A Place of Infinite Possibilities

Materials Engineering's New Home

PURDUE **MATERIALS**

ENGINEERING**IMPACT**

WINTER 2007-08

John Underwood

On My Mind

I will be leaving Purdue at the end of December. On October 22, the United States Department of Energy announced my appointment as director of the Ames Laboratory in Iowa. My wife, Chris, and I will be moving to Iowa in time to start this new position on January 1, 2008.

It is an incredible privilege to have been associated with Purdue and especially the School of Materials Engineering for the last eight and a half years. This has been a great ride on a consistently rising trajectory, all made possible by the way that the school has responded to the opportunities that have come our way. Every member of the school—students, alumni, faculty and staff— has contributed in some way to our success, and I am immensely grateful for all of their hard work, unwavering loyalty, and for the friendships that I share with so many. A piece of my heart will be forever gold and black, and I hope that I will continue to have a strong connection with this outstanding School of Materials Engineering.

On November 28, 2007, Dean Jamieson announced that Professor Keith Bowman will become the new head of the school. Despite the changing administrative environment, I am confident that the school is well-placed to continue on a path of increasing reputation and prestige.

Alex King
Head, School of Materials Engineering

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Q&A With Carlos Martinez

Welcome Materials Engineering's newest professor.

Carlos Martinez, assistant professor of materials engineering, arrived at Purdue this fall—fresh from a two-year stint as a visiting scientist at Harvard. Martinez received his bachelor's degree from the University of Puerto Rico at Humacao (1994) and his PhD from the University of Illinois at Urbana-Champaign (2002). From 2003 to 2005, he was a postdoctoral fellow at the National Institute of Standards and Technology.


John Underwood

Carlos Martinez standing in Armstrong Hall

Q:> How did you get hooked on materials?

A:> From a young age, I wanted to be a scientist—that was a given. When I was finishing up my undergraduate degree, I wasn't really sure what route to take. And when I applied for a graduate fellowship, they asked me what I wanted to study. I told the committee that I was interested in a field that merged different areas like physics, chemistry, and engineering. One of the committee members said, "That's easy! Study materials." And I said, well, that sounds like a good idea!

Q:> Give us a 30-second, simple explanation of your research.

A:> That's impossible for an engineer! Let's see. My research interest lies in gaining a fundamental understanding of soft materials physics and then applying this knowledge to the development of functional structures for applications such as drug delivery, photonic materials, cell encapsulation, and chemical sensing.

Q:> Are you enjoying West Lafayette?

A:> I have a wife and a two-year-old son, and we find it to be a very active place with a lot of things going on. So far, it's been good. But we actually haven't had a chance to do much—we've been in the process of unpacking, cleaning, and getting our house together. When we're not doing that, we go to the park.

Q:> Why Purdue?

A:> This is a very exciting time to be here, a lot of great things are happening. There's a tremendous amount of growth. In terms of the materials program, I like the fact that the school is very student-oriented. I feel like the research and education here are done better than any other program in the country. ■

From the Bottom Up

A professor helps students wrap their minds around the concepts of nanotechnology.

Photo courtesy of Alejandro Strachan

Alejandro Strachan with family.

Alejandro Strachan is trying to get materials engineering students to see the small picture. More to the point, he's trying to get them to envision the tiniest of building blocks that will lead to something bigger. His goal: to strengthen student aptitudes in both the materials sciences and the realm of the imagination.

"We think in terms of atoms and build up to real materials," says Strachan, an assistant professor of materials engineering. His intent is to help students, who may eventually work in nanotechnology areas, develop stronger backgrounds and begin thinking in terms of "micro," not "macro."

With a background in physics, the native Argentinean (from Buenos Aires) is interested in statistical mechanics, or how things average out to complex phenomena. A theorizer and not an experimenter, Strachan says that Purdue "felt like the right place." Here, he does have the opportunity to collaborate with experimentalists from materials engineering and elsewhere.

So how does he work this all into a teaching philosophy? "In many cases the bottom-up approach is useful," Strachan says. "You can explain and understand things a lot easier if you start with a few atoms and a little bit of quantum physics. If you know the hydrogen atom, for example, which is not a very difficult problem to solve analytically, you can explain much about bonding and why carbon silicon behave differently from one another. That is the type of intuition we're trying to achieve."

To help further this understanding, Strachan and his students make use of and contribute to Purdue's Network for Computational Nanotechnology (NCN), the National Science Foundation-sponsored center where researchers are able to demonstrate novel computing devices. NCN allows students to simulate and "play" with atoms—heating them up, slowing them down, and testing their limits all based on theories handled by computer programs.

It's a type of technology that wasn't available to Strachan when he was a student. "We'd use coins to build models of atoms, and then move them around," he says. "I believe the NCN tools provide much more fidelity."

His students seem to be high on the fidelity as well. Within a class of about 18, Strachan will typically have students from a variety of disciplines: from materials and mechanical engineering, to electrical and computer engineering and even pharmacy. Anyone really, he says, interested in becoming more familiar with an intuition that will better serve science.

For Strachan, recipient of the school's 2007 Reinhardt Schumann, Jr. Undergraduate Teaching Award, learning is not just about solving equations. Through the development of intuitive skills, he's helping that mix of students figure out what equations need to be solved. "We can provide the tools and facilitate," he says, "but in the end, it's up to the students to discover and learn."

And from atoms up through skyscrapers, Strachan has got them seeing the materials world in a whole new way. ■ **William Meiners**

Winding Path

A father's suggestion leads to a career in materials engineering.

From an early age, I've always had an interest in mechanical things. My father was a machine tool technical representative, servicing the midwest automotive trade. At the point where I was beginning to think about what I wanted to do when I grew up, dad observed that almost every time he made a sales call, the purchasing agent would have a metallurgical engineer attend the meeting. Thus, dad concluded that metallurgical engineering must be a decent profession.

I was interested in what dad had to say and wrote to the Metallurgical Engineering department at Purdue. They inundated me with information and invitations to visit. It all looked good to me and the next thing I know, I'm in college and enrolled in metallurgical engineering.

During my senior year, we went on a tour of U.S. Steel's East Chicago plant. Ugh! That tour and the Vietnam War made graduate school an attractive next step. Next on the list was a research thesis. With the help of one of my graduate committee members, I went on to the equivalent of a post-doc at what was then the Aerospace Research Laboratory at Wright-Patterson Air Force Base.

I went on to my first real job at Babcock and Wilcox's (B & W) Lynchburg, Virginia, research center, doing things I'd never imagined. This center supported B & W's commercial nuclear power business. I started out designing and running in-reactor experiments on ceramic nuclear fuel.

I have to say that, when I first started out, I didn't have a clue how to carry out the assignments I'd been given. But, with the help and mentorship of colleagues (which was priceless), I muddled through and became something of an expert. The opportunities were exciting beyond compare. Along the way, I spent many days camped on the edge of a spent fuel pool near Clemson, South Carolina, making detailed measurements on pre- and post-irradiated fuel assemblies. I was put in charge of B & W's hot cell facility, and oversaw the shipment and disassembly of discharged fuel assemblies.

Then came the Three Mile Island event, and the nuclear industry went into decline. B & W company officials said, "Let's move Mike to Washington DC to seek funded energy and defense research and development projects." Being a country boy from Indiana, I did not find that prospect to be exciting. Regardless, I made the move, and it resulted in

Mike Rigdon

me finding the Institute for Defense Analyses (IDA). IDA is a federally funded research and development center—sometimes known as a think tank—that supports the Office of the Secretary of Defense.

My apprenticeship at IDA coincided with the initiation of a Materials and Structures Office within the Strategic Defense Initiative. My work dealt mainly with the development of various lightweight, low-thermal expansion composites for large space platforms.

Ten years ago, as my hair was slowly turning gray, I was asked to serve as deputy director for IDA's Science and Technology Division, and began the move into IDA management. That move was completed six years ago, when I became director of the division.

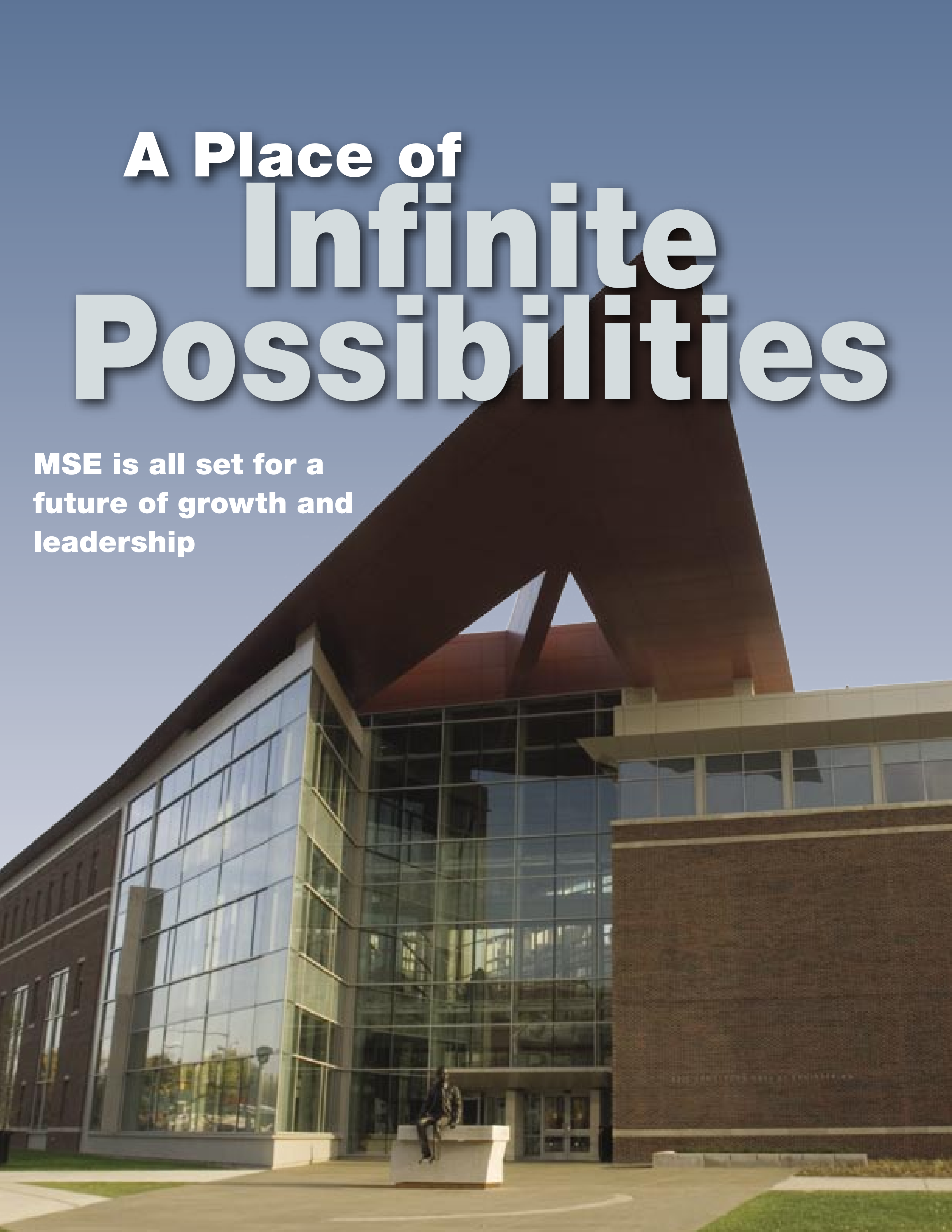
When students begin interviewing for jobs, the questions they get are likely to include: "Where do you want to be in five years," or "What do you want to be when you grow up?"

I don't think I ever gave an answer to one of those questions that remotely resembled what actually happened. The best I can suggest to people at the beginning of their career is do the best they can and be willing to tackle new opportunities.

Also, keep in mind that it sometimes pays handsomely to listen to your dad. ■ **Mike Rigdon**

A Place of Infinite Possibilities

MSE is all set for a future of growth and leadership



Mark Smith

By Linda Thomas Terhune

With its overhanging roofline angled upward like the edge of a futuristic wing, Purdue's new Neil Armstrong Hall is a fitting home for engineering programs that are educating students who will send humans farther into space, expand the frontiers of biomedicine, and power ever faster computers and more environmentally friendly cars.

This world of the future will require a special breed of engineer, one that the National Academy of Engineering (NAE), in a series of recent reports, defined as "The Engineer of 2020." This person must be equipped for the global, technological, economic, and societal challenges of the 21st century.

Purdue's School of Materials Engineering (MSE), one of the programs that moved into Armstrong Hall in August, began teaching to the 2020 model more than a decade ago when it implemented a new curriculum incorporating 21st-century concepts such as teamwork, collaboration, communication, and global thinking. Though ahead in some areas, the school was behind in terms of space. The recent move has now provided MSE with room to grow and aggressively position itself as a leader in materials research and education, especially in the areas of processing, manufacturing, and nanoscale technology.

continued on next page


Vincent Walter

Growing Pains

Along with MSE's curriculum changes came significant growth. The number of graduating MSE seniors has grown in the last decade from an average of 15 per year to around 30. The faculty increased in that same period from 11 to 22. The move allows for increased enrollment at the undergraduate and graduate levels, a larger faculty, and an evolving curriculum. Alex King, head and professor of materials engineering, would like to see the graduate program grow from its current enrollment of around 55 students to 90. This is now possible.

King, who came to Purdue from the State University of New York at Stony Brook in 1999, attributes the school's growth, in part, to the explosion of the field of nanotechnology—a subject of great interest to materials engineers—and the presence of Purdue's Birck Nanotechnology Center. That has made it easier for the program to recruit some of the top faculty in the world.

"For many years, during the dot-com boom, basic metals was not a hot item," King says, "but as Asia absorbs more steel and concrete, the demand is there."

Evolution

Nanotechnology is now one of the core research areas for materials engineering, which came to life in the late 1900s when schools of mines were created to teach metallurgical and ceramic engineering. In the late 1960s, materials engineering began to emerge as its own discipline, one that included the study not only of metals and ceramics but also of glasses, polymers, and semiconductors. The world had changed, and in the early 1990s, Purdue's MSE undergraduate curriculum was revised to meet its needs. As a collective project of the faculty, the school is in the process of fine-tuning the curriculum to reflect the increasing amount of computation in the science and engineering of materials, and the need for basic science related to nanotechnology and other emerging areas of research.

New courses include one for lower-level students on the physics of materials and a senior-level course on the applications of materials that will tie science and applications together. As always, MSE students spend a lot of time in the laboratory—more time, according to King, than those in any other engineering program. It is especially significant, then, that Armstrong Hall gives MSE 35 percent more laboratory space than its former home. And the labs are well equipped.

In the previous facility, materials engineering students had access to two high-quality microscopes and watched on a large screen as the instructor lectured about specimens under a microscope. Now, they will each get a microscope during lectures for hands-on learning; the new facility contains 12 new optical microscopes for metallographic studies, each with the ability to collect digital images for computer analysis. The microscopes are worth up to about $30,000 a piece.

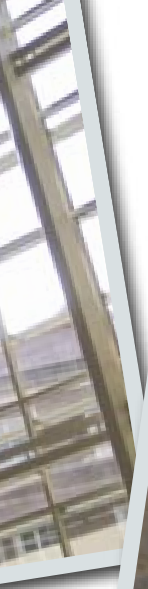
"It's going to be a huge improvement. Having a better microscopy teaching facility is going to move us ahead by a large amount," King says. The laboratory is probably the best equipped of all MSE teaching facilities across the country, he adds.

Armstrong Hall also contains a new lab for polymer synthesis—an entirely new capability for MSE—and new computer machine rooms. The building also allows for interdisciplinary work between materials engineering and aeronautics and astronautics, which occupies the third floor of the building, because of the shared electron microscopy, mechanical testing, and computer facilities. The machine room contains racks of array microprocessors, each functioning as one computer. MSE did not have this resource in its former home, because there was no space suitable for the amount of heat generated by the operation.

The 2020 Model

Purdue Engineering's plan for educating the Engineer of 2020 calls for a commitment to undergraduate educational experiences that mirror the world in which engineering as a global profession is practiced. Teaching must support teamwork and communication and foster open-ended design and problem-solving skills, among other areas.

King maintains that MSE has been teaching a very large fraction of the "2020" model for many years and is preparing its graduates to meet the challenge of what the NAE terms the "gathering storm" of international competition. He also says that the school is committed to "doing more and doing it better."



Erin Ingram


Martin Sickafoose


Erin Ingram

The school supports global learning—one of every six MSE students spends time studying abroad, a figure King hopes will double within five years. Communication skills are enforced and reinforced throughout the program. The rich student-to-faculty ratio (roughly two undergraduate students for each professor), of which the school is especially proud, leaves plenty of room for undergraduate research opportunities and direct interaction with faculty members. Laboratory work is collaborative with students directly engaged in processing and evaluating materials. And the senior capstone design course ties it all together.

Wrapping it up With Industry

MSE's two-semester capstone course, taught by a group of professors, including Rodney Trice, Matt Krane, and Carol Handwerker, gives MSE students hands-on experience in applying the knowledge they have learned throughout their studies. The students are divided into teams and work on real-world problems—such as the optimization of heat treatment for metal components of diesel engines—that are suggested by the school's industry partners. The projects call on classroom learning, teamwork, communication skills, program planning, consideration of ethics, and open-ended problem solving—all elements of the Engineer of 2020.

The direct involvement with industry makes Purdue's capstone unique among MSE programs across the country, King says: "It is industrially driven. Companies such as Cummins, Rolls-Royce, Howmet, GE and General Motors define projects and provide engineers to work with the students, and we think that's a very important part of our program. It teaches students what the real world is like, problems of interest in industry, basic survival skills, and it brings home what we've been drilling them on. We do that to a fault in this program." ■

Experience Guaranteed

Senior design ensures every graduating senior has real-world experience under their belt.

The materials engineering senior design course has not always been industry focused. Before associate professor Matt Krane took over as head of the course 11 years ago, the focus had been on research issues, not industry problems.

"It was more a course on research methods and how to conduct research," explains Krane. "This is very useful, but we thought, given the fact most undergrads will not end up as academics or doing research, that experience and exposure to industry projects was more important."

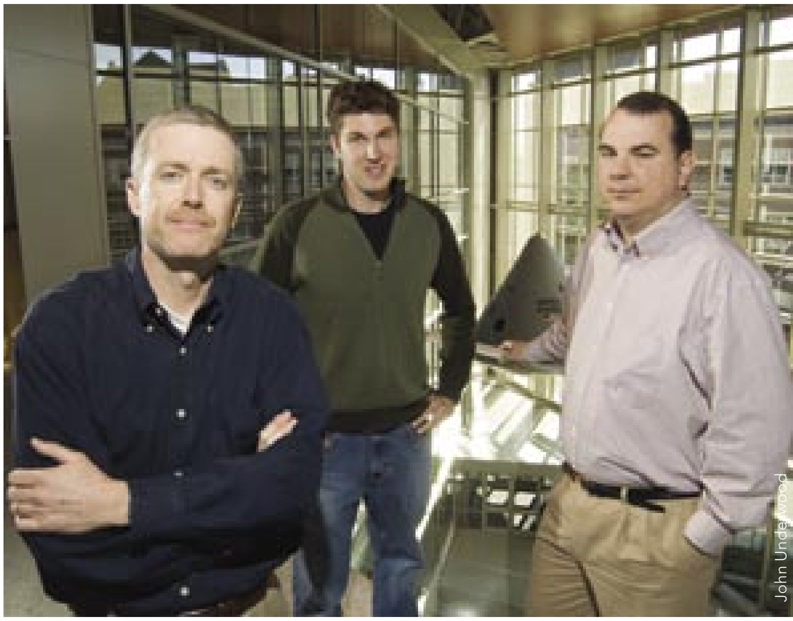
However, Krane does not credit himself with the change. "The professor who worked on the class before me had started the move into industrial project experience. It was a great idea, and I merely improved on it."

The improvements have given way to a senior design course that effectively bridges the gap between industry and education, providing students with hands-on, real-world experience with some of the country's leading companies.

Materials engineering students John Koppes, Joshua Haynes, Isaac Janson, and Ryan Ostrye spent their senior year working with General Electric's Global Research Center in Niskayuna, New York, before graduating with their bachelor's degrees in May 2007. "They wanted us to examine the possibility of using brazing as a method to repair cracks in turbine blades," explains Koppes. "We conducted a diffusion and modeling study that examined the feasibility of repairing the cracks using silicon additions to the base alloy."

Other industry partners Purdue has paired with in the past include Rolls-Royce, Alcoa Engineered Products, and Delphi. Jonathan Vernon (BSMSE '07) presently a graduate student at Georgia Tech, and the rest of his senior design team were asked by Rolls-Royce to characterize the interactions of a particular contamination with current thermal barrier coatings used to protect turbine engine components. "Rolls-Royce was developing new coatings in order to remedy the shortened engine life span resulting from exposure to certain contaminants during service. Our team was asked to evaluate some of these coatings," says Vernon.

Regardless of the industry sponsor they worked for, or the problem they were given, students agree that



John Underwood

the experience they got from senior design was immeasurable. "It was a whole new world for us as students," says Koppes. "It was really exciting because we were finally given the opportunity to apply the knowledge and skills we developed as undergraduates to a problem that our industry partner was facing."

Nathan Smith (BSMSE '06, MSMSE '07), a materials engineer in the Mechatronics Department at Harris Corporation, says, "During every one of my job interviews, I discussed the senior design project and how it applied to an actual industry application. I think it gave interviewers an idea of how I might work with others and approach problem solving situations within their organization."

"Although many engineering students gain experience through an internship or co-op, the senior design course ensures that every graduating senior in the School of Materials Engineering has the opportunity to work on a substantial engineering project with an industry partner," explains Krane. "This gives our students an important edge over other engineering students entering the workforce."

■ **Kristen Senior**

Reaching Beyond Materials Engineering

I left Purdue in 1993 and have been a professor in mechanical and materials engineering at Washington State University (WSU) for 10 years now. I have two things—besides research— that I'm very interested in: getting undergraduates involved in research early, and letting people know about materials engineering. After a while it's tiring to be the best-kept secret, and materials as a field definitely has its shy streak.

At WSU everyone has to be well-rounded, which entails each student taking courses from outside of their major. Several years ago, another faculty member and I started a course called "Materials: The Foundation of Society and Technology." We decided that, rather than trying to convert more students to materials, we'd subvert the system by teaching business, agriculture, and political science students about materials.

In our own unique way, we explain how materials fit into modern society and without using that standard triangle we all grew up with. We instead intersperse materials within the world's history (e.g. the "ages") and use topical materials such as transportation and sports materials to explain their role in the past and today. If we want to reach more people, we've got to talk about the things they're interested in. We know this works when students who aren't in materials engineering—a music major, for instance—use the Griffith Criteria in a paper!

I also spend a lot of time leading undergraduate research activities. Conventional wisdom in all the engineering fields—at least when I was an undergrad—was that we did senior projects. Why? Because we'd learn the basics and then apply them in a hands-on project. I've run an undergraduate research program each summer for nine years, and even had several Purdue students out for the summer. And, yes, they did a great job. So, this shows that I'm a big fan of starting students earlier.

Retention in engineering is abysmal across the country, with less than 50 percent of freshman students making it to graduation. And I suspect a lot of that has to do with our holding back the "fun" parts (or at least the more creative parts) until near the end. We're seeing more professors starting to realize that getting freshmen and sophomores interested in research or active learning pays off in terms of retention within the field. We should consider ourselves a field that lets undergraduate students explore, design, create, and discover things alongside our faculty and graduate students. While a freshman isn't a miniature graduate student, they can do valuable work on projects with some guidance and can take an active role in shaping questions and finding answers.

Dave Bahr

Basically, it comes down to a need for more materials engineers out there—at least that's what the companies hiring our students tell us. I think there's something special about being in materials engineering, partly because it's a small and friendly discipline. But there are things we can do to make it a slightly bigger and well-rounded club. ■ **Dave Bahr** *(BSMSE '92, MSMSE '93, Ph.D 1997, University of Minnesota, Minneapolis) is a professor of mechanical and materials engineering at Washington State University and director of undergraduate research for the university's Office of Undergraduate Education. He was awarded the ASM International Bradley Stoughton Award for Young Teachers in 2003 and the Presidential Early Career Award for Scientists and Engineers in 2000.*

Turning Over a New Leaf

Cheryl Waller sets off for a new journey.

This year marks an end and ushers in a new beginning for Cheryl Waller as she concludes a 32-year career at Purdue and moves to nearby Benton Central High School to teach Spanish. She's off to a second career, renewed in vocation and still focused on being an agent of change. Her compassionate, energetic spirit has left an indelible mark, and she's left behind mighty big shoes to fill. Here's a look back.

Early Days

Waller grew up in a rural town an hour north of Purdue, where she graduated from high school in 1974 and within six months started a job at 19 in Purdue's Memorial Union food service.

"I made $2.10 an hour," she recalls. "That's what the rate was in the '70s, and that was considered an okay salary!"

As one of the young members of the Union's staff, Waller was considered the "baby"—and when she married her husband, Chuck, her co-workers made her cake and catered the wedding.

She left the Union in 1976 and went to Earhart Hall—an all-girls dormitory at the time—to work for the hall director. And while employed at Earhart, Waller gave birth to the first of her three children.

Waller then worked in the Vet school and in Aeronautics and Astronautics for Henry Yang, whom she kindly refers to as a "character" and a very hard worker. Yang, who is now chancellor at the University of California at Santa Barbara, remembers her well: "She was one of the most diligent and determined persons in the world. She is kind-hearted, and I cherish her collegiality and friendship."

> *She took great care of us with small acts of kindness, encouragement, and advice. She also took a great interest in our lives, not just with academics.*
> - Ryan Roeder

A Material(s) World

In 1982, her seventh year at Purdue, Waller joined Materials Engineering as a secretary.

Her task at the time was to assist professors Reinhardt Schuhmann, Jr. ("Schuh") and Paul Eaton. "Cheryl's view was to 'get it done now.' She was very good at getting faculty to do what they should—an attribute that has served the school well over the years," says former Materials Engineering head Jerry Liedl. "I remember walking by Cheryl's office and seeing her with a phone tucked onto her shoulder and typing away like mad—usually from Schumann's recorded dictation."

After the school's move to the MSEE Building in 1988, Waller's responsibilities expanded. In addition to serving as a mom to her children Brian, Keith, and Max, she also served as a mom to the MSE undergraduate and graduate students, and a number of faculty. Her duties grew to include assisting faculty with their daily operations and helping MSE student organizations plan meetings and social gatherings.

And, over the years, she facilitated the recruitment of many graduate students and faculty. "Our numerous international students fondly remember her for all the assistance she provided in finding them a place in which to live and get settled down at Purdue," says Alex King, head of the school.

One of Waller's major contributions was the work she did to prepare award documents for the Alpha Sigma Mu National Honor Society,

> *She cared about our grades, our sleep, and interactions with each other. She allowed us into her life, and even shared her most precious possessions with us, her children.*
> - Kim Blackman

which resulted in Purdue receiving many awards over the years. And in the last couple of years, she volunteered to help develop and maintain the school's Web site.

It was in the mid-'90s when Waller decided to add earning a bachelor's degree to her to-do list—along with maintaining her many responsibilities in the school, running the finances of her family's business, and managing summer baseball leagues. Her motivation for pursuing a college education at the time was to be able to help her eldest son, Brian, with college math. She had a lot of support from her husband, who did a lot of the cooking and laundry while Waller took classes.

"I'd always wanted to go to college. My boss at the Union tried to talk me into it. Henry Yang also was very supportive—but it was my time in Materials when I took most of my classes," Waller says. "I started learning from scratch. When you do that 30 years after high school, your brain is like, 'I don't want to do that.' I didn't really know what I was in for. I just started taking classes."

When she'd have trouble with a math or science class, she'd bring in food—the key to any student's heart— and graduate students Kim Blackman (BSMSE '94) and Ryan Roeder (BSMSE '94, PhD '99) would help her over lunch or after work. "Some of these students are like my kids, and they've become brothers and sisters to my sons," she says with affection.

Her work paid off. Waller graduated in 2005 with a bachelor's degree in Spanish education.

Adios

It's hard to imagine the thoughts spinning through the mind of someone leaving after 30-plus years at one place. Excitement? Uncertainty?

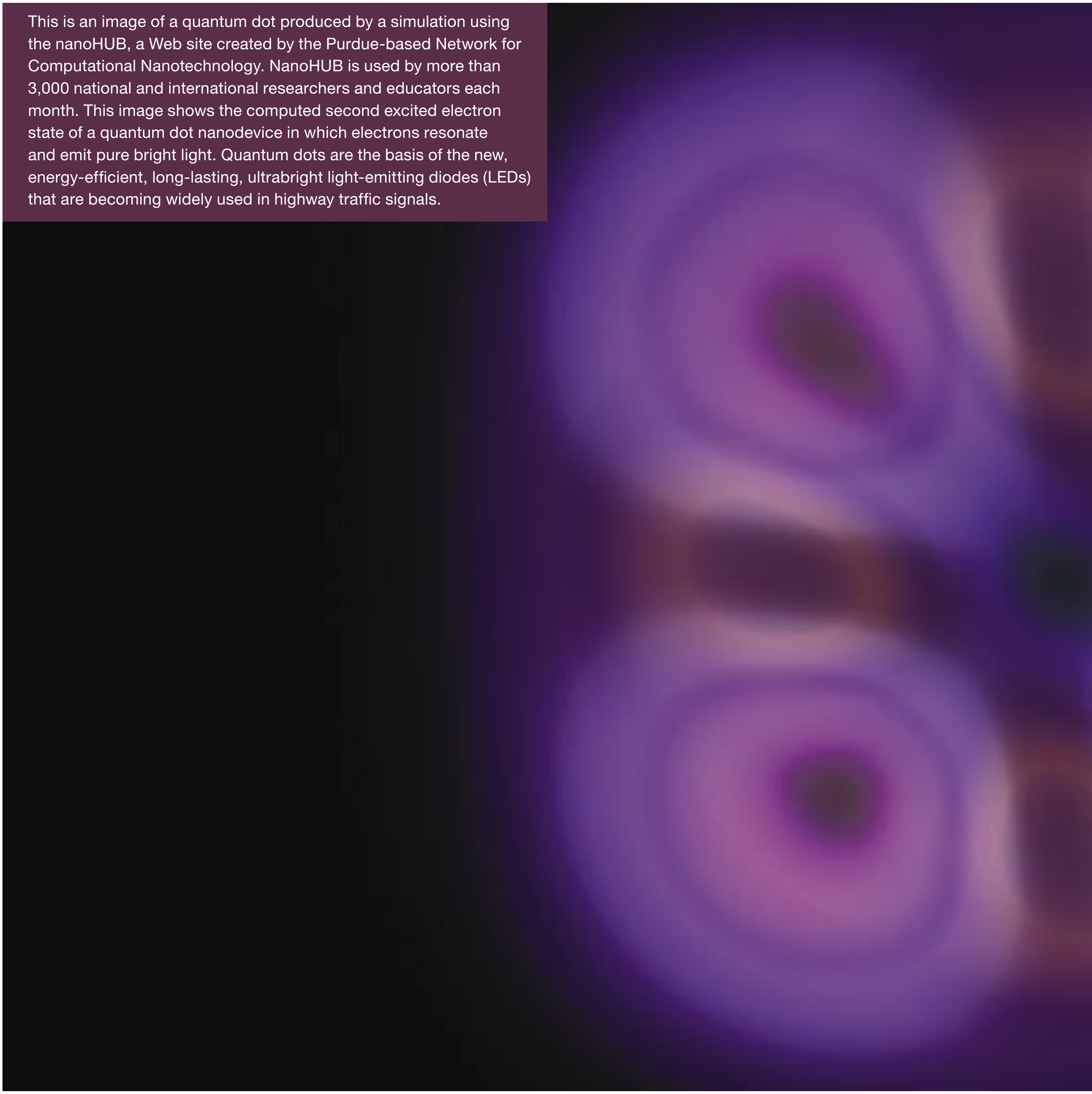
"I'm a little scared about the move," Waller admits. "But, it'll be nice to say that I've had two careers. These folks in Materials are family. I think I have to move on, though."

Perhaps Liedl said it best when he recently likened Cheryl's departure to a weather warning: "I see this new change in Cheryl's life as just one more challenge that she is undertaking, and I wish her well. Watch out, Benton Central! You probably don't know the tornado coming your way!"

With her trademark smile, Waller jokes, "Everybody says they're going to miss you, but behind my back they're probably saying, 'Get out of here, you've been here too long!'"

■ **Lee Lamb with Keith Bowman**

aperture



This is an image of a quantum dot produced by a simulation using the nanoHUB, a Web site created by the Purdue-based Network for Computational Nanotechnology. NanoHUB is used by more than 3,000 national and international researchers and educators each month. This image shows the computed second excited electron state of a quantum dot nanodevice in which electrons resonate and emit pure bright light. Quantum dots are the basis of the new, energy-efficient, long-lasting, ultrabright light-emitting diodes (LEDs) that are becoming widely used in highway traffic signals.