SIGNALS
Department of Electrical and Computer Engineering
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Dream big, design intensely, build exceptionally: Exceed Lab Opens

CSE freshmen work to complete sleds for the holiday competition.

Early visitors to the lab included (from left) Adam Pagel, Anna Dooley, and Joe Niezner. Hosting the visit were Kyle Dukart and Susan Kubitschek.

A touch screen (left) for immediate online Web access for research and tool chests (right) filled with needed equipment for engineering projects are among the items that fulfilled student requests. Work study students help supervise the lab when project work is in session.

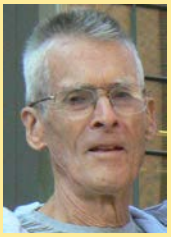
- **ECE planning E-Newsletter**
  We need your current email address in order to provide timely delivery of ECE news. (see back cover for details)

In December 2013, collaborative efforts were rewarded when the College of Science and Engineering (CSE), the Department of Electrical and Computer Engineering (ECE), and a consortium of student groups established an experiential learning lab—the Exceed Lab—to provide a space for students to start and complete engineering projects. Located in Keller Hall on the second level, the lab is designed to accommodate student teams working on extra-curricular science and engineering projects through affiliated student groups or through the industry- and alumni-supported Envision Fund. Outfitted with necessary machining tools, electrical components, work benches, a room-length dry erase board and a touch-screen display and computer, the Exceed Lab is a young engineer's dream space for innovating, designing, and building.

Barely open for a week, the Exceed Lab was the site of CSE freshmen feverishly working on their CSE 1001 Sled Competition projects for the contest on Dec. 6. Held in Mariucci Arena, the competition judged the best sled design and the sled that slid the furthest from among 28 teams. Other projects created in the Exceed Lab include a hand-held dot-matrix Tetris Game (Envision Fund); wind turbines for Nicaraguan villages (Innovative Engineers); build your own hexacopter (Envision Fund); and the equipment for the annual CSE Light Show (Tesla Works student group).

Instrumental in the planning, funding and design were student groups Innovative Engineers and Tesla Works, and Kyle Dukart, ECE Administrator and former Undergraduate Academic Advisor. Dukart located a dry-erase wall paint specifically created for large spaces and painted the fronts of all storage lockers to serve as planning surfaces. His guidance also included the placement of a large touch-screen computer for students to use when researching their ideas. Susan Kubitschek, CSE assistant dean – collegiate life, helped to procure the funds for remodeling the space. Ultimately, it was the students who drove the project, providing labor to clean out the space and the ideas that led to its current configuration. The Exceed Lab is managed by the ECE Department in collaboration with Innovative Engineers and Tesla Works.

Thank you to our Exceed Lab Start-Up Donors



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Thanks to donations from U of MN alumni Russ Penrose (EE'49) (left) and Micro Control Company CEO Harold Hamilton (MEE'72) (center), and Barr Engineering and Digikey, the Exceed Lab went from dream to reality in a short time. Remodeling began in mid-fall 2013 and the lab opened to its first rush of students for the winter projects in December 2013.

To learn more visit z.umn.edu/exceed.

COLLEGE OF Science & Engineering
UNIVERSITY OF MINNESOTA

Antarctica Research Adventure for Prof. Joseph Talghader and graduate student Wing Chan proves challenging

The Siple Dome Research site, Antarctica, where Prof. Joseph Talghader conducted optical borehole logging research to advance knowledge in glaciology.

It's an honor and an exceptional opportunity to be invited to conduct research in Antarctica. It's also a challenge for life and limb, creativity and ingenuity, as well as patience. Rapidly-changing weather can become life threatening, inhibiting travel and research plans.

The Science

ECE Prof. Joseph Talghader became involved in technology called optical borehole logging because of his interest in Antarctica and how optics might be used to advance knowledge in glaciology—more specifically how properties of optics could be used to determine the crystal properties of glacial ice. His research is funded by the National Science Foundation.

Current methods of studying ancient ice use core samples drilled out of the ice sheets in places like Antarctica. Optical borehole logging involves sending a laser instrument down the open borehole that remains after an ice core has been drilled and using that laser to determine the dust content of the ice. As the logger is lowered deeper and deeper into the ice, if it encounters a dust layer, for example one produced by a past volcano eruption, the laser will scatter off of that dust and produce a spike in the light received by the logger detector. Dust signatures in the ice can range from obvious dark layers a centimeter thick, such as might come from a huge volcanic eruption, or they can be subtle features that vary over kilometers such as the dust record from glacial and interglacial cycles. A specific set of dust layers can be compared to other dust layers seen in other parts of Antarctica to produce a characteristic chronology that tells scientists how old the ice is at each depth.

Beyond dust, studying ancient ice crystals reveals more information about geological events that have occurred over the last few hundred thousand years. However, attempting crystal structure analysis with a borehole logger will require more advanced optics than a dust logger and is a primary goal of Talghader's program. In traditional crystal studies, an ice core is pulled from the ice sheet, taken into a laboratory, sliced into sections, and placed between crossed polarizers that are illuminated by polarized light. The resulting images show irregular areas of dark and light corresponding to different crystal within the ice. From this information, scientists can draw conclusions about local temperatures and ice flow from many thousands of years. Currently, however, crystal data obtained from studying the ice cores can be unreliable. When the ice is taken out of the borehole, changes can occur in its structure, through bubble formation or recrystallization. These changes are due to the post-extraction loss of the surrounding ice sheet pressure.

To solve this problem, Talghader, and a graduate student, Wing Chan, teamed up with Dr. Ryan Bay of UC-Berkeley, who constructed some of the earliest optical borehole logging instruments. Bay's devices measure dust rather than crystal structure, but before attempting to build an instrument that had the new crystal capabilities, Talghader's group cut their teeth this field season by constructing a logger with similar capabilities to the Berkeley dust instrument but made from optical fiber to make it smaller and more lightweight.

The two researchers brought loggers built in their respective university labs; in Antarctica, they tested both and are now processing data and comparing measurements. Results so far show that where the Berkeley and Minnesota instruments overlap, there are great similarities in the data—a successful first step. Next year, Talghader and Bay will return to the Antarctica to test the Berkeley dust logger and the Minnesota crystal logger at the West Antarctic Ice Sheet (WAIS) Divide.

The Antarctic Experience

This was the scientific expedition that almost wasn't. During the recent U.S. government shut down, Talghader wondered if the trip would even happen. When the budgetary dust settled, he learned the trip was on, but the destination site had changed. WAIS Divide, the original plan's first-year test site, had become a victim of government budget cuts and was closed for a year. Talghader's team was switched to Siple Dome, a remote site that is used primarily as a fuel depot and emergency stopover point for planes flying over the continent. Its personnel this season consisted of only two people before Talghader's five-person team arrived (three researchers: Talghader, Bay, and Chan, plus two support personnel from the USAP Drilling Office, Elizabeth Morton and Josh Goetz who were going to test a new winch system at the site.)

In a trip that covered more than 15,000 miles each way, Talghader and Chan traveled from Minneapolis to Dallas to Los Angeles to Sydney, Australia to Christchurch, New Zealand to McMurdo Station, Antarctica to Siple Dome Base, Antarctica and back. The first four flights were standard commercial ones and occurred all in a row, but several days separated the commercial flights from the trips to and from the continent.

Visiting researchers are cautioned not to interact with the penguins.

On their first day (Dec. 18) in Christchurch, New Zealand, Talghader and Chan went to the Clothing Distribution Center and were issued the Extreme Cold Weather (ECW) gear that they would use and then return at the end of their research trip. They watched orientation videos about environmental concerns, how to interact with wildlife, and what conditions are like in this cold place.

Their first flight out of Christchurch towards Antarctica went straight into a 100 mile per hour head wind. After 4.5 hours, the pilot turned back. "We were flying in a Lockheed C-130 Hercules military transport plane that was fitted with landing skis rather than wheels," Talghader says. "What took 4.5 hours out, took only

2.5 hours back to Christchurch. We spent the next four days waiting for weather and mechanical issues to resolve before another flight actually took off."

Finally on Dec. 23, near midnight, they arrived at Pegasus Air Field on the Ross Ice Shelf. A giant multi-wheeled vehicle—IVAN—took them to McMurdo Station where they were handed their keys for the dorms and shown the cafeteria (open 24 hours a day.)

McMurdo Station, Antarctica

The team took a number of trainings—what to do, what not to do. "Then it was on to the main training session—officially called Snowcraft—but universally called "Happy Camper" by USAP participants," Talghader says.

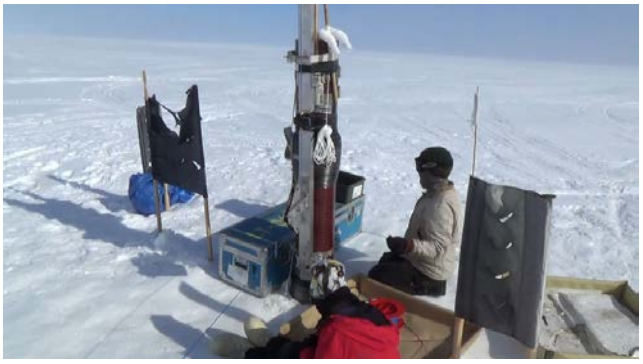
Located on the Ross Ice Shelf, Happy Camper is where Talghader and Chan learned to build snow walls, pitch tents on the ice, tie the correct knots to secure the tents, use a shortwave radio, and survive a white-out storm at an isolated base.

Transport to Siple Dome from McMurdo, was delayed by weather, mechanical issues, and other on-continent priorities, so Talghader, who had access to an office cubicle at Crary Labs, wrote and submitted a white paper he had been preparing. "Good thing I submitted it then," he says. "When we returned from Siple Dome, it was eight days later than we expected, and the paper would have been many days late!"

Finally, on Jan. 3, the team arrived at Siple Dome. Living conditions were simple. A heated "rack tent" (about 20 x 20 ft.) served as a kitchen and dining hall. Each member of the research group had his or her own one-person tent for sleeping on the ice sheet. The team subsisted on decade-plus-old food supplies that had been stored in a freezer space dug into the ice sheet. "We found we definitely could eat food many years past its expiration date without getting sick," Talghader says. "We had no fresh food, but we ate well—Thai chicken curry, lobster tails, whatever we could dream up from the ingredients and supplies that had been laid down many years before.

"Upon arrival, we unloaded our equipment and met the Siple site team, Dan and Cricket, husband and wife, who took care of the camp during the summer. They showed us the snowmobiles we'd be using and the locations of unstable ground. Then we went out to the borehole, which was about two miles from camp, and set up a tent near it for our scientific equipment. We checked out an automated weather station that was about a mile from the borehole and then went back to camp."

For the next five days, the team worked outside every day in blue-sky weather with 10-20 degrees Fahrenheit temperatures.



Testing the optical borehole loggers at Siple Dome.

Bay set up his logger in a day and a half and tested it for a day. His logger was fairly large but had been used in many boreholes before and was easy to use. Talghader's equipment, designed for the WAIS Divide borehole, had to be reworked to fit into the smaller Siple Dome borehole.

"I was glad we had a site to ourselves because we weren't in anyone's way while we retooled the logger. As we yanked off the protruding stabilizing arms to make the diameter of our logger smaller, Bay let us borrow some of his mechanical supports to ensure that our logger stayed in the center of the hole. We completed our testing the next day. Our results were very good; we went down about 250-300 meters. Bay's data and our data exhibited similar features with few differences even though the wavelengths of our lasers were very different. Light from his logger scatters many times in the ice while ours scatters once, or at most a few times, before being absorbed. Even though we had trouble adapting the logger to Siple instead of WAIS site, eventually we got everything to work well."

The team had a late lunch on the last day of testing (the sixth day) and prepared to leave the site. As the fog began to roll in, they quickly took down the logger tent and transported all the equipment back to the Siple Dome base camp. The return flight to McMurdo was supposed to arrive the next day, but storms rolled in and between weather and organizational issues, it was eight days before they could be transported out.

To pass the time, Talghader worked on a proposal, prepared meals with the team, and completed tasks around the base (shoveling out the fuel bladders and packing pallets with equipment for transport.) "It was pretty boring; we had no Internet access and our only connection to the outside world was a satellite phone. But I did find an old novel someone with a sense of humor had left behind on a shelf—H. P. Lovecraft's *At the Mountains of Madness*, which is an Antarctic horror story where an expedition discovers the ruins of an ancient non-human civilization and, of course, most of the expedition dies off before the leader finds even greater horrors buried in the ice. That book helped pass the time. We finally left Siple Dome on Jan. 17 rather than Jan. 9. Dan and Cricket told us that the weather while we were performing experiments was the best they'd had all season. The storms and fog while we were waiting to leave was much more typical. Siple has a reputation of having some of the worst weather on the continent."

The team returned to McMurdo and within two days flew to New Zealand and returned their ECW without incident.

Next year, two researchers from Minnesota will return to Antarctica to test a newly built crystal structure logger at the WAIS Divide site.

Awards

Prof. Ned Mohan elected to the National Academy of Engineering

Prof. Ned Mohan, a long-time professor of electrical and computer engineering in the University of Minnesota-Twin Cities, College of Science and Engineering, has been elected to the National Academy of Engineering (NAE). Mohan received the honor for contributions to the integration of electronics into power systems and to innovations in power engineering education with the goal of making our nation's power grid cleaner, smarter, and more reliable. Election to the National Academy of Engineering is among the highest professional distinctions accorded to an engineer. Only 67 new members nationwide and 11 foreign associates received the honor this year. Mohan also was named the University of Minnesota Graduate and Professional Teaching Award recipient in March.
For more: go to www.ece.umn.edu/

Prof. Nikos Sidiropoulos elected Fellow to EURASIP

Prof. Nikos Sidiropoulos has been elected a Fellow of the European Association for Signal Processing (EURASIP) for his contributions to tensor decomposition and signal processing for communications. In addition, he has been invited to deliver the Inaugural Lecture at the 2014 EUSIPCO Conference in September in Lisbon, Portugal.

Prof. Paul Imbertson receives Morse Alumni Award

Prof. Paul Imbertson received the Horace T. Morse University of Minnesota Alumni Association Award for Outstanding Contributions to Undergraduate Education.

New Faculty

Prof. Soheil Mohajer joins ECE Faculty

Soheil Mohajer joined the University of Minnesota, ECE Faculty as an assistant professor at the beginning of 2014 Spring Semester. He is part of the department's Communications, Signal Processing, and Networking research group. Previously, Mohajer was a Postdoctoral Research Associate at the Department of Electrical Engineering and Computer Sciences, University of California at Berkeley (hosted by Prof. David Tse) from October 2011 to December 2014. He received his Ph.D. in Communications Systems in 2010 from the Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland. His expertise lies in wireless communications, multi-user information theory, bioinformatics, distributed storage, and video transmission.
For more information, go to http://www.ece.umn.edu/facultyECE/ECEMOHAJERZEFREH.html

New Facility

Physics and Nanotechnology building is completed

In just two years after Minnesota Gov. Mark Dayton and the 2011 State Legislature approved $51.3 million in bonding funds, work has been completed. Faculty and staff moved into the new facility in December 2013. A Public Open House is planned for April 23-24, 2014.
For more information, go to: www.mnc.umn.edu

College of Science and Engineering Calendar

blog.lib.umn.edu/itcomm/events/

Physics and Nanotechnology Building Grand Opening
April 23-24

College of Science and Engineering Graduate Commencement
Friday, May 2
1 p.m. , Mariucci Arena

ECE and ME 2014 Spring Senior Design Show and Senior Honors Posters
Thursday, May 8
2-4:30 p.m., Coffman Union, Great Hall

College of Science and Engineering Undergraduate Commencement
Friday, May 16
7 p.m., Mariucci Arena

First year report: C-SPIN Develops spin materials that function well at room temperature

Jian-Ping Wang, ECE Professor and C-SPIN Director

The Center for Spintronic Materials, Interfaces, and Novel Architectures (C-SPIN) had several exciting achievements in its first year of operation that moved it closer to its goal of building computer systems that use electron spin as the basis of information storage and transfer. Such systems can potentially be much smaller and require much less energy to operate than current computer systems.

In particular, C-SPIN researchers developed materials for magnetic tunnel junctions, spin channels, and spin interfaces that can function well at room temperature, a key requirement for potential commercialization.

In addition, C-SPIN researchers completed several important device and circuit designs based on the latest studies of the spin Hall effect (SHE), a property of magnetic materials that, until recently, was not well understood but underlies the functionality of spin-based devices.

SHE, named for physicist Edwin Hall, refers to the curved path that electrons follow as they move through a specific material that possesses a large spin-orbital coupling. The curved direction is caused by the interaction between the physical trajectory of the electron and its natural spin, similar to the spin on a golf ball as it curves to the left or right. Circuit designs that incorporate SHE functionality will have positive effects on the future of computing in the areas of cost, efficiency, and speed.

Jian-Ping Wang, ECE professor and C-SPIN Director, says the Center will continue studying new spintronic materials and interfaces while building a variety of spin-based devices for testing. He also expects the Center to develop refined tools for simulating spintronics devices and circuits.

The Center, which is sponsored by DARPA and the Semiconductor Research Corporation, coordinates research aimed at developing computer systems that use electron spin as the basis of information storage and transfer.

C-SPIN research is carried out by 32 Principal Investigators and 98 Ph.D. students and postdoctoral fellows from 18 U.S. universities, and nine University of Minnesota faculty members including seven from the Department of Electrical and Computer Engineering, one from the Department of Physics, and one from the Department of Chemical Engineering and Materials Science.

For more information, go to www.cspin.umn.edu.

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In 2014, we are implementing an **ECE E-Newsletter.** The reasons for this change are:

- More timely delivery of ECE information to you
- A cost savings in printing and postage charges
  Currently one issue of *Signals* costs $7-7.5K for postage, labor, and printing. We will dedicate this savings to student labs.
- Green operations - less paper and ink waste

Please send your name, current street address, and current email to ecenews@umn.edu

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