CU Engineering Alumni FOCUS
Fall 2004
University of Colorado at Boulder • College of Engineering and Applied Science

CU's Particle-ALD Technology Wins 'Oscar Of Invention'

It isn't a household name just yet, but wait a little while. Particle-ALD™, a technology invented at the University of Colorado that controls the surface chemistry of particles at the nano scale, has been ranked among the world's greatest inventions—up there with the flashcube, the fax machine, and HDTV.

Invented by researchers in CU-Boulder's Department of Chemical and Biological Engineering and developed by the spin-off company ALD NanoSolutions, Particle-ALD was selected by *R&D* Magazine this fall as one of the 100 most technologically significant products introduced into the world marketplace over the past year. The R&D 100 awards have been called "The Oscars of Invention" by the *Chicago Tribune*.

CU professors Steven George and Alan Weimer say the value proposition of Particle-ALD is based on the effect of the surface area in determining particle properties. For example, a simple metal iron particle with a diameter of 1 micron contains roughly 40 billion atoms. The outer surface of that particle exposes roughly 60 million atoms, which represents only 0.15 percent of the entire number of available atoms.

But if the diameter of that particle is reduced to 10 nanometers—a factor of 100—then 15 percent of the atoms of the particle are at the surface. For any given weight of metal particles, the difference in reactivity between particles that are 1 micron and 10 nanometers in diameter becomes enormous because of the important effect of the surface area. This difference leads to a completely different set of interactions, reactions, and properties from the exact same material.

Particle-ALD, which is based on atomic layer deposition coating chemistry and processing methods developed by George and Weimer, allows conformal, pinhole-free, nano-thick films to be chemically bonded to individual primary substrate particle surfaces, providing for the control of ultra-fine particle chemical, electrical, optical, magnetic, oxidation resistance, and other surface properties.

By placing a nano-thick protective film such as alumina or silica onto the surface of primary nano-sized cobalt and iron particles, it is possible to maintain the strong magnetic moments of these particles, which would otherwise be lost during surface oxidation. Such novel materials would have significant application in medical diagnostics, defense, and drug delivery industries, among others.

Oxidation-resistant, ultra-high thermally conductive, nano-sized copper or aluminum substrate particles that are electrically insulated can be fabricated in a similar manner and used as thermal fillers to improve heat removal for plastic-based microelectronics applications.

As the surface chemistry is developed, new conducting and catalytic particles can be made by placing nano-thick films of silver, gold, or platinum metals onto the surface of inexpensive nano-sized oxide particles in order to achieve the ultrahigh surface area effect of nano-metals without producing the expensive nano-metal in bulk. Such a development would provide for the widespread utilization of cost-effective hydrogen fuel cell technology today.

Viewing the technology from a commercialization perspective, Mike Masterson, chief executive officer of ALD NanoSolutions, says the challenge isn't about manufacturing smaller particles. The gateway to the future is through the ability to innovate at the surface level where particles interact with the surrounding environment. Particle-ALD as an enabling technology is the gate, potentially providing for the control of ultra-fine particle chemical, electrical, optical, magnetic, physical, and other surface properties.

For more information, visit www.aldnanosolutions.com.

Professors Alan Weimer, left, and Steven George, right, received the R&D 100 award for their invention of Particle-ALD, a technology that controls the surface chemistry of particies at the nano scale.

R&D 100 Awards

Dubbed "The Oscars of Invention" by the *Chicago Tribune*, the R&D 100 awards have recognized such winning products as:

- Polacolor film, 1963
- Flashcube, 1965
- Automated teller machine, 1973
- Halogen lamp, 1974
- Fax machine, 1975
- Liquid crystal display, 1980
- Printer, 1986
- Kodak Photo CD, 1991
- Nicoderm antismoking patch, 1992
- Taxol anticancer drug, 1993
- Lab on a chip, 1996
- HDTV, 1998

Inside

College Opens New Testing Facility for Earthquake Engineering Research

Professor Benson Shing works with a student to fine-tune the new FHT system in the Structures and Materials Laboratory.

Everyday, an earthquake is recorded in some part of the world. Most of them are minor and go unnoticed, but a single strong earthquake can devastate an entire city in a matter of minutes, leaving scores dead or injured, mostly under buildings that have collapsed.

For decades, engineers have been studying ways to make buildings safer and more earthquake-resistant. Now, through a massive effort by the National Science Foundation to improve the seismic design and performance of our nation's civil and mechanical infrastructure, the equipment available for earthquake engineering research has taken a major step forward.

A unique Fast Hybrid Test system, which combines real-time physical testing with online model-based simulation to more accurately evaluate the effect of a severe earthquake on structural components and systems, opened Nov. 15 in CU-Boulder's Department of Civil, Environmental and Architectural Engineering.

The $2 million system developed by Professor Benson Shing can deliver a rate of earthquake loading that is significantly higher than in conventional pseudodynamic tests, and approaches the real-time response of a structure under earthquake loads.

The system, which includes three high-speed hydraulic actuators that can apply up to 100 tons of force, both vertically and horizontally on a structure, allows researchers to test the most critical structural subassemblage, where severe inelastic deformation or damage is expected to develop, and model the rest of the structure in a computer.

The FHT system is linked to earthquake engineering facilities at 14 other universities as part of the $81.9 million George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES). A high-performance information network called the NEES Grid makes the system accessible to researchers all around the world.

For more information, visit http://nees.colorado.edu

Professor Combines Engineering and Law to Promote Good Environmental Policy

CU engineering students typically call her Professor, but they might just as well start addressing her as "Counselor."

Jana Milford, an associate professor of mechanical engineering who has taught in the college since 1994, donned a backpack three years ago and returned to life as a student in the CU School of Law. She subsequently survived the "Paper Chase" and what she says is a very different way of approaching exams to graduate and pass the Colorado Bar in 2004.

Now she is back in the Mechanical Engineering Department teaching the core thermodynamics class to junior-level engineering students, while also working half-time as a senior scientist at Environmental Defense, a non-profit, non-governmental organization with some 300,000 members nationwide.

Her new second job allows Milford to combine her expertise in science, engineering, public policy, and law to analyze and promote good environmental policy based on solid scientific data. For Milford, that has been a long-term goal.

In the 1980s, after earning her doctorate in engineering and public policy at Carnegie Mellon University, she worked at the U.S. Congressional Office on Technology Assessment, performing long-term studies on air pollution and climate change. Unfortunately, Milford says, that office was later disbanded.

"The point was to give Congress some objective, technical information on which they could base policies. Now, it's lobbyists on one side or the other that give them all of their technical information," she says.

With 20 years experience in the study of air pollution, Milford says "the first step is to acknowledge and recognize the science."

Since joining Environmental Defense last summer, Milford has been working with Rocky Mountain National Park officials and their partners to document the sources and effects of air pollution on the park and develop appropriate responses. The work, Milford says, is particularly rewarding because "there's a possibility of seeing something happen in response to the research."

Milford, who directed the college's Environmental Engineering Program from 1998 to 2001, also looks forward to incorporating her knowledge of environmental law and policy into courses at CU: "I think students have a real interest in this too," she says.

CU wins Major Grant for Cognitive Technologies Research

Individuals with cognitive disabilities have long been marginalized by society's unwillingness to include them within their local communities, educational systems, and workplaces—in short, into the very fabric of society.

While technology undoubtedly can play a vital role in decreasing this marginalization, there have been very few attempts to date to produce a coherent and sustained approach to identifying and lessening barriers for people with significant cognitive disabilities through the use of technology.

CU Professors Cathy Bodine of the Health Sciences Center and Michael Lightner of the CU-Boulder Electrical and Computer Engineering Department received a major grant this fall to address this issue, and will co-direct a new Rehabilitation Engineering Research Center on Cognitive Technologies, the first such center established in the country.

The center is funded by a five-year, $4.25 million grant from the U.S. Department of Education and the National Institute on Disability and Rehabilitation Research, with $1.34 million in matching funds provided by the Coleman Institute for Cognitive Disabilities and Imagine!, a Colorado non-profit providing support to people with cognitive, developmental, and physical disabilities.

The goal of the new research center is to research, develop, evaluate, implement, and disseminate innovative technologies and approaches that will have a positive impact on the way in which individuals with significant cognitive disabilities function within their communities and workplaces.

The center will focus on a dozen research and technology development projects to assist people with cognitive impairments, including Alzheimer's, mental retardation, and traumatic brain injury. CU will be the lead institution, but several other universities also will be involved in projects.

One example is a project to provide wireless power to miniature sensors, which could be used for a variety of tasks in community living environments or group homes. Wireless power would eliminate the large maintenance factor faced by staff in making sure that battery units are working. CU electrical and computer engineering professors Zoya Popovic and Regan Zane are investigating how to "scavenge" ambient forms of energy and deliver it efficiently to low-power sensor electronics.

Several projects in CU's Computer Science Department also are funded by the grant, including development of technologies for people residing in group homes, perceptive animated interfaces for workforce training, and research on technologies for remote family support of people with cognitive disabilities.

CU Team Finds Security Flaws in Popular Internet Chess Site

In sports, there's a saying that the best offense is a good defense. The same is true for computer security, according to CU-Boulder assistant professor John Black.

Black, along with graduate student Martin Cochran and undergraduate student Ryan Gardner, tested the security of the popular Web-based Internet Chess Club and showed that the site wasn't secure. In fact, they proved users could cheat rather easily.

Internet Chess Club has more than 30,000 members worldwide and claims Madonna, Nicolas Cage, Will Smith, and Gary Kasparov as players.

Black says the main lesson is that even really smart people shouldn't try to create their own security systems unless they are experts.

"Unless you have a lot of experience, don't try to invent your own security system it will just be broken," says Black. "Believe me, it's better to leave that job up to the experts."

As the threat of cyberterrorism lurks and with more confidential information being shared on the Web, the significance of secure computer sites and systems continues to grow. Black's group isn't the first to find security flaws in a widely used piece of network software. Other examples include the break of the Netscape browser's random number generator in 1995 and recent flaws exposed in the Diebold electronic voting system.

Black, who in 2002 received the National Science Foundation's most prestigious award for promising junior faculty, a $324,000 CAREER award, says the only way students and professionals can create good security systems is to learn the typical methods used by hackers.

"There has been an open debate about this topic," says Black. "One side of the argument is that you are helping create the next generation of hackers by offering this type of experience. The other side, which is where I stand, says that you can't be a good defender without knowing the offense.

"I don't think the FBI is creating more terrorists by teaching its people about methods used by terrorists," he says.

To crack the security weaknesses in the Internet Chess Club, Black enlisted the help of two students and received grant support from NSF. While they did successfully "hack" the site, Black and his students suggested simple ways of fixing the security problems and don't plan to release the software they created to do the job.

"My objective was just to learn as much as I could," says Gardner, a senior majoring in computer science and mathematics. His involvement in the research was funded through the NSF Research Experience for Undergraduates program that allows students to work with professors on research projects and gain valuable experience. "I definitely understand why a good security system is important," he says.

Computer science Professor John Black, rear, worked with students Ryan Gardner, left, and Martin Cochran, right, on the project.

To view the team's paper, "How to Cheat at Chess: A Security Analysis of the Internet Chess Club," go to the Cryptology ePrint Archive at http://eprint.iacr.org/2004/203.

DEAN'S PERSPECTIVE

By Robert H. Davis

The College of Engineering and Applied Science at CU-Boulder continues to be a place of remarkable achievement. As you are reading *Alumni Focus*, you will see this achievement in the research advancements led by the faculty and in the outstanding educational opportunities provided to students.

You also will see it in your own achievements as alumni of the college. We are excited to reconnect with many of you and to share news from CU engineering alumni around the world in this newsletter.

We also are pleased to report on some of the ways that CU faculty and students are advancing knowledge in such critical areas as nanotechnology, computer security, earthquake-resistant structures, and technologies to assist people with cognitive disabilities.

College research grants increased 14 percent last year to more than $42.8 million, the highest amount ever awarded to the college. Private support of more than $10 million, along with interdisciplinary grants to faculty administered outside the college, bring our total annual research support to more than $67 million.

Such notable success leads to increased opportunities for students and benefits society as a whole. The college piloted Discovery Learning and Earn-Learn programs for students last year, involving more undergraduate students in research and service learning than ever before. Thanks to the alumni support we received for this initiative, we are well on the way to achieving our goal of involving every undergraduate in at least one significant discovery, professional, or service learning experience while they are here in the college.

Although student tuition has risen due to the decline in state revenues for higher education and the campus-wide Quality for Colorado initiative, the cost of attending CU engineering is still well below that of most of our peer institutions. While we continue to strengthen our programs to achieve the highest levels of research and educational excellence, we have dedicated a portion of these additional tuition revenues for increased financial aid.

We believe the excellent opportunities afforded by the college should be accessible to the best and brightest students regardless of background or income.

Osram Sylvania Awards Grant To Enhance Lighting Education

Osram Sylvania has lit some of the nation's most important treasures, including Niagara Falls, the Hoover Dam, the Thomas Jefferson Memorial, and Boston's Old State House. Now the company is illuminating a different kind of national resource: students in the field of lighting.

Osram Sylvania has made a long-term commitment to further the development of CU-Boulder's lighting education program — a sub-discipline of architectural engineering — by providing $50,000 per year to create more extensive and integrated coursework and to integrate lighting engineering and technology with design and architecture.

CU-Boulder offers the largest undergraduate program in lighting and illumination engineering in the country, graduating about 20 students each year for jobs in the lighting industry.

"The University of Colorado values an integrated, interdisciplinary approach to lighting education that we fully support," said Henny Peters, executive vice president of general lighting for Osram Sylvania. "We see this grant as an investment in the future of the industry and are proud to be contributing to the program."

Faculty members David DiLaura and Robert G. Davis will use the grant to develop a new capstone design course tailored to senior-level students who have completed previous lighting courses and participated in a summer internship in lighting design or manufacturing. The first capstone course will be offered in fall 2005.

Colorado
University of Colorado at Boulder

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Alumni Focus is published annually by the College of Engineering and Applied Science at the University of Colorado at Boulder.

Managing Editor: Carol Rowe, Director of Engineering Communications

Design and Production: Lynn Reed, CU Publications and Creative Services

Photography: Larry Harwood, Holly Kleinman

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Printed on recycled paper

Meteorite Crash-Lands in Berthoud, CU Studies Origins

John and Megan Whiteis, and their son Casper, walked out the backdoor of their Berthoud home one October afternoon, when suddenly

something streaked over their heads and fell with a thud in their horse pasture.

Could it have been a model rocket, they wondered? Maybe a part falling from a passing airplane? Both scenarios seemed unlikely.

After 20 minutes of searching, they found the object—a softball-sized meteorite (later weighed in at over 2 pounds) with a shiny black fusion crust, almost completely buried in the dirt.

The family's find put Berthoud, Colorado (located about 25 miles northeast of Boulder) on the map for meteorite falls, and gave the University of Colorado at Boulder a fresh specimen for planetary and geologic research. The Whiteis family donated the meteorite to the university when they learned it was only the fifth to have been seen fall and subsequently be recovered in Colorado since 1924.

Scott Palo, assistant professor of aerospace engineering sciences and an expert in radio meteors—the ionized meteor trails in the upper atmosphere —says thousands of meteors enter the upper atmosphere every day, but most are pulverized by the time they reach the Earth's surface.

The size of the Berthoud meteorite, as well as the fact that it was seen falling, makes it valuable for research. Engineers and scientists hope to trace the meteorite back to its origin, gaining a glimpse of the earliest years of the solar system and the building blocks of life.

Initial testing, including gamma ray and isotope tests, will be performed at the Pacific Northwest National Laboratory, after which a very small piece of the meteorite will be cut away for petrology and composition studies, Palo says. These tests will include looking at the sample under polarized light to determine the crystalline structure and using a mass spectrometer to determine the composition of the sample.

A team of experts assembled by Palo believes the meteorite may have broken off Vesta, a large asteroid that is geologically similar to terrestrial worlds such as Earth and Mars.

Nick Schneider, associate professor of astrophysical and planetary sciences, said the meteorite's igneous composition reveals that it was chipped off an asteroid large enough to undergo some form of volcanic activity.

The meteorite will be displayed and discussed in CU and K-12 classrooms and at Fiske Planetarium (see www.colorado.edu/fiske) while not undergoing analysis. Search parties also are returning to the vicinity of the fall in an attempt to find other meteorite fragments.

Witnessed Meteorite Falls in Colorado

Johnstown, July 6, 1924—27 fragments found, largest weighing 51.8 pounds

Denver, July 11-15, 1967—one half-pound meteorite falls through a warehouse roof

Canon City, Oct. 27, 1973—3-pound meteorite falls through a garage roof

Elbert County, Jan. 11, 1998—3 fragments found, largest weighing 1.5 pounds

Berthoud, Oct. 5, 2004—2.2-pound meteorite lands in pasture

Source: Jack Murphy, Curator Emeritus, Denver Museum of Nature and Science