THE UNIVERSITY OF NEW MEXICO SCHOOL OF ENGINEERING

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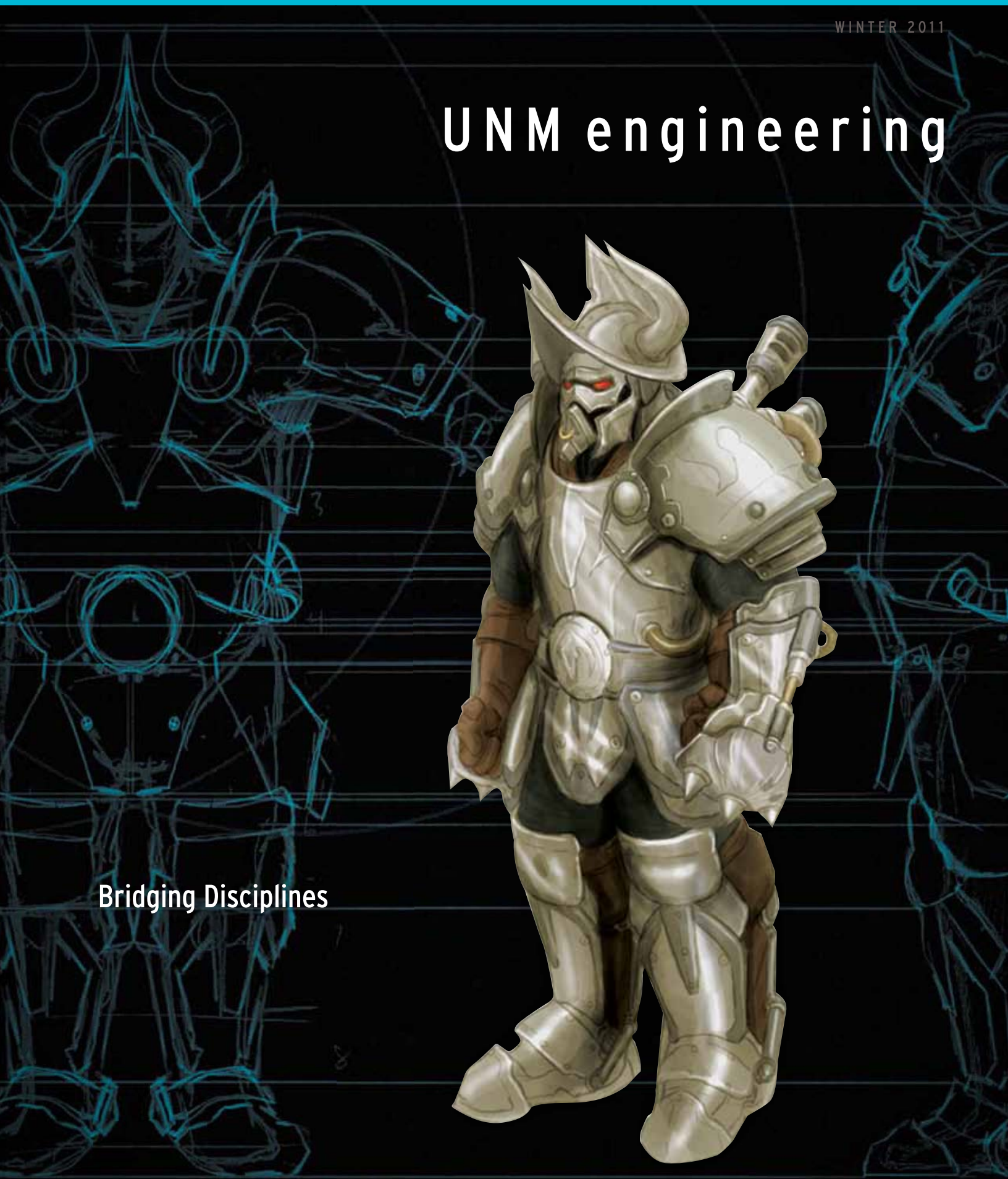
UNM engineering



Bridging Disciplines

From the Dean

The theme of this magazine, "Bridging Disciplines" is best illustrated by the number of new interdisciplinary curricula we have initiated in the past couple of years. As you read about these programs and their impetus to economic development, it is important to acknowledge the tenacity of the people that make such programs possible. While national accreditation requirements and a discipline-centric tenure model are pillars that strengthen our core mission, they are often deterrents to interdisciplinary activities. Yet the rapid change in the industry and the workplace dictates that we embark on new journeys.

The article on 'Mastering the Automated Reasoning' illustrates how research in computer science is central to the reliability of numerous tasks performed by computers that we take for granted. Likewise, we have come to expect certain levels of efficiency and reliability from our infrastructure, which affords us the highest standard of living and economic competitiveness.

Professor Hall's reflection on his 30+ years at UNM highlights not just the importance of day-to-day things, but also the diversity of values among the faculty of the School of Engineering.

Greater exposure to the world economy makes it necessary that engineering education in the US is more connected to its context. In the future we will be required to broaden our definition of 'interdisciplinary' to be more inclusive of the social sciences and the arts. An individual's quest for uniqueness will always be weighed against an institution's responsibility to ensure quality. Just as flexibility, toughness and strength are usually traded against each other in metallurgy, the tradeoffs between interdisciplinary activity and discipline-specific research and teaching will be the engaging debate for years to come.

With best regards,

Arup K. Maji

Interim Dean, UNM School of Engineering

Contents

Points of Pride

UNM Adds Massive Supercomputing to its Video Game Research

High-end computer graphics processor manufacturer NVIDIA announced that the University of New Mexico's Advanced Graphics Lab and Center for Advanced Research Computing have jointly been selected as one of the company's CUDA Research Centers. This selection follows the announcement in September of a National Science Foundation Major Research Instrumentation award of $435,077 to UNM CARC to acquire a GPU-accelerated supercomputer and associated terabyte storage system. The new supercomputer will enable UNM students and researchers to perform advanced, computationally intensive research.

New Graduate Degree Programs

UNM will offer a new biomedical engineering concentration in the Ph.D. in engineering degree program and a new Master of Engineering (M. Eng.) degree in civil engineering starting in Fall 2011. The biomedical engineering graduate degree will prepare students for positions in academia and in laboratories across the nation and worldwide as well as in the large number of biotech companies in New Mexico. The M. Eng. degree in civil engineering, in contrast to the M.S. degree which includes a thesis, is a practice-oriented degree program designed to augment the education received at the undergraduate level in civil engineering practice and design.

Bridging Disciplines

02 Meeting of the Minds

Interdisciplinary programs: forums for innovation and collaboration

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On the Cover
Preliminary sketches and concept art for El Toro, a character for a video game being developed in the Advanced Graphics Lab under the direction of Dr. Pradeep Sen. The sketches are by Ryan Knudsen and the concept art is by Andrew Yang.

From Left: Abhaya Datye, Charles Fleddermann, Chang-Yi Lin, Pradeep Sen, and Steven Graves

meeting of the minds

Interdisciplinary programs: forums for innovation and collaboration

If you walked around the School of Engineering (SOE) in the early 1990s, you'd find chemical engineers using microscopes in their labs, mechanical engineers building devices in workshops, and computer scientists writing code on computers in their offices.

Today you can find all three working in the same lab on the same project, often accompanied by physicists, biologists, physicians—even artists. To help solve interrelated global challenges, develop new technologies, and create economic opportunities, engineers and computer scientists are increasingly collaborating with those in other disciplines. "Technology does not respect our traditional disciplinary boundaries," says Charles Fleddermann, associate dean for academic affairs. "In the past 20 years there has been a real acceleration in cross-disciplinary efforts."

Just as an interdisciplinary approach is now the norm in research and industry, it's also an integral part of an SOE education. Today the school participates in six interdisciplinary degree programs as well as many other interdepartmental opportunities for students. "These programs let students broaden their knowledge and skills by working with students and faculty from a wide range of disciplines," says Fleddermann.

Students aren't the only ones benefitting from the SOE's interdisciplinary focus. "By developing these educational programs, we're fostering New Mexico's economic development," explains Fleddermann. "Plus, we have opportunities that other places don't because we can interact with the national labs that are here."

The following four interdisciplinary programs reflect unique opportunities for students to learn new approaches from multiple disciplines, participate in cutting-edge research, and apply what they learn in both emerging and established career fields.

"Technology does not respect our traditional disciplinary boundaries," says Charles Fleddermann, associate dean for academic affairs. "In the past 20 years there has been a real acceleration in cross-disciplinary efforts."

Luke Lester
Chair of Optical Science and Engineering

Chang-Yi Lin
Doctoral student in Optical Science and Engineering

1 Optical Science and Engineering Program

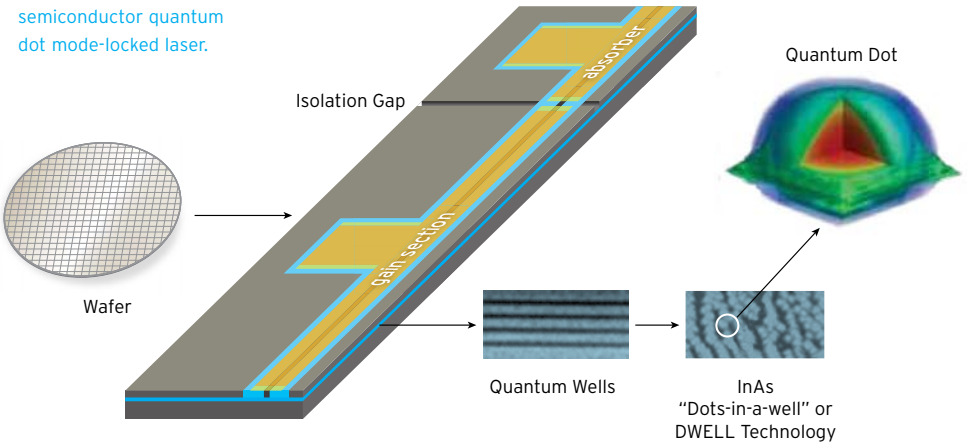
Optical science touches many aspects of everyday life—from fiber optic communications and medical imaging to tattoo removal. In 1983, the SOE recognized the importance of these specialized engineers and started the Optical Science and Engineering Program (OSE). The graduate degree program, a collaboration between the Department of Electrical and Computer Engineering and the Department of Physics and Astronomy, is the school's oldest interdisciplinary graduate program.

UNM is one of only a handful of universities in the country that offers a master's and doctoral degree in optics and photonics. "Early on we recognized that there was a lot of knowledge and skill in the government labs and local industry, and many people were interested in optics-related research," explains **Luke Lester,** chair of the OSE. "We wanted to create this program to satisfy that need and to create the next generation of people to work in optics."

The program, which offers about 30 courses, is popular with students because optics has broad applications in biology, medicine, mechanical engineering, communications, and astronomy. Participants choose from three concentrations: optical science, photonics, or imaging science. An average of five doctoral candidates and a dozen master's candidates graduate from the program annually.

Chang-Yi Lin, a doctoral candidate, enrolled in UNM in 2005 specifically to be a part of the OSE program. Lin's research focuses on the semiconductor quantum dot laser that generates high-speed optical pulses to be used in computer chip interconnects and optical communications. He says the program's interdisciplinary approach gives him opportunities now and will open doors as he searches for a position as a corporate research scientist. "Because of the OSE program, I have a strong background in both the microwave world and also in optics, so I have an advantage over other people who may have only worked in one field," says Lin.

Device layout of a semiconductor quantum dot mode-locked laser.



"Digital media is all about the synergy between arts and engineering," says Pradeep Sen, co-founder, Advanced Graphics Lab.

2 Film and Digital Media Program

Box office blockbusters and some of television's most popular shows are filmed in New Mexico, resulting in the Land of Enchantment being dubbed "Tamalewood." The state's aggressive business incentives and unique locations are central to the industry's success here, as is the growing pool of local technical talent.

By launching the Interdisciplinary Film and Digital Media (IFDM) Program in 2008, UNM took an active role in developing that talent pool. The undergraduate program is offered by the SOE, the College of Fine Arts, and the College of Arts and Sciences.

Now in its third year, the IFDM offers core classes and electives that provide the critical, creative, and technical skills students need to apply digital technologies in innovative ways. Students can customize their coursework to match their interests, whether they're focused on the creative or business side of film industry.

The IFDM isn't just for aspiring filmmakers. Students interested in graphics, scientific visualization, animation, gaming, and interactive media can also take a range of courses offered by the Advanced Graphics Lab (AGL), which has a game development program now ranked in the top 50 nationally.

"Digital media is all about the synergy between arts and engineering," says **Pradeep Sen,** one of the lead faculty of the Advanced Graphics Lab and an assistant professor in Electrical and Computer Engineering. "Engineering students who want to be successful in this field must not only know the technical aspects of the field, they must also have an understanding for artistic subjects such as photography, composition, and drawing, Likewise, students in fine arts must know how to program and work their way around computer code. Programs like the one we have at UNM bring artists and engineers together so they can get this kind of exposure while still in school."

3 Biomedical Engineering Program

Prosthetics, blood alcohol detectors, and engineered proteins are all developed by biomedical engineers. By applying engineering principles and tools to biomedical and biological problems, these cross-trained engineers help solve the critical biological and medical challenges of our time.

Biomedical engineering research has been underway at the SOE for years; now the school is creating a new graduate degree program in the field. Graduates of the biomedical engineering program will have no shortage of job opportunities, as the demand for biomedical engineers is expected to increase 21% over the next decade.

Steven Graves
Associate Professor of Chemical and Nuclear Engineering

"One of the areas of growth in the country and the world is biomedical engineering and health science," says **Steven Graves,** associate professor of chemical and nuclear engineering. "With the intersection of our outstanding School of Engineering, the national labs, and our excellent medical school, there's a unique opportunity for UNM to train students to work in the biotech industry and inspire the development of a biomedical engineering research hub that will do a lot for the local economy."

UNM plans to launch the full-fledged, state-sanctioned Biomedical Engineering doctoral program this spring and add a masters' degree this fall. Four faculty members were hired specifically for the program and another 23 faculty members from chemical and nuclear engineering,

Andrew Yang and Pradeep Sen in the Advanced Graphics Lab, the principal research center at UNM for computer graphics, image processing, visualization, and related fields in digital media.

Carlee Ashley in a Biosafety 2 lab at the Advanced Materials Laboratory, a building shared by UNM and Sandia Labs that has fostered numerous interdisciplinary research projects.

computer science, electrical and chemical engineering, mechanical engineering, physics and astronomy, biology, and pathology will teach the courses. "That diverse input is the new norm," says David Whitten, research professor in chemical and nuclear engineering. "Everything has changed and in recent years much of the cutting-edge research crosses several fields. Things are really changing and the SOE is right at the center of it."

4 Nanoscience and Microsystems Program

The industrial revolution of our time may be based on elements that are 50,000 times smaller than a human hair. Those nanoscale building blocks are the materials, structures, and machines of the future. When integrated into microsystems, the potential is limitless.

The importance of nanoscience is growing rapidly and UNM is one of the few universities in the country to offer a degree in the discipline. "Those of us who have been researching nanomaterials felt that there was a need to attract students from outside our individual departments, so that's why we needed an interdisciplinary program," says **Abhaya Datye,** distinguished professor of chemical and nuclear engineering. "It's important to have programs that rejuvenate graduate education."

The Nanoscience and Microsystems Program (NSMS) began as a joint effort between the SOE and the College of Arts and Sciences and started offering masters and doctoral degrees as well as a minor for doctoral students in 2007. Faculty from all SOE departments, as well as physics, chemistry, biology, mathematics, earth and planetary sciences, and the biomedical sciences are involved in teaching integrated courses that bridge science at the nanoscale with microsystems technology. Currently over 70 students are enrolled and, to date, two PhDs, three MS majors, and five PhD minors have graduated from the program.

In fall 2010, the curriculum was expanded to include the Anderson School of Business and the Health Sciences Center. A new master's degree includes courses from the business school and participation of students in the technology business plan competition. In October 2010, one of only six five-year Cancer Nanotechnology Training Center (CNTC) grants in the nation was awarded to UNM specifically support NSMS research focused on improving the diagnosis and treatment of cancer. Clinicians and biologists in the Health Sciences Center are teaming with SOE faculty to develop new courses that integrate key problems in cancer diagnosis and treatment.

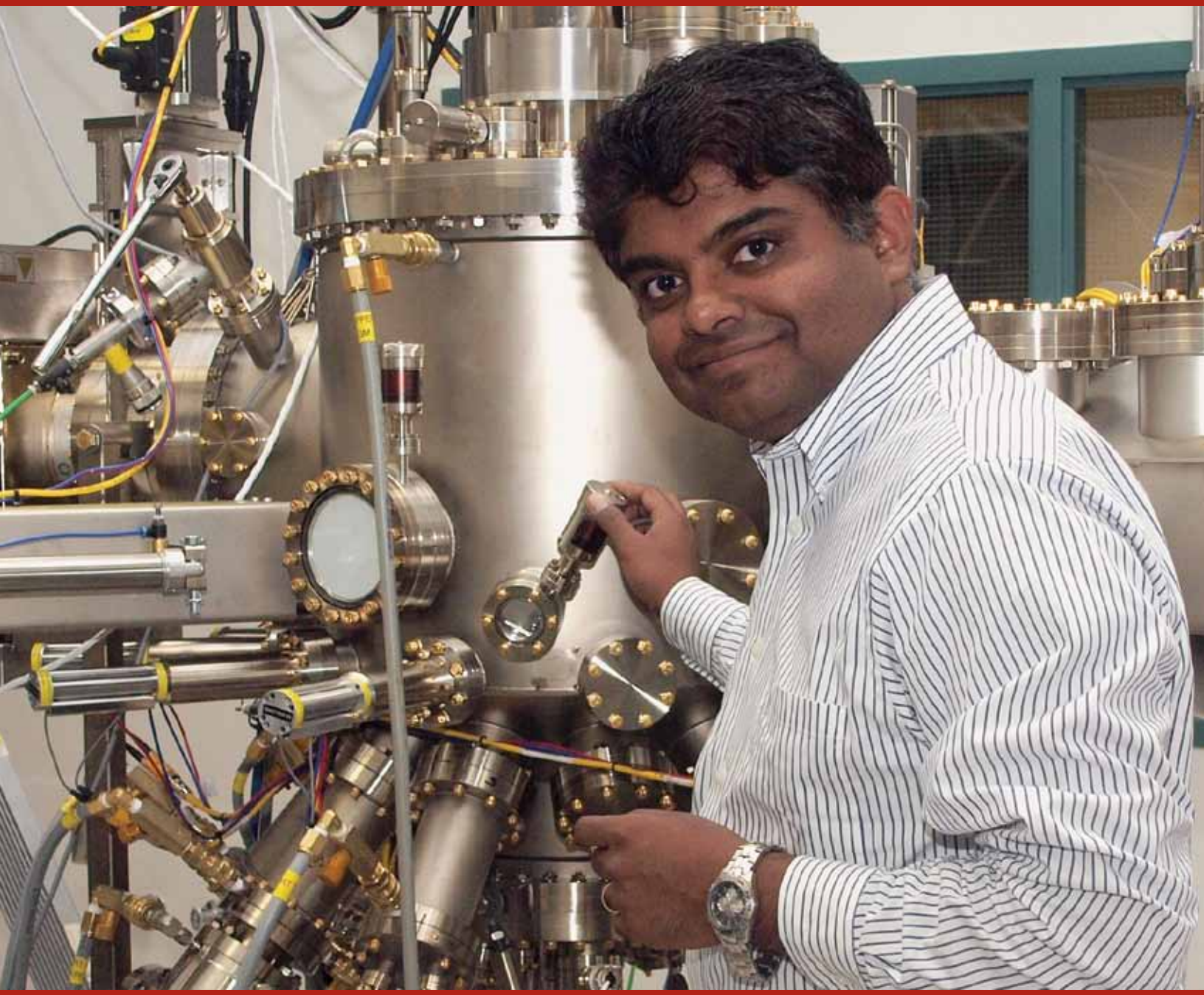
Abhaya Datye
Distinguished Professor of Chemical and Nuclear Engineering

The CNTC grant provides stipends for six graduate students and two postdoctoral fellows each year.

A recent NSMS graduate, **Carlee Ashley,** was awarded one of two prestigious Harry S. Truman Fellowships in National Security Science and Engineering offered by Sandia National Laboratories for 2010-2013. As a post-doctoral fellow at Sandia's Livermore, CA site, she's researching how virus-like particles can be engineered for targeted delivery of therapeutic agents to cancer, pathogenic bacteria, and cells infected with viruses. She says her current research and early career successes are an extension of an interdisciplinary collaboration between Jeffrey Brinker, distinguished professor of chemical engineering, and David Peabody, professor of molecular genetics and microbiology, that was a direct result of the NSMS program. "Had I not been involved in the NSMS program, I would have worked on a very different research project, and I probably wouldn't have gotten the Truman Fellowship," says Ashley.

Engineering Innovation Synergy

Teaching the next generation of engineers to excel is just one facet of an SOE professor's job. With his history of innovations, interdisciplinary collaborations, multiple outreach projects, teaching responsibilities, and a fledgling company, Sanjay Krishna, professor in the Electrical and Computer Engineering Department and associate director of the Center for High Technology Materials (CHTM), demonstrates the synergy of innovative teaching and research.



Sanjay Krishna next to the new VEECO Gen-10 MBE machine complete with a robotic arm. It is the first such MBE for compound semiconductors in the world.

A Quantum Change in Infrared Detection

Krishna's current research at CHTM is developing an "infrared retina" that will encode spectral information similar to the cones in the human eye. This new camera features the next generation of infrared detectors made with two nanoscale materials: quantum dots and superlattices. Both technologies can be engineered as sensors and incorporated into detection devices, like cameras, to clearly "see" things the human eye cannot, such as the top of a mountain through thick fog or a repository of noxious chemicals through a brick wall.

Quantum dots, just 10-20 nanometers in diameter, are based on a more mature GaAs (gallium arsenide) technology that can work at a higher temperature, allowing for a smaller device with less cooling equipment, useful for firefighting or surveillance operations. Superlattices, alternate stacks of semiconductor material just few nanometers thick, have a higher quantum efficiency so they can detect lower infrared signals, ideal for faint background applications such as astronomy, where scientists use infrared imaging to see distant galaxies.

CHTM has three molecular beam epitaxy (MBE) machines, which use atomic beams from hot elemental sources of gallium, aluminum, indium, antimony, and arsenic to grow nanoscale crystals on a heated wafer in an ultra-high vacuum environment. Once the dots and lattices are constructed, the team makes electrical connections between them and bonds them to a silicon circuit to create a nanoscale infrared detector.

Five years ago, the team used the circuits to make the first-ever infrared camera using a computer chip loaded with quantum dots. The infrared detector chips can be used interchangeably in an infrared test bed about the size of an early-model video camera. The two technologies will be adapted for different markets.

A Multidisciplinary Team

Krishna is coordinating the many phases of this Department of Defense-funded research with a multidisciplinary team of researchers, graduate students, and undergraduates. "Designing these technologies requires a lot of physics, quantum mechanics, and materials engineering," he says. Beyond the different skills each researcher brings to the table, Krishna says bridging disciplines creates new viewpoints. "We are all trained in a certain way in our own disciplines. Having someone from outside our discipline gives a great dimension to the work because they see a different perspective and that's very helpful," he explains. Ultimately, the researchers hope the nanosensors will be the foundation of a sophisticated infrared retina that can be inserted into high-powered detection devices. Much like the human eye, the infrared retina would include rods and cones to detect color. The "rods" and "cones" would be made of quantum dots and superlattices engineered with different spectral capabilities so they could detect polarization, gain, and phase information.

The potential for Krishna's research is already being recognized by industry. "I think there is a big future in this research because there is a strong interest by the

Infrared image taken with a superlattice camera fabricated at UNM capable of measuring temperature differences less than 25 mK. The thermal imprint of a coke can is clearly visible.

Department of Defense to migrate infrared technology to the materials that Sanjay Krishna is pioneering," comments Ed Smith, senior principal engineer at Raytheon Vision Systems. Smith, who has worked with Krishna for five years, adds that Krishna's group is unique compared to other researchers who generally focus on one facet of the research. "Krishna's group has a well-rounded skill set and a closed loop of development—they can design devices, grow the materials, fabricate the devices, and test and characterize them."

Krishna isn't just waiting for industry to step in, he's also busy transferring the technology he is researching into his own company, which he's running with his wife. (See sidebar on page 8.)

Expanding Outreach

At the other end of the spectrum, Krishna dedicates his time to outreach efforts, connecting with students from elementary school to undergraduates in order to build their interest in engineering. "One of the biggest challenges the U.S. faces is the lack of next generation

When you work in industry you don't have a choice of who you work with. Students can be very smart but the question is: "Can you work in a team and collaborate?"

SANJAY KRISHNA

technology workforce," explains Krishna. "Our outreach is designed to bring the excitement back into science."

He advises several student organizations at UNM, judges science fairs, mentors students, and encourages his students to do the same, saying, "The best way to learn is to teach." In 2005 Krishna extended his outreach efforts by starting Expand Your Engineering Skills (EYES), designed to increase the quality of students enrolling in Electrical and Computer Engineering graduate programs. EYES brings high-caliber international students to the ECE for a summer research program guided by a faculty advisor.

Engage — Then Educate

Krishna is known at UNM for his engaging teaching style and dedication that extends well beyond the lecture hall. "Teaching is not restricted to the time you spend in the classroom," he says. "It's about hallway conversations, one-on-one meetings, and mentoring students."

After considering his own educational experience and attending teaching seminars, Krishna created a student-centered, active learning approach, which combines short lectures, plenty of interaction, and actively gathering student feedback. He emphasizes group problem solving and semester-long group projects for undergraduates. He assigns students to groups, mixing their personalities, strengths, and weaknesses. "This simulates the industry environment," he says. "When you work in industry you don't have a choice of who you work with. Students can be very smart but the question is: 'Can you work in a team and collaborate?'"

His enthusiasm for teaching and unique approach garnered Krishna several recent teaching awards, including the 2010 UNM Teacher of the Year Award and the 2009 Regents' Lecturer Award. "It was a most rewarding experience to be the teacher of the year," he says. Chaouki Abdallah, chair of the department of electrical and computer engineering, nominated Krishna for the award. Abdallah sums up the spectrum of Krishna's work at UNM saying, "Professor Krishna, while an excellent researcher, has also proven that he cares about undergraduate education and about mentoring graduate students," explains Abdallah. "He continues to maintain an interest and involvement in teaching without sacrificing his research. He demonstrates the synergy of interdisciplinary research, teaching, outreach, and entrepreneurship. His career is a shining example for junior professors." ✦

Taking a clear picture of skin cancer

One in five Americans will develop skin cancer during the course of a lifetime. Current diagnosis procedures are both subjective and, in the case of biopsies, invasive.

A faster, more accurate skin cancer diagnosis tool would save time and save lives. Sanjay Krishna and his wife, Sanchita, who holds a Ph.D. in cancer biology from UNM, are combining their expertise to achieve that goal.

In early 2010 they registered a new company, SK Infrared LLC (SKI), which will harness advances in nanoscale infrared imaging technology from Sanjay's research group to create a noninvasive technique for skin cancer diagnosis. They plan to use nanoscale infrared sensors as the foundation for a low-cost, portable camera that could scan a person's skin, sense a change in temperature given off by cancerous lesions, and provide conclusive evidence that the patient has skin cancer without the need for biopsy.

They are working closely with researchers from the School of Medicine, including Marianne Berwick, professor in UNM's Department of Epidemiology, a world renowned expert in melanoma, and Steve Padilla, Chairman of UNM's Department of Dermatology, to undertake a pilot study on a small set of patients. The Krishnas have signed an option agreement to license technology they create from STC.UNM and have applied for funding from NSF and NIH to build a prototype camera.

Five for Dr. Jerry Hall

Jerry Hall, professor of civil engineering, has taught hundreds of SOE students about transportation engineering, highway design, traffic safety, and other engineering topics over the last 33 years. And as the department's senior advisor for the past 20 years, he's also helped oversee the path to graduation for all of the department's undergraduate students.

Besides his teaching and advisory talents, Hall's most important contribution to the SOE was his idea for creating a comprehensive, hands-on class for seniors that reflects the interdisciplinary nature of civil and construction engineering. In 1993, Hall spearheaded the development of the Capstone Design Course, where teams of seniors work with practicing professional engineers on real-world projects such as bridges, water treatment plants, and even New Mexico's Spaceport.

Seventeen years later, more than 30 engineering firms and agencies have participated, and the Capstone Course is a highlight for students and professors alike. "It's really opened students' eyes to the fact that they have to work as a team because that's the way they'll have to work in the real world," explains Hall.

The Fall 2009 Capstone Course garnered a prestigious award from the National Council of Engineering Examiners for "engaging students in collaborative projects with professional licensed engineers."

1. What's a research highlight for you?

I worked with the Insurance Institute for Highway Safety to study accidents in New Mexico where single vehicles overturned. I sent teams of students to take engineering measurements at the sites of 150 fatal overturning crashes throughout the state. We documented that these crashes occurred more frequently on roadway sections with adverse alignment conditions on the approach to the crash site.

2. You teach an ethics class for engineering students. Why is that so important?

The engineering code of ethics requires all engineers to hold paramount the safety, health, and welfare of the public. However, the importance of ethical behavior and the consequences of unethical behavior are rarely addressed in standard engineering courses.

3. What's brought you the most satisfaction in your career?

Seeing our students graduate... shaking their hands as they cross the stage and seeing their family's celebration reinforces my efforts.

4. What is the greatest feat of modern civil engineering?

I think it's our nation's system of Interstate and Defense highways. It's facilitated dramatic economic growth in the United States over the past 50 years.

5. What's our society's most important civil engineering challenge?

To me it's the deterioration of our country's infrastructure. Roads and water lines are wearing out, nearly a quarter of all the country's bridges are functionally or structurally deficient, and we don't currently have the resources to address these problems.

Editor's Note: *In "Five for..." a new article format, we ask professors to answer five key questions about their careers and experiences at the SOE.*

Interdisciplinary research opens up new avenues of study that have yet to be explored.

ZAYD LESEMAN

Pushing the Boundaries of Nano Innovation

Leseman blends mechanical engineering and chemistry to create nanomaterials

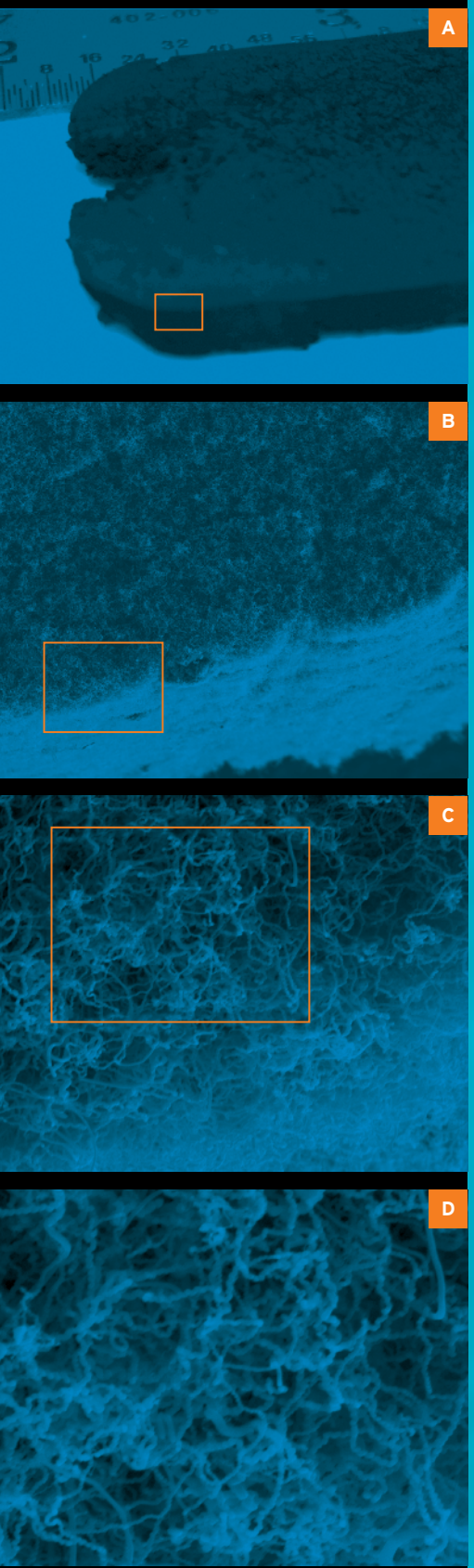
A "pinch" of material. A "dash" of powder. "Stir" in together. Pour into a "mold." When Zayd Leseman, assistant professor of mechanical engineering, talks about his research, he borrows many terms from the culinary arts. What he's really doing is mixing mechanical engineering, chemistry, and industrial manufacturing processes to cook up the amazing materials of the future.

An interdisciplinary collaboration with Jonathan Phillips, a UNM/Los Alamos National Laboratory research professor of chemical and nuclear engineering, sparked Leseman's focus on creating nanocarbon materials. "They have unique mechanical, thermal, and electrical properties so they're very interesting," says Leseman.

Fiber Foams

With funding from NASA, Leseman is researching carbon nanofibers, which have varying diameters, lengths, and surface textures, as well as important thermal, electrical, and mechanical properties that are appealing to the space agency. The challenge has been how to rapidly grow a large volume of carbon nanofibers.

Leseman and Phillips are resolving that problem by using complimentary chemistry and a simple industrial process. By literally mixing specific catalysts together and then flowing a mixture of gases over them,



Fibrous carbon foam at increasing magnification. Boxes indicate section in next image (A) 1X (B) 1,000X (C) 10,000X (D) 20,000X

they've been able to grow nanofibers at a rate more than 140 times faster than previously possible. "We're speeding growth rates up to levels no one has seen before," says Leseman. By accelerating fiber growth rates, the UNM team is making mass production of carbon nanofibers possible and more commercially viable.

Nanofibers are the basis for the team's newest invention: carbon nanofoam. By combining a pinch of catalyst and putting the mixture into a furnace for an hour while flowing a mixture of gases, Leseman, Phillips, and graduate student Mark Atwater have created a block of tangled carbon nanofibers that is extremely strong—but is more than 95% air. When dropped, the carbon nanofoam gently floats to the ground. The next step for the group of researchers is to convert the nanofoams into composite materials that are even stronger than the nanofoam itself.

Experimenting with Nano Origami

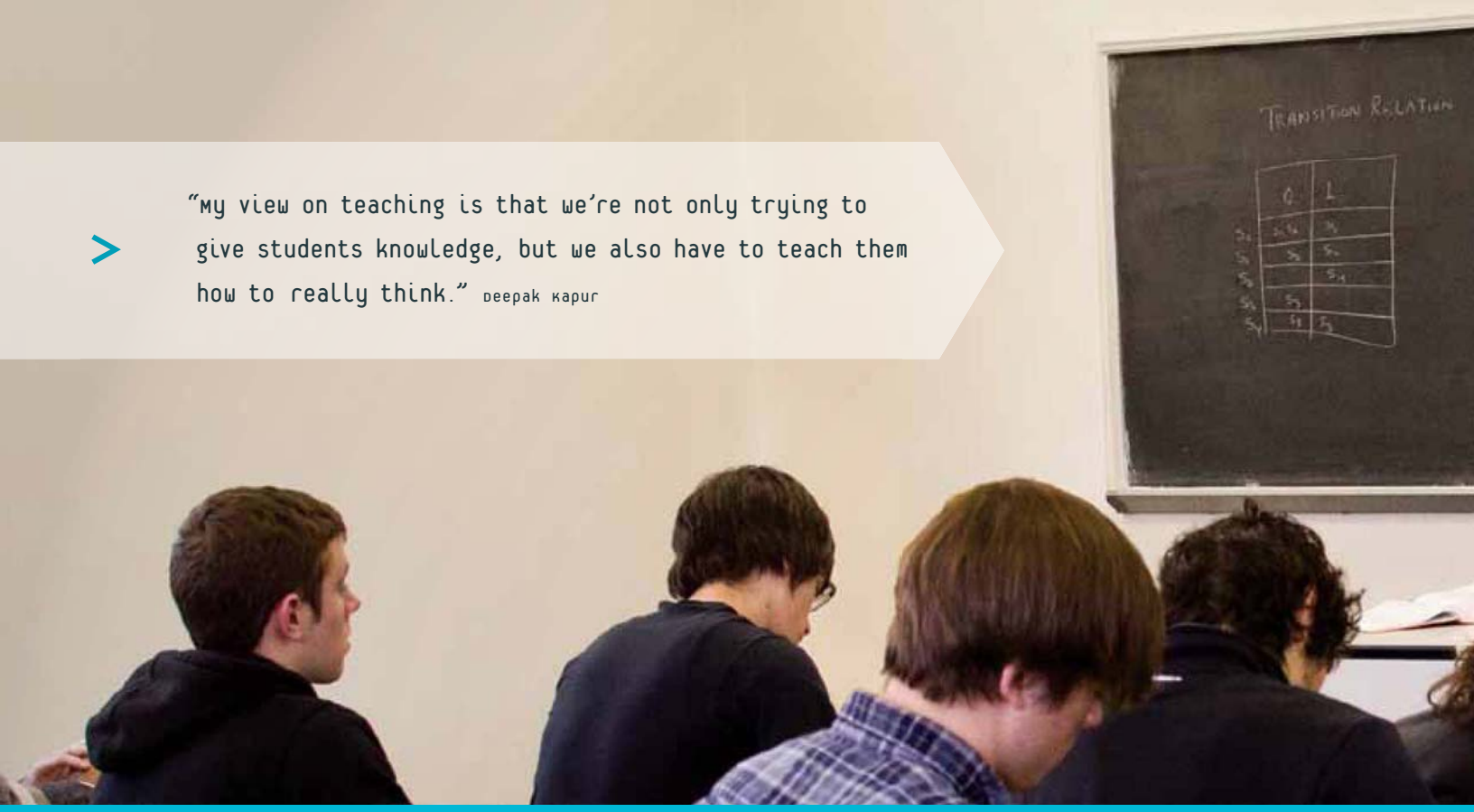
With help from Ron Salesky, a doctoral student in the Nanoscience and Microsystems Program, Leseman is developing a new method for assembling carbon nanotubes (CNTs) into three-dimensional shapes; a process that results in what he calls "nano origami." Generally, when researchers grow CNTs, they can't control the chirality or position of the carbon nanotubes. Their positioning drastically affects the density of CNTs, and the chirality determines whether they're semi-metals or semi-conductors.

So Leseman and Salesky developed a novel self-assembly method that uses nanosurface chemistry to determine CNT chirality. By coating CNTs with a protein and mixing them in a solution of DNA strands with known sequences, they are able to select CNTs of known chiralities. Thus by using the DNA strands, Leseman and Salesky are capable of selectively picking the semimetal and semiconducting CNTs. The researchers filter out the CNTs they don't want, leaving behind a volume of tubes with specific properties that can be arranged and attached into nano 2-D and 3-D structures, thus the term "nano origami."

Leseman notes that by achieving such density, they're upholding Moore's Law. "Right now you can only pack so many transistors into a certain area. We can place these nanoelectronics just a nanometer apart so the density goes up drastically," he says.

They plan to pack and stack CNTs tightly on to surfaces to create nano electronic circuits. Currently, the researchers are addressing the issue of bonding at the junctions between the CNTs in order to realize fully functional nanoelectronics created using these techniques. Beyond the size and power advantages, nanoelectronics made with CNTs have excellent thermal properties which help keep machines cool and improve performance speeds.

Whether it's tubes, fibers, or foams, Leseman is combining disciplines to accelerate the development of nanomaterials while creating new types of materials. "Interdisciplinary research opens up new avenues of study that have yet to be explored," says Leseman. "The people you work with have one set of knowledge and you have another set. When you combine the two, you end up with a new understanding or new way of making things."



> "My view on teaching is that we're not only trying to give students knowledge, but we also have to teach them how to really think." DEEPAK KAPUR

MASTERING THE AUTOMATED REASONING

When you send a document to your printer, you expect it will print your file, then stop. Accountants trust that the arithmetic operations behind the formulas on their spreadsheets are exact. And when radiologists treat patients, they rely on medical equipment to deliver precise doses of radiation. In each case the accuracy of the hardware and software depends on the correct implementation of the algorithms within them.

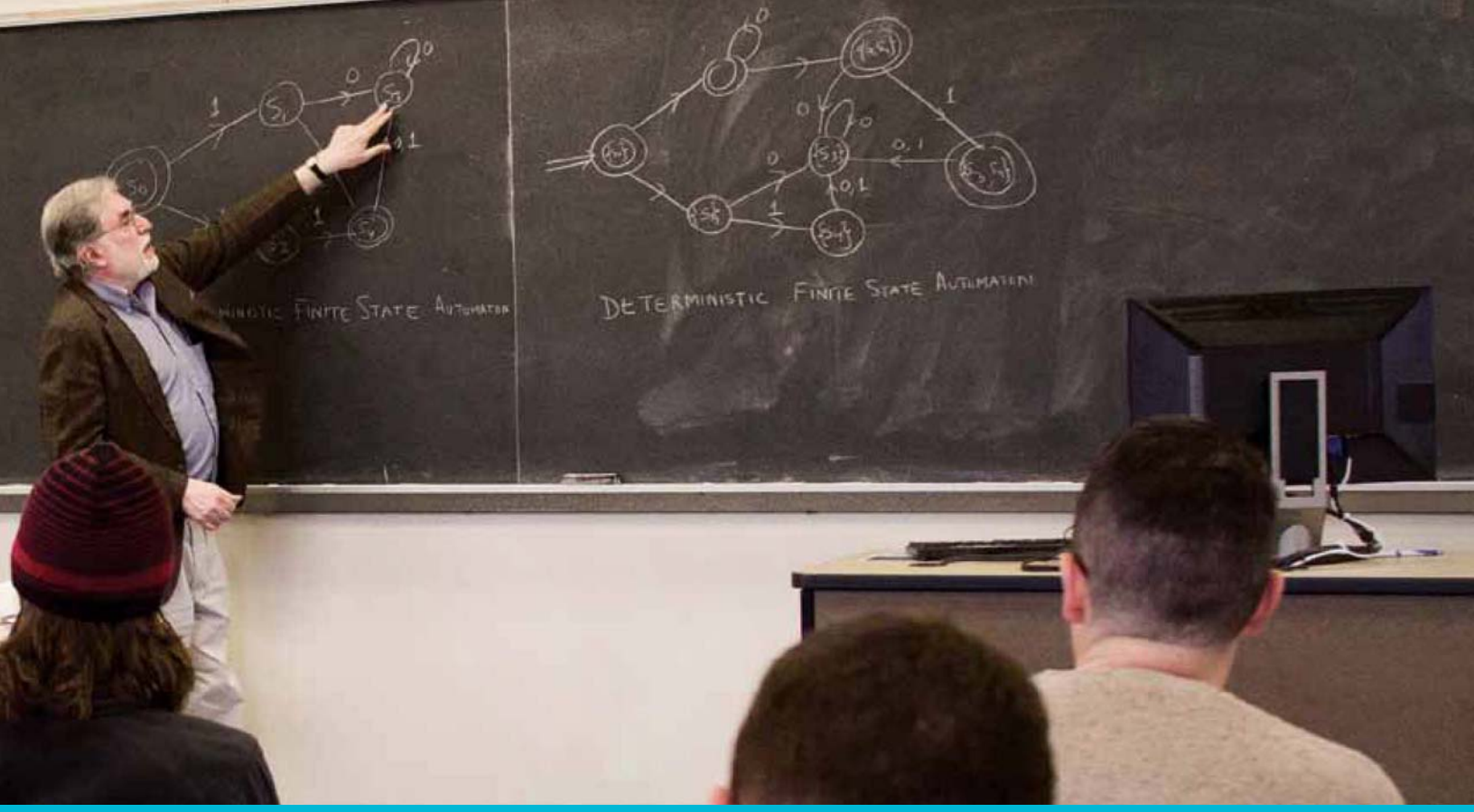
But who checks to be sure that the associated algorithms and their implementations are correct?

Deepak Kapur, distinguished professor of computer science, does. In his research on automated reasoning, formal methods, and program analysis, Kapur builds computer programs to analyze the behavior of other computer programs that run the high-tech products we use daily to ensure that they work according to specifications. For instance, Kapur showed that the floating-point divide (FDIV) bug found in Intel's 1994 Pentium chip could have been avoided using automated reasoning methods.

His research, conducted with graduate students and collaborators around the world, includes creating and analyzing algorithms and then implementing them to ensure their efficacy. He has developed software tools that can be applied to engineering challenges ranging from scene analysis based on geometric reasoning to robotics, hardware verification, and software analysis.

The findings are relevant to many companies, including Microsoft, Intel, and NASA, which have published papers referencing Kapur's work and research results. "This process is beneficial in producing products that can be relied upon, especially in life-critical applications," he says.

Perhaps Kapur's most important contribution to the realm of automated reasoning is linking algebraic and logical reasoning. Sir Tony Hoare, a winner of the Turing Award (the Nobel Prize of computer science) coined the term "invariants associated with programs." But until recently, there was hardly any connection to the concept of invariants in algebra. In collaboration with his former student Enric Rodriguez-Carbonell, Kapur proved that program invariants that can be expressed in algebraic form are indeed invariants mathematicians had been studying for a long time. Using these insights, Kapur created a method that integrates both types of reasoning for automatically generating invariants



THAT MAKES TECHNOLOGY WORK >>

needed to ensure that programs run correctly. "These results have been the most satisfying for me because, for a long time, the research community had the impression that these two different areas were not at all related," comments Kapur.

In recognition of that important finding as well as other contributions to numerous areas of automated reasoning, in 2009 he received the prestigious Herbrand Award *(pictured at left)* given by the International Conference on Automated Deduction (CADE) to honor an individual who has made distinguished contributions to the field of automated reasoning. The award citation for Kapur recognized "his seminal contributions to several areas of automated deduction including inductive theorem proving, geometry theorem proving, term rewriting, unification theory, integration and combination of decision procedures, lemma and loop invariant generation, as well as his work in computer algebra, which helped to bridge the gap between the two areas."

Kapur is as committed to teaching as he is to research and often discusses his research with his classes. He conducts undergraduate and graduate courses using a Socratic method designed to engage and challenge students. "My view on teaching is that we're not only trying to give students knowledge, but we also have to teach them how to really think." In addition to teaching technical courses, Kapur introduced a new course in 1999 on Social and Ethical Issues in Computing, which he taught for many years. With Roli Varma, a professor in UNM's School of Public Administration, he has been researching reasons behind low enrollments of underrepresented groups in computer science in the US and contrasting them with high enrollments of women, especially, in India and China and other emerging countries.

And while Kapur teaches the next generation of computer scientists to follow in his footsteps, it's his own thinking, reasoning, and research that helps keep the software and hardware we use every day working the way it should. ✦


Olga Lavrova


Svetlana Poroseva


Lydia Tapia

New Faculty

Olga Lavrova, lecturer III in Electrical and Computer Engineering, has been affiliated with UNM as visiting faculty since 2007. Her research interests include photovoltaics and nano-scale semiconductor structures for photovoltaic applications, as well as Smart Grid and emerging energy generation, distribution and storage technologies. She also heads the UNM solar car project.

Svetlana Poroseva, assistant professor in Mechanical Engineering, joined the department last summer. She holds a Ph.D. in fluid and plasma mechanics from the Novosibirsk State University, Russia. Her research areas in computational fluid dynamics, wind energy, network resilience to massive damage, and uncertainty analysis are expanding the department's strengths in renewable energy.

Lydia Tapia, assistant professor in computer science, joined UNM in the Spring 2011 semester. She received a Ph.D. in computer science from Texas A&M in 2009 and most recently was an NSF Computing Innovations Post-doctoral Fellow at the University of Texas, Austin. Tapia's research studies intelligent motion planning with application to robots and molecules.

Khraishi Named ASME Fellow

UNM Professor of Mechanical Engineering **Tariq Khraishi** has been named a Fellow by the American Society of Mechanical Engineers. Khraishi is an internationally recognized researcher in the study of dislocation dynamics/theory and mandibular fractures/fixation. His work has resulted in more than 100 referred papers, numerous patents, book chapters, and books.


Tariq Khraishi

Staff Recognition Award

The UNM Office of the President and the Staff Council recently honored **Candyce Torres,** an administrative assistant in the Department of Civil Engineering, and two other UNM staff with the 2010 Gerald W. May Staff Recognition Award. Awardees are chosen for contributions including exceptional service to the UNM community, initiative, innovative performance of job duties, and exemplary commitment as UNM staff.

Summer Science Camp Brings Middle School Students to Campus

Fifty middle school students from Arizona and New Mexico came to UNM for two weeks last summer to learn about science, math, leadership, and citizenship in a university setting. The American Indian Science and Engineering Society (AISES) and UNM hosted the ExxonMobil Bernard Harris Summer Science Camp, a free residential program that targets American Indian students and promotes the idea that it's cool to be smart. This year's theme was "Traditional Knowledge, Modern Challenges." The program included hands-on activities in robotics, bridge building, and solar energy; experiments, individual, and team projects; weekly field excursions, and guest speakers. "This program identifies and rewards highly motivated students who may not have this type of opportunity in their communities," said Steve Peralta, Director of Engineering Student Services. "It is designed to excite them to pursue a degree in the STEM field and see how they can already start making a difference in society."

Symposium Celebrates Contributions to Research and Teaching

Over 100 people attended a symposium celebrating **David G. Whitten**, a research professor who has been a thesis advisor and mentor to more than 38 Ph.D. students and co-author of scientific papers with more than 275 colleagues. Whitten is a research professor in the Department of Chemical and Nuclear Engineering and the interim director of the Center for Biomedical Research. He is internationally recognized as a leading scientific researcher in the field of photochemistry and is the longtime editor of "Langmuir," the leading professional journal in interphase materials research. Symposium organizer and colleague Scott Sibbett says, "There are only a few professors in the world today who are as productive, influential, and well-loved as David."

$3.2 Million Grant Received to Design Secure Software Systems

Chair and Professor of Computer Science **Stephanie Forrest** received a $3.2 million grant from DARPA, the Defense Advanced Research Projects Agency, to lead a team to develop resilient, automated computer security systems. The team, comprised of computer scientists from the University of Virginia and UNM, is using computational analogs of biological evolution to develop software that automatically repairs itself. "We were asked to develop a clean slate design for computer systems that can resist cyber-attack and repair themselves after attacks have succeeded," says Forrest. "This is an exciting opportunity to try a new approach to a pernicious and important problem."

Stephanie Forrest

CAREER Awards

Two assistant professors in Electrical and Computer Engineering recently received CAREER awards. **Jamesina Simpson's** research aims to enhance, on a global scale, our understanding of the electrodynamics associated with space weather, particularly relating to the effects of coronal mass ejections on the operation of power grids. **Mani Hossein-Zadeh's** research aims to explore the radio frequency signal-processing potentials of optomechanically coupled resonators and developing signal processors and sensors using radiation-pressure-driven optomechanical oscillation.

Jamesina Simpson

Mani Hossein-Zadeh

In Memoriam

Electrical and Computer Engineering Distinguished Research Professor Carl Baum (1940–2010) joined UNM in August 2005 after retiring from the Air Force Research Laboratory at Kirtland AFB. In a career that spanned five decades, this remarkably creative engineer introduced innumerable new concepts in mathematics, electromagnetic theory, and system design that have left a lasting legacy.

Electrical and Computer Engineering Emeritus Professor Peter Dorato (1933–2010) joined the ECE Department in 1976 as its chair, a position he held through 1984. Dorato remained committed to students and involved in the Department, even after his 2005 retirement. He was internationally known for his research in systems and control and innovative ideas for teaching.

Electrical and Computer Engineering Professor Bob McNeil (1945–2011) taught at UNM for 20 years, where his passions included research and mentoring students. An entrepreneur and consultant with expertise in developing measurement equipment for the semiconductor industry, McNeil worked at Micron Technologies in Longmont, CO for the last seven years.

Today's Research, Tomorrow's Diagnosis

Margaret Bell, a 1973 University College alumna, has a personal interest in Parkinson's disease, a disorder of the central nervous system that often impairs the sufferer's motor skills, speech, and other functions. As Bell was beginning to make philanthropic plans for her estate, she wanted to consider programs that would have a personal effect as well as a far-reaching impact.

Margaret Bell

Bell was introduced to Eva Chi, assistant professor in the Department of Chemical and Nuclear Engineering and member of the School of Engineering's Center for Biomedical Engineering team (CBME). Chi's lab is investigating the formation of the plaques and tangles found in the brains of Alzheimer's and Parkinson's disease patients. Results from her research will help advance the detection, diagnosis, and treatment of such diseases. Bell liked what she heard about Chi's work and found a match for her personal passion, resulting in a significant estate gift to support CBME research on neurodegenerative diseases.

Bell, who had a 30+ year career in federal government marketing, contracting, and management, is currently an associate broker with Signature Southwest Properties. Bell says, "I believe that an endowment created through planned or estate gifting is a true statement of a donor's confidence that an institution is and will continue to conduct cutting-edge research long into the future."

From Grieving to Giving

Ronnie and Elaine S. Plotkin's son Raymond, a healthy 18-year old UNM freshman nuclear engineering student from Houston, Texas, contracted the H1N1 flu virus and died in November of 2009. The family honored their son's memory and his love of UNM with a generous initial gift that established the Raymond E. Plotkin Scholarship. "It's a way to keep Raymond's memory alive and to help other students who have the same drive and optimism about the future that he did," his mother Elaine said. The family included friends and others to contribute and raised enough money to create an endowed scholarship to provide future engineering students with assistance in reaching their scholastic potential. The first scholarship was awarded this fall to Sean Chavez, a computer engineering major from Albuquerque. The Plotkin family continues to promote gifts to the scholarship fund so that even larger awards can be given in future years.

Raymond Plotkin

Second Life for Valuable Equipment

William "Tim" Turner, '82 BSEE, '92 MEMBA, and co-founder of WaveFront Sciences (now part of Abbott Medical Optics), has worked on countless high tech computer-controlled instrumentation projects for Sandia National Labs and the International Space Station. He knows well the cost of highly specialized equipment. Recently, Turner generously donated a WaveFront tool that allows for the precise measurement of the "flatness" of a semiconductor wafer. This is especially useful for the infrared focal plane arrays that are being developed at the UNM Center for High Technology Materials.

According to Turner, "While this product was no longer being pursued commercially due to business direction changes, we still felt that the prototype was an exquisite instrument that could provide a great deal of value to the right user. One of Abbott's core values is giving back to our community, so as a UNM alumnus, I was very excited to learn that the UNM CHTM could use this instrument to support the advancement of their research."

Steven Brueck, CHTM Director and Sanjay Krishna, CHTM Associate Director, are grateful that Turner and AMO WaveFront selected CHTM to give back to the community. As they explain, "Very expensive, unique equipment is critical to the success of many of the research projects at the Center for High Technology Materials. In-kind donations of specialized equipment from industries like AMO WaveFront and from New Mexico's national labs fill a critical void that allows us to leverage contract dollars and increase productivity."

CS PhD student Nicholas Pattengale (left) receives the Computational Thesis Award from QForma Chairman Roger Jones in May, 2010.

Ensuring Excellence in Computing

QForma, a Santa Fe-based provider of advanced analytics and predictive modeling technologies for the health sciences industry, has funded two new awards in the UNM Computer Science Department. The QForma Junior Faculty Award is a $5,000 annual salary stipend for a non-tenured faculty member who shows extraordinary promise and the ability to develop a successful research program in computer science. The $5,000 QForma Computational Thesis or Dissertation Award is given to the best computational MS thesis or Ph.D. dissertation each academic year. The company has committed to funding the awards for a minimum of three years. "We believe it is in the best interest of northern New Mexico technology companies and the New Mexico economy, in general, to support key educational institutions," QForma's Chairman Dr. Roger D. Jones states. "This will help provide quality employment opportunities for New Mexicans and quality employees for the New Mexico technology economy."

Setting Goals, Giving Back

Jake M. Hollowell

Jake M. Hollowell, a 2008 UNM electrical engineering graduate employed by Lockheed Martin, was very excited when he made his first gift to the UNM School of Engineering: he beat his initial goal of donating $500 by six months. Hollowell's next goal is to donate as much scholarship money as was provided to him during his four years at UNM. Hollowell says he has learned about the importance of setting goals and giving back by listening to motivational tapes during his 2–3 hour commute. "I now have written goals that I review every day and one of them is to give 10% to charity," he says. "It is about having an abundance mentality. When I give to charity, it makes me realize that I have more than enough for myself." As an undergraduate, Hollowell was a research assistant in the Plasma and Fusion Science Lab in the Electrical and Computer Engineering Department and was mentored by Professor Mark Gilmore.

Making Discoveries, Realizing Dreams

Alumni, supporters, and friends play a vital role in the innovative research and student success at the School of Engineering. For ways to help SOE faculty and students, please contact the SOE development office at 505.277.0230.

Keep us Posted!

Have you been promoted, taken a new job, or received an award honoring your achievements? Please let us know. Send your update to UNM Engineering, MSC01-1140, 1 University of New Mexico, Albuquerque, NM 87131 or email soedev@unm.edu. You'll find more information about School of Engineering alumni, donors and friends on soe.unm.edu.

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