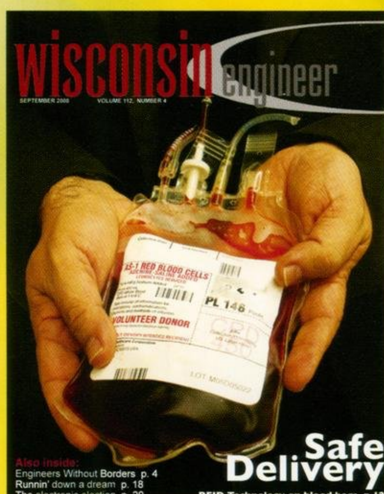

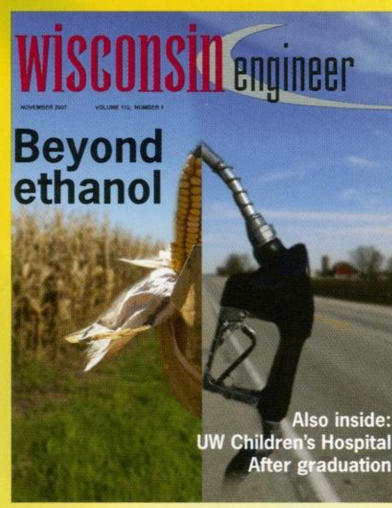

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