

SIGNALS

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

SPRING 2002

ECE Department Helps Energize Minnesota and U.S. Economy

For more than a century, Electrical and Computer Engineering (ECE) alumni and faculty have played a crucial role in founding new companies and bringing new technologies to the marketplace.

What is it about ECE alumni and faculty? They seem to possess more than their fair share of talent for starting new companies and moving new technologies to the marketplace. Of the 1,000-plus companies founded by alumni of the University of Minnesota Institute of Technology, more than 250 of them were founded by alumni and faculty of the ECE department. *(For a complete list, turn to page 4.)*

More than a century ago, fellow alumni Charles Chalmers (1894) and C. T. Hibbard (1897) founded the very first company formed by graduates of IT: Electric Machinery company (now Dresser-Rand). As recently as last year, ECE Professors Ramesh Harjani and Jay Moon founded Bermai, Inc. a semiconductor chip company focusing on a segment of the wireless communications market.

In between, ECE alumni and faculty members have founded every size, shape, and sort of company imaginable. From one-person engineering shops to industry leaders with thousands of employees (such as Medtronic and ADC Telecommunications Inc.), these companies crisscross the United States; from Brainerd, Minnesota to Waco, Texas, from Portland, Maine, to San Jose, California. Including Minnesota, which is home to the vast majority of ECE-founded companies, 24 different states have seen their economy strengthened by these companies.

Like Chalmers and Hibbard, alumni have often teamed up to tackle their entrepreneurial dreams. Ralph E. Allison and Walter Lehnert—both from the class of 1930—joined forces to start ADC Telecommunications. Seymour Cray (49), Elmer Engstrom (23), and William Keye (43) were at the core of

the group that founded Control Data Corporation (now Ceridian). Later, Cray teamed up with George Hanson (42), Frank Mullaney (43), and Noel Stone (42) to form Cray Research, Inc. the world's first and foremost supercomputer company.

More than 30 alumni have started at least two or more companies. In fact, some ECE alumni can't seem to stop starting new companies. At last count, Edward Orenstein (54) was leading the way, having founded nine different companies. Richard P. Daly (49) has founded six different companies, Thomas G. Kamp (49), five.

Every time a new company is formed, our economy is strengthened and new technologies are carried from

energize, continued on p. 3



Ramesh Harjani



Jay Moon



Matt O'Keefe

When Faculty Prosper, So Does the U

When ECE alumni start companies, benefits typically come to the ECE Department in a variety of forms. A certain amount of prestige accrues, and a job market is often created for the students it trains. Perhaps more importantly, alumni who have done well in business have historically ranked among the department's most generous benefactors.

When faculty form new companies, however, the payback is often more direct. Any technology developed "on University-time" is subject to licensing and yields a direct payback to both the ECE department and the University at large. All such activities are regulated through the University's Patents and Technology Marketing office.

"With start-up companies, we typically get an equity position, along with royalties from any licensing agreements," says Beth Trend, a licensing associate with Patents and Technology. "A recent start-up from another IT department returned roughly \$8 million to the University [after the University divested its stock position] when the company went public."

Royalties from licensing agreements follow industry standards, ranging from one-half of a percent to five percent of sales.

faculty, continued on p. 3

My column in the 1997 issue of *Signals* highlighted the resurgence of demand by industry for electrical and computer engineers, following several lean years in the high-technology sector. The year 1997 (and even 2000) now seems quite distant, given the current cyclic contraction of the market for many of our graduates, which has been magnified by the general slowdown in the economy and the tragic events of last September. Those of us who have been in this business for some time, however, know that the positive half of the cycle is on the horizon. Of course, we are forging ahead with the provision of outstanding edu-



cation and training to our students, deepening and expanding our scholarly activities, and providing opportunities to those who take advantage of this slower period to obtain additional graduate training. It is not a secret that the core specialties of our field will continue to form the backbone of technologies that support how we live, work, and play. The “hot” job market for our graduates will soon be back.

Along with the rest of the engineering programs in the Institute of Technology, the Department underwent its normal six-year accreditation review. The accreditation team from the Accreditation Board for Engineering and Technology (ABET) visited the campus in early December 2001, and will issue its report this summer. The procedures that we have put in place as part of the ABET 2000 process continue to play important roles in the continuous improvement of our educational program. (Please see:

<http://www.ece.umn.edu/academic/ugrad-studies/ee>) We very much welcome constructive feedback from you as alumni and employers of our graduates regarding our educational objectives and outcomes.

Once again we have been very fortunate to attract several outstanding colleagues to our faculty ranks this past year. These colleagues, who are more fully introduced in the “Faculty Update” section of this issue of *Signals*, are Associate Professor Jaijeet Roychowdhury, and Assistant Professors Beth Stadler and Heiko Jacobs. Jaijeet, who is also a core faculty member of the Digital Technology Center, brings new

expertise to the Department in analysis and computer-aided verification of analog circuits communication systems. Beth strengthens our materials work in optics and magnetics, and Heiko brings cross-disciplinary expertise to our activities in nanotechnology.

Our alumni and faculty have made significant contributions to the economy of the State and the Nation through their entrepreneurial activities. It is a great pleasure to have a chance in this issue of *Signals* to celebrate these contributions by listing the names of the many companies that have been founded by these alumni and faculty. If we have missed listing your company, please accept our apologies and send us a message with the appropriate information.

The Department has again benefited from the generosity of our alumni and friends. Contributions to the Hartig Fund have continued unabated, as have donations from industry and foundations in support of our education and research. Of particular note was an additional contribution of \$500,000 to the Nordby Scholarship by Roger and Ruth Nordby. On behalf of our students and the Department, thank you very much again for your generosity. Your support during these difficult economic times is farsighted and inspiring.

*With my best wishes,
M. Kaveh
Professor and Head
Centennial Chair in EE*

SIGNALS

M. Kaveh

Department Head

L. L. Kinney

Associate Head & Director of Undergraduate Studies

B. Wollenberg

Director of EE Graduate Studies

G. Sobelman

Director of CompE Graduate Studies

Signals is an annual newsletter published by the University of Minnesota Department of Electrical and Computer Engineering. We welcome letters, news about electrical and computer engineering alumni, and story ideas from all readers. Correspondence should be addressed to: *Signals*, Department of Electrical and Computer Engineering, University of Minnesota, 200 Union Street S.E., Minneapolis, MN 55455. The ECE web page can be found at: www.ece.umn.edu

The University of Minnesota is an equal opportunity employer and educator.

PRODUCTION

Chuck Benda, *Managing Editor*

Dawn Mathers, *Designer*

John Marchetti, *Photographer*

Trend and her colleagues not only oversee new company start-ups, patents, and technology licensing, but they also help faculty members bring their entrepreneurial dreams to life. For example, they sometimes help pair faculty members who have developed marketable technology with investors willing to finance a start-up. In the end, a sort of symbiotic relationship is formed.

Two recent additions to the family of companies with close ties to the ECE Department (Sistina Software—founded by ECE Professor Matt O’Keefe—and Bermai, Inc., founded by Harjani and Moon) further illustrate how this arrangement benefits both the University and the entrepreneurs.

“Being successful in the business arena is largely about having the right kinds of people—for us, engineers—readily available,” says O’Keefe. “I couldn’t have founded a company like Sistina without a good, strong university—like the University of Minnesota—nearby.”

Although O’Keefe started Sistina in December of 1997, it wasn’t until May of 2000 that he really began to ramp it up. Already they have some 20 major customers, including Sprint, Dell, NASA, and Deutsche Bank. They employ about 30 people, 20 of them engineers. About 70 percent of the engineers are alumni of the University of Minnesota.

Sistina designs and develops software for storage management. The software allows multiple servers to share storage devices, which increases efficiency, improves performance, centralizes management, and saves money. The software technology upon which Sistina is founded is licensed by the University and yields regular royalty payments. Furthermore, the University holds a small equity position in the company. Although the direct yield to date has been small, the potential is there for a substantial payday down the road.

Bermai has forged similar arrangements with the university. Although it has yet to ship its first products, the company is growing fast, and also

“The technology that is the foundation of our company was developed through our research at the University. That research activity not only provided the basic technology, but it also helped us attract the investors we needed to get it going.”

—JAY MOON

holds great potential for the future. Currently, they have some 50 employees working out of offices in Minnetonka and Palo Alto, California. They design and develop chipsets that will facilitate wireless communications similar to Bluetooth technology. Their chipsets, however, can handle much higher data rates and longer distances. A primary application will be to provide wireless Internet access.

According to Moon, Bermai’s employee list is also heavily weighted with alumni from the University of Minnesota. Providing potential jobs for ECE alumni is only one way the department benefits from such start-ups, however.

“The technology that is the foundation of our company was developed through our research at the University,” Moon explains. “That research activity not only provided the basic technology, but it also helped us attract the investors we needed to get it going.”

Whatever monies eventually come to the University through these and other such arrangements, they are divided amongst a number of interests, according to Trend. One-third is returned to the inventors/developers of the technology. One-third goes to the Office of the Vice President for Research. Eight percent goes to the College to which the faculty member belongs, and 25 percent is returned to the department to support additional research.

The bottom line? Everyone’s a winner.

academia into the private sector, where other companies and the public can then employ them. Their efforts spread throughout the world, like the branches of an enormous tree.

While it is certainly beyond the scope of this article to calculate the overall impact—economic and otherwise—that ECE-founded companies have made, one can begin to get a picture of how far-reaching that impact is. Consider just five of the largest companies founded by ECE alumni and faculty:

- ADC Telecommunications
- Control Data Corporation/Ceridian
- Cray Inc. (formerly Cray Research, Inc & Cray Computer)
- CyberOptics Corporation—founded by former ECE Professor Steven V. Case and Jeffrey A. Jalkio (83)
- Medtronic—Earl E. Bakken (48)

These companies are internationally recognized for leadership, excellence, and innovation. As a group they employ more than 45,000 people, worldwide. During fiscal year 2001, they generated almost \$10 billion in revenues. What’s more, these companies have created products that have forever changed the world in which we live. (Consider just two products developed by these companies: the Cray supercomputers and Medtronic’s implantable pacemakers).

Though perhaps not quite as visible, the rest of the ECE-founded companies—running the gamut from computer software and hardware companies, to law firms, to radio broadcasting companies, and more—change the shape of our lives on a daily basis,

Indeed, it would be hard to imagine what our lives would be like without these companies. It’s not an exaggeration to say millions upon millions of people throughout the world have had the quality of their lives improved by these companies.

Whatever it is that moves ECE people to start companies, it is definitely a good thing.

The Entrepreneurial Touch

In the early 1990s, the staff members from the University of Minnesota Institute of Technology (IT) Dean's Office conducted a number of surveys to try to determine how many companies throughout the world had been founded by IT alumni. By 1993 they had identified more than 1,000 such companies. Of that total, more than 250 were founded by alumni of the Electrical and Computer Engineering Department.

Following is a list of those companies. Since that time, certainly other ECE alumni have founded companies. We would like to hear from you. If your company is not on this list, please let us know. Send your emails to: Bettylou@ece.umn.edu and we'll publish the information in *Signals*.

Adams, Theodore P. (69) Audiosciences AngeMed Creative Toy Corporation	Brockway, Brian (75) Data Sciences, Inc.	Cray, Seymour (49) Control Data Systems, Inc. (now Ceridian) Cray Research, Inc. Cray Computer Corporation	Engstrom, Elmer (23) Control Data Systems, Inc. (now Ceridian)	Hamilton, Harold E. (72) Micro Control Company
Allison, Ralph E. (30) ADC Telecommunications	Brown, Wesley A. (51) Aulos Company	Daggett, Gary G. (75) Duo-Sonic	Erhart, Tim A. (71) Emerson EMC (formerly Kiowa Company)	Hanschen, Richard J. (45) New Business Resources, Inc. Teldar
Anderson, David J. (69) Birch Hill Communications	Bucher, Steven (84) I-Tech Corporation	Dahl, Peter W. (66) Peter W. Dahl Company	Eriksson, Larry J. (69) Digisonix, Inc.	Hanson, George (42) Cray Research, Inc.
Anderson, Donald E. (54) Rho Delta, Inc. MITOR Industries, Inc. Phenix Composites, Inc.	Cain, Jay J. (72) Cain Ouse Associates, Inc.	Dale, Everett H. (49) Dale and Associates	Faser, Richard V. (63) Faser Technical Sales, Inc.	Harkonen, Wesley S. (49) Lakehead Electric Company Continental Engineering Group, Inc.
Anderson, James A. (60) Marcom, Inc.	Carisch, George (59) Carisch, Inc.	Daly, Richard P. (49) Comserv Corporation Technet Information Systems Professional Processing, Inc. Consatech Ultimap Corporation Camelot Manufacturing Software	Ferquist, Cyril (53) Data Panel, Inc.	Hartmann, Richard J. (58) Arjay Automation, Inc.
Anderson, James R. (49) Research, Inc.	Carlson, David (57) Renco Corporation	Danner, Neil C. (76) Sysdyne Corporation	Fiers, Thomas A. (74) Conner Peripherals, Inc. Visonic Memories	Hastad, C. J. (56) Hastad Engineering Company
Anderson, Robert K. (63) Valleylab Critical Care America	Carlson, Kenneth G. (72) LSS Data Systems	Day, Robert A. (50) Tufco, Inc.	Fillmore, Robert L. (46) Fillmore Systems, Inc.	Hawkings, J. D. (73) Noramco Engineering Corporation
Anderson, Walter L. (44) General Kinetics	Carlson, M. Edward (45) Carlson Associates International, Inc.	Dossett, Royal J. (59) Datamyte Royal J. Dossett Corporation	Fishbaine, David (83) Intellimetrics	Heise, Richard A. (68) Advanced Technical Products
Angell William M. (62) W.M. Angell & Associates	Case, Steven V. (former ECE faculty member) CyberOptics Corporation	Droegemueller, Thomas A. (49)	Foot, Norman J. (50) Footronics Engineering	Hendrickson, Thomas E. (77) VTC Quadic Systems Silicon Concepts Cypress MN
Arneson, George S. (49) Arneson and Company	Cecchi, Willard J. (63) Blueline Software	Tadson, Inc.	Frank, Rollyn W. (48) R. W. Frank Consultants	Hibbard, C. Truman (1897) Electric Machinery/Dresser- Rand
Bakken, Earl E. (48) Medtronic, Inc.	Chalmers, Charles H. (1894) Electric Machinery/Dresser- Rand	Duggan, Steven (62) Veritas	Fritze, Curtis W. (47) Curtis, Inc.	Hines, Theodore G. (58) Pine Instrument Company
Bakken, Orville L. (49) Gulf Coast Hardware, Inc.	Cherne, Lloyd G. (50) Cherne Medical, Inc.	Dundovic, Joseph (49) Nortornics Company, Inc.	Garrity, James F. (70) Hauge Engineering	Hogan, John (49) Nortronics, Inc.
Balmer, Al (76) Electronic Controls, Inc.	Childs, Gailand M. (55) Childs Communication Corporation	Edell, Robert T. (60) Merchant, Gould, Smith, Edell, Welter & Schmidt, P.A.	Goffstein, Albert A. (31) ATR Electronics, Inc.	Holewa, Andrew J. (72) Holewa Management Consulting Group
Baril, Wilfred B. (76) Integrated Measurement Systems, Inc.	Christenson, Stafford V. (47) Vanalt Company, Inc.	Edison, James, Sr., (58) Edison Controls, Inc.	Golden, Michael G. (68) Girard Electronics	Holiday, Patrick D. (65) Product Development & Marketing
Bergren, John P. (50) J.P. Bergren Company	Churchill, Robert W. (57) ADA Engineering	Ehrhorn, Richard (560) Ehrhorn Technological Operations, Inc.	Gonzalez, Richard (82) Argee Electric	Holland, Rodney W. (85) CBA
Bissell, Henry M. (54) Henry Bissell Professional Law Corporation	Clarke, Bob (67) Sysdyne Corporation	Emerson, Donald W. (63) Extron Power Mod Company	Gorder, Mark S. (75) Resistance Technology, Inc.	Holman, Charles M. (65) Sys-Tec Solid State Time
Bohn, Gerald K. (66) Applied Vacuum Technology, Inc.	Clendening, Paul L. (69) Linden Electric Company, Inc.	Emmons, P. I. (67) Noramco Engineering Corporation	Grundeen, Gordon M. (64) CD Systems of Minnesota, Inc.	Horst, George F. (48) STRATMAP, Inc. Union Royalty, Inc.
Boll, Harry J. (56) GGB Industries, Inc.	Colbert, Charles (40) Clinical Radiology Testing Laboratory, Inc. Foundation for Skeletal Health Research PIDEAC, Inc.	Ehrhorn, Richard (560) Ehrhorn Technological Operations, Inc.	Hagfors, Norman (59) Norsen Medical Wellness Technologies, Inc.	Hove, Paul E. (65) International Research & Development CIOP, Inc.
Brannon, Craig (83) Advantage Enterprises	Conlin, Robert J. (62) Automation Displays, Inc. Video Monitors	Hallblade, Larry (67) Electronic Innovators, Inc.	Hajicek, David J. (67) D. Hajicek Engineering	Hovland, C. T. (80) Applied Biometrics, Inc.

Hyde, Johyn E., Jr. (39) KDHL Broadcasting Company	Lambert, Richard C. (67) R. C. Lambert and Associates, Inc.	Nietz, Malcolm L. (55) Malcolm Nietz, Consulting Engineers	Rivkin, Julius (47) Arkay Construction	Talmo, Robert E. (49) Micro Gage, Inc.
Irwin, Phillip A. (74) Irwin Manufacturing	Lang, Frederick W. (49) Analysts International Corporation	Norberg, Hans A. (27) Heavy Duty/Nelson Norberg Industries	Roberts, Harold A. (49) H. A. Roberts Consultant	Tenley, Richard A. (60) Reflections Software
Iverson, Rolf (77) Applied Vision Systems	Dicomed Corporation	Nordling, Neal F. (65) Nonin Medical, Inc.	Rose, Glen R. (48) Cimcorp (PAR Systems)	Thimmesch, David M. Powertron, Inc.
Jalkio, Jeffrey A. (83) CyberOptics Corporation	Lange, Robert (60) Mesabi Control Engineering, Ltd.	Ong, Lincoln T. (64) LecTec Corporation	Schlegel, Robert D. (64) Schlegel, Mittelstadt and Associates, Inc.	Thorndyke, Keith (82) DataMax
Jensen, Arthur J. (59) Cross Technologies, Inc. Solutions Plus, Inc. MJR	Lares, Renaldo V. (75) West Ridge Farm, Inc.	LecTec Technology PTE, Ltd. T. C. Medical, Inc.	Schmidt, David P. (45) David P. Schmidt, P.E.	Thornton, James E. (50) Network Systems Corporation
Jerson, Sidney N. (60) Astrocom	Larson, Denis L. (81) Innovative Design Solutions	Orenstein, Edward (54) Data Display	Schott, Oscar (34) Schott Corporation	Timm, Gerald W. (63) Mentor Corporation American Medical Systems, Inc. Dacomed Corporation
Jeutter, Lawrence P. (74) ADA Engineering	Lauderbaugh, Mark E. (69) Trident Process, Inc.	Northern Telecom, Inc. (formerly Data 100)	Schroeder, John H. (42) DuPage Precision Products Company, Inc.	Tobias, Richard J. (85) Richard James Tobias, Inc. White Eagle Systems Technology, Inc.
Johnson, C. B. (67) Johnson Scientific Group, Inc.	Lee, Gordon (38) Central Research Laboratories	Lee Data Corporation Enercon Data Corporation Lumonic-Laserdyne	Schuck, Edward A. (63) EdenTec	Tomash, Erwin (43) Dataproducts Corporation
Johnson, Edgar F. (21) E. F. Johnson Company	Lee, Herbert H. (45) KDHL Broadcasting Company Lee and Associates	Commonwealth Leasing Xor Corporation Neon Dynamics Corporation	Schwalm, Arthur W. (62) Cardiac Pacemakers, Inc.	Uttermark, John A. (69) SP International
Juran, Joseph M. (24) Juran Institute	Lee, Sang Joon (71) Samsung Semiconductor Omni Microelectronics American NeuraLogix	Bar Code Dynamics Corporation	Schwittek, Elmer W. (48)] RF Communications	Vidovic, Hugh (73) DMR Electronics, Inc.
Kakach, Gary D. (69) Instrument Control Systems, Inc.	Lehnert, Walter (30) ADC Telecommunications, Inc.	Palmberg, Paul W. (59) Physical Electronics	Sharma, Raghu (69) Multi-Tech Systems, Inc.	Vo, Nam Viet (84) Nuvo Technology
Kalisher, Dennis E. (63) Tensleep Desing	Locke, Eugene A. (49) Oftedal, Locke, Broadston & Associates	Patrick, Robert A. (73A) EIA	Sheldon, Donald F. (43) Computer Science Engineer- ing Services	Vu, Tho Truong (77) Top-Vu Technology, Inc.
Kamp, Thomas G. (49) Computer Peripherals, Inc. Magnetic Peripherals, Inc. Disk Media, Inc. Peripheral Components, Inc. FRS Company (formerly Premier Computer)	Loftman, Russell E. (51) Image Information, Inc.	Paulson, Larry G. (73) Pattern Processing Technologies	Shifflet, Glenn W., Jr. (60) Datamyte Micro Dynamics	Walte, Gary (59) Datamyte
Karkela, Larry W. (62) Karkela Construction Company	Luther, William (67) Luther Ballenthin & Carruthers	Perala, Rodney A. (65) Electro Magnetic Applications, Inc.	Skoe, R. C. (49) United Wild Rice Co-op Clearwater Rice Gourmet House	Walvatne, Ervin (50) Walvatne Industrial Services
Kaster, Robert L. (62) Medical, Inc. Kastec Company	Markson, Paul A. (31) Van Bergen and Markson, Inc.	Persson Eric G. (81) Analog Circuit Design PS Engineering	Smith, Donald H. (44) Railcar Classic of America, Inc.	Ward, Harlan W. National Computer Systems
Keye, William (43) Control Data Systems, Inc. (now Ceridian)	Mills, Perry (74) Data Sciences, Inc.	Persson, Erland K. (55) Erland K. Persson Caompany	Stasz, Peter (62) Applied Engineering Everest Medical Corporation Falcon Recreational Industries	Wargo, Peter (56) Wargo and Company
Kissling, Christopher (86) Automation Systems Engineering, Inc.	Mittelstadt, Donald R. (59) Schlegel, Mittlestadt and Associates, Inc.	Pickard, Allen J. (82) Digital Audio Laboratories	Stone, Noel (42) Cray Research, Inc.	Weber, Roland (62) Physical Electronics
Kiszewski, Robert F. (81) ATI, Inc.	Mlazgar, Raymond L. (50) R. L. Mlazgar Associates	Pinkerston, Milo S. (77) MSP Real Estate, Inc. MSP Construction, Inc.	Stordahl, Ronald A. Digi-Key	Welch, Gary A. (69) IIC, Inc./Milltronics Manufacturing
Knight, Arnold W. (62) Knightronix, Inc.	Moll, Donald R. (48) Moll Associates, Inc.	Podas, Norman F. (44) Emanuelson-Podas, Inc.	Strobl, Frederick T. (71) CNS, Inc.	Westby, David (70) By-West Engineering
Kosters, Wyane A. (82) I-Tech Corporation	Morley, Spence G. (82) St. Paul Growth Ventures	Poole, William S. (46) Enviornmental Systems, Inc. Cedar Creek Consultants, Inc.	Stroncek, Steven J. (83) Advantage Enterprises	White, Phillip J. (80) AZX International Corporation
Kubicek, William G. (42) SURCOM, Inc.	Mullaney, Frank C. (43) Control Data Systems, Inc. (now Ceridian) Cray Research, Inc.	Puhek, Michael I. (72) MPD Engineering Data Backup Service	Sutherland, William T. (70) Minnesota Technical Advisory Bureau, Inc.	Williams, Gerald I. (50) Transistor Electronics Corporation Williams Sound Corporation
Kuehn, Andrew, III (50) Systematics, Inc.	Murname, Robert P. (43) Mumco	Raihala, William I. (60) Noramco Engineering Corporation	Swanson, Loren E. (44) Central Engineering	Wingrove, Robert C. (61) Medical Devices, Inc.
Kytola, W. E. (63) Wayne's Woods	Naka, F. Ropbert (47) CERA, Inc.	Reichenberger, Ronald M. (73) Measruement Technology Corporation	Swanson, Roger B. (53) Glasstite Manufacturing	Wolfenson, Sidney J. (r0) Wolfenson Electric, Inc.
LaCroix, Blakeley (77) Wrenchman, Inc.	Nereson, Gary L. (74) Judd Supply Company	Ressmeyer, James J. (72) Martronics	Swoffer, Alfred H. (39) Swoffer Instruments, Inc.	Wright, Donald A. Interactive Computer Technology
	Nicolai, Tom (56) Haugen & Nicolai	Rhodes, Ned W. (75) Software Systems Group		

The New World of Electric Power Systems

Electric power research, like other “mature” technologies, often takes a backseat to newer realms of scientific inquiry—until something goes wrong or the landscape is drastically altered. This isn’t anything new or particularly surprising to Electrical and Computer Engineering Professor Bruce Wollenberg.

“I was a hot commodity a year ago or so when the rolling blackouts were plaguing the electric power systems on the west coast,” recalls Wollenberg, who is the director of the University of Minnesota Center for Electric Energy (UMCEE). “At the time, the president of Xcel Energy predicted the same thing would happen here within five years. There was a big hubbub for a time, I was on TV when President Bush came to St. Paul, and then nothing. It’s amazing how these stories flash and then die.”

For Wollenberg, however, the study of electric power systems never grows old. For nearly forty years he has worked in the electric power industry, taught, and conducted research. A

native of Buffalo, New York, Wollenberg earned his undergraduate degree in electrical engineering and his master’s degree in electric power engineering from Rensselaer Polytechnic Institute in 1964 and 1966 respectively. He earned his Ph.D. degree in systems engineering from the University of Pennsylvania in 1974 while working as a senior engineer for Leeds & Northrup Company in Philadelphia. He then took a position with Power Technologies Inc. of Schenectady, New York, and then as a principal consultant for Control Data Corporation.

During his time in the private sector, Wollenberg also began teaching as an adjunct professor—first at Rensselaer, then at the University of Minnesota. In

1989, he relinquished his career in the industry (although he continues to serve as a consultant) to take a position as a full professor in the ECE department. Along the way, he earned many honors, including the Control Data Corporation Technical Excellence Award (1987), IEEE Fellow (1988), and the IEEE Third Millennium Medal (2000). His most recent was receipt of the Outstanding Power Engineering Educator Award from the Power Engineering Society of IEEE. Among his many publications is the popular textbook (co-authored with A.J. Wood) *Power Generation, Operation and Control*.

The advent of deregulation, which has transformed the playing field for the electric utilities and created both new problems and new opportunities, has created a renewed interest in electric power research. All of a sudden, Wollenberg and others in his field are once again hot commodities.

“A few years ago, the advisory board for the Center for Electric Energy recommended a study of loss allocation along power transmission lines,” Wollenberg recalls. (The majority of funding for UMCEE comes from a consortium of midwestern electric power companies. These companies participate on an advisory board that helps UMCEE researchers identify pertinent research topics.) “As we got into the research project, we discovered the calculations were a bit more complex than we expected.”

The basic principles underlying transmission losses are simple enough. Anytime power is transmitted through electrical lines, a portion of the energy is lost as the transmission wires heat up. If one were calculating the losses on a single transmission over a closed system, the process is relatively straightforward. On average, about four percent of the power is eaten up through transmission losses. That was essentially the situation that existed prior to deregulation. Most transmissions of power were within a single system owned and operated by a single



Bruce Wollenberg

company. As a result, each individual company simply included transmission losses as part of the cost of producing electricity and there was little interest in being able to separate out the actual cost of those losses.

Since deregulation, however, thousands upon thousands of kilowatt-hours worth of electricity are being transmitted back and forth across both the U.S. and Canada.

A single transaction might involve electricity being transmitted through lines owned and operated by several different power companies. Furthermore, at any given moment, there are typically numerous transactions underway, with power flowing in many different directions.

Under this new scenario, calculating transmissions losses becomes quite complex.

With electricity flowing literally in every direction, some transactions can actually lower transmission losses, while others can increase them. When it comes time to pay for the electricity bought and sold across these many systems, who then should bear the cost of the transmission losses? And how do you divvy it up?

"The industry didn't have any way of accurately allocating losses, so they simply decided to use a constant factor: such as two percent," Wollenberg explains. "The truth is, it may be double or triple that for some transactions, while others might actually be lowering the losses because of a counter-flow situation."

As Wollenberg and his graduate student, Aniss Fradi, began working on the problem they began to discover ways to approximate the losses associated with each transaction. They also discovered, however, that as you throw in additional transactions over the same system the difficulty of accurately allocating losses grows.

"With a single transaction, losses can be calculated using the square of the current flow times the resistance of the

"One of the drawbacks of deregulation is that they haven't yet figured out how to monitor all these transactions well enough to protect the integrity of the system. If you allow parts of the system to become overloaded or overstressed with all of these transactions, the whole system becomes vulnerable."

—BRUCE WOLLENBERG

transmission line," says Wollenberg. "As soon as you throw in additional transactions, however, it becomes impossible to determine how much loss is due each."

For a time, the mathematics of the solution eluded Wollenberg and Fradi. They divided the problem up into many small pieces and began to come up with bits and pieces of the final solution. Over many hours of work, the bits and pieces began to fill the dry-erase board in Wollenberg's office with dozens of seemingly incomprehensible mathematical symbols. A twist of fate changed everything.

"One day, Aniss and I were working on the problem in my office over lunch," says Wollenberg. "I walked another one of my graduate students, Sergio Brignone. He took one look at the problem on the board and said: 'Oh. Numerical integration.' Suddenly the curtain parted, the birds began to sing, and our problem was solved."

Brignone joined the research project and the three of them refined their methodology to the point where, according to Wollenberg, they can accurately calculate losses down to six decimal points. Even though loss allocations are currently calculated at just 2 percent of the total transaction, with the enormous amount of electricity being moved around the grid these days, annual savings could mount into the millions for some companies.

Although the pioneering part of this research has been completed, there is still a need for it to be packaged within a professionally developed software program. Wollenberg and his cohorts are working on several angles to get that completed and to publicize the work that they have done. While individual companies here and there are eager to get their hands on a software package they can use, the industry as a whole is preoccupied with other issues they believe they must resolve first, according to Wollenberg.

"With the tragic events of September 11th came a renewed interest in system security and risk assessment," he says. "One of the drawbacks of deregulation is that they haven't yet figured out how to monitor all these transactions well enough to protect the integrity of the system. If you allow parts of the system to become overloaded or overstressed with all of these transactions, the whole system becomes vulnerable. A simple random event—like a short circuit in a transformer or an overhead line being struck by lightning—could blackout half of the U.S."

As he's winding down his work on calculating loss allocations, Wollenberg is beginning to address these new issues. He's begun developing software that will allow the power companies to assess both the probability of some sort of breakdown and the financial risk associated with individual transactions.

As it has in the past, interest in Wollenberg's research is likely to continue to wax and wane. Given the turmoil that has accompanied deregulation, however, Wollenberg isn't worried he'll run out of interesting and important research work anytime soon.

"To begin with, the power companies still haven't figured out how to set up a smoothly operating open market—let alone, how to operate a system that can adequately serve that market," he says. "I think I can find enough to do to keep me busy for as long as I care to be."

Movie Magic and More

—at any time during the last 10 years—you’ve watched television, gone to the movies, or visited any of a half dozen theme parks around the world, then you’ve seen the work of John Hughes’ company: Rhythm & Hues Studios. From the animation for *Babe* (which won the Studio an Oscar for making Babe’s lips move in synch to the words) to the popular series of



John Hughes ('70, '75), CEO and founder of Rhythm & Hues Studios.

Coca Cola television commercials with those lovable polar bears, to the “Energy” theme park at Disney World in Orlando, Florida, Hughes’ company has built a reputation as one of the best companies in the world

when it comes to creating character animation and visual effects for the entertainment industry.

“Early on, we did a lot of animated logos for television,” Hughes recalls. “As our company grew in skill and reputation, we undertook more challenging work, starting with television commercials and then graduating, if you will, to movies and other projects.”

Today, Rhythm & Hues Studios employs from 300 to 400 people, depending upon the number of projects underway, and their list of credits and accomplishments is long and growing longer. During 2000-01, for example, they contributed their artistry to more than two-dozen feature films. Born in Nashwauk, Minnesota and raised in Hibbing (his father worked in the iron mines on the Range; his mother was a housewife), Hughes never dreamed he’d find himself living in the fast lane in L.A.

“When I came to the University, I planned on becoming a lawyer,” says

Hughes. “Through my undergraduate physics classes I became interested in electrical engineering, but I also studied economics, which seemed to be in line with my goal of becoming an attorney.”

By the time Hughes had completed his undergraduate studies, however, (earning bachelor’s degrees in economics and electrical engineering) his interest in becoming a lawyer had faded. He stayed in school, pursuing his interest in a variety of scientific disciplines.

“I took just about all of the computer science classes offered,” he says. “Then I started taking systems and control theory, and biomedical engineering classes. By the time I finished, I had completed the degree requirements for both biomedical and electrical engineering, but I chose electrical engineering for my master’s.”

He began working for the Walker Art Center, helping them develop their audio-visual technology, lighting, sound projection, and so on. A good friend soon persuaded him to take a job in L.A. with Robert Abel Associates. They needed an electrical engineer to help apply computer technology to creating visual effects for filmmakers.

He moved there in 1976 and helped pioneer the application of motion control to filmmaking. The method for producing visual effects at that time involved physically moving the cameras around models in a studio to create the illusion that the model (of a space ship, for example) was moving. In order to create realistic visual effects, the filmmakers had to shoot several versions of the same footage and combine them into a composite. This meant they had to be able to move the camera along the exact same path each time, which is where Hughes’ motion control knowledge came into play.

In the early to mid-1980s, the use of computer animation in filmmaking grew rapidly. Hughes and five of his colleagues decided to start their own business in 1987 to seize the opportunity they anticipated. The fledgling company developed proprietary software that, as it evolved, set a very high

standard for both photo-real and stylized character animation and visual effects.

The demand for their work grew rapidly, and as the business grew, Hughes discovered that his penchant for exploring many different disciplines would serve him well in the business world.

“It takes a lot to get a business like this going and keep it going,” he says. “You have to wear a lot of different hats; entrepreneur, businessman, engineer, and then some.”

Other Animation Work by Rhythm and Hues Studios

The work of John Hughes and his associates is literally all around you. If you want to check out some of their latest work, they created some 50 shots in Harry Potter, including the sorting hat, Norbert the Dragon, and many of the owls. Other work they’ve done includes the following.

MOVIES

The Sum of All Fears
Lord of the Rings
Harry Potter
Cats and Dogs
Planet of the Apes
Dr. Doolittle 2
Fantasia 2000
How the Grinch Stole Christmas
The Green Mile
Stuart Little

COMMERCIALS

Budweiser
Chips Ahoy
Dodge
Ford
3M Post-It Notes
Mazda

THEME PARK ANIMATIONS

Star Trek: The Experience—Las Vegas
Seafari—Wakayama, Japan
Le Visionarium, EuroDisneyWorld, France

The demands of his business become apparent when you consider the effort that goes into creating a few seconds of movie animation. Although the technology has evolved enormously from when he first got his feet wet, it is still a painstaking process.

"Making an animal look like it's talking, for example, involves many different steps," Hughes explains. "First, the director shoots a live action shot of the animal 'acting' as close as possible to what is needed in the final cut. We model the head on the computer and read in the live action footage. Frame by frame, we place our computer model over the live action head and match the movements."

Through steps to numerous to recount, Rhythm and Hues personnel tinker with every expression, the lighting, the texture of the computer model, and more.

"All told, it may take several of our employees as long as three to five weeks to create four seconds of animation."

Animation technology continues to evolve at a rapid pace, and as it does, filmmakers find themselves with capabilities they never dreamed possible. And, although his firm is among the industry leaders, Hughes notes that they don't typically get involved in anything the scientific community would consider original research. But they do take advantage of what physicists and others have to offer.

"What matters most to us is that the final product looks right," he says. "When we're working with simulations of smoke or water, for example, we simplify the well-known Navier-Stokes equation for calculating fluid flow. The original equation is very complex requires an enormous amount of computer time to complete the calculations. To make it more affordable, we might leave out variables like temperature and so on."

Judging from the success of Rhythm and Hues Studios, the final product looks right far more often than not.

McNaughton and Yau Receive U's Highest Honor

Russell J. McNaughton (57) and **Leo Yau** (65) were recently honored by the University of Minnesota with the highest honor afforded its alumni: the Outstanding Achievement Award (OAA).

McNaughton, who earned his bachelor's degree from the department, was presented with his OAA on June 5, 2001. He is retired from 3M, where he was group vice president of 3M's Electro Products Group, after a 40-year career. McNaughton guided the development of a core group of three embryonic technologies that ultimately led to the formation of three large, successful divisions within 3M. He was cited for being an "esteemed executive who ably led his organization through transitions, resolving technological, financial and personnel problems with sensitivity and integrity," and for being a "committed advocate of education and champion of many University initiatives."

Yau, who earned his master's degree from the department, was presented with his OAA on September 28, 2001. He is retired from a distinguished career with Intel, where he served as director of Innovative Technology Modules. Yau was named an Intel Fellow, the company's most prestigious technical recognition. His pioneering research laid the groundwork for the development of the microprocessor and contributed enormously to the evolution of the computer microchip. Yau holds 15 patents and is a Fellow of the Institute for Electrical and Electronic Engineers. He was cited as an "enthusiastic mentor who leads others by giving them his unwavering respect and confidence, inspiring them to elevate their performance."

1940

Roger M. and Ruth Nordby have given an additional major gift of \$500,000 to the Nordby Scholarship Fund.

1963

Dr. J.Y.S. Luh (Ph.D.) received the Pioneer in Robotics and Automation Award for his contributions to and leadership in robotics and automation.

1967

Congressman Bill Luther is currently serving his fourth term in the United States House of Representatives. Luther, who is a Democrat, represents Minnesota's 6th Congressional District located in the Twin Cities' suburbs. Luther, who also earned a law degree from the University of Minnesota Law School in 1970, is a member of the House Commerce Committee. As a member of that committee he helped write new consumer protection legislation in the wake of the Firestone tire recall. In 2000, Luther was named the most fiscally responsible of all 435 members of Congress by the non-partisan watchdog group, Taxpayers for Common Sense.

Luther is married to Darlene Luther, a state Representative in the Minnesota Legislature. They are the parents of two children, Alex (24) who works in downtown Minneapolis, and Alicia (20) who is a college student in Boston.

News By Email!

ECE Signals can now take "News About You!" via email. If you recently got a promotion, a new job, or have any other news to share with your classmates, send it to Bettylou@ece.umn.edu and we'll make sure it gets into the next issue of your newsletter.

Real-World Challenge Inspires Senior Design Group

Innovation sometimes follows a circuitous path—with preparation, coincidence, and inspiration (each in their turn) playing major roles. Take, for example, the recent efforts of Electrical and Computer Engineering (ECE) Professor Jim Holte's senior design class.

The preparation.

"A couple of years ago, the students in my design class worked on a project to develop a portable, multimedia information-capture system that could combine Global Positioning Satellite (GPS) information with video," says Holte. "The original idea came from a rowing coach who wanted to be able to put the system into rowing shells, both for coaching purposes, and to enhance the spectator experience at races by transmitting the information to a jumbo video screen display."

That design class was able to design and build a workable system that did a good job with the GPS part of the challenge, but during the 15 weeks of the class, they didn't complete all the work necessary for the jumbo video display. While Holte considered their class work quite successful, it also proved to be just the beginning of an intriguing possibility.

Enter the coincidence.

The following spring, Holte got the opportunity to do a "ride-along" with his son-in-law, Ben Marks, who had just recently completed his probationary period as a trooper for the Minnesota Highway Patrol.

"When I saw how much time he had to put into report preparation, and the kinds of information he needed to keep a record of, it became clear that the system our students had been working on for the racing shells could do a lot of good in a highway patrol cruiser," says Holte.

The potential proved tantalizing. If a trooper could record his entire eight-

hour shift on one videocassette—including an audio track and a track containing GPS information every step of the way—the trooper's job would suddenly get a lot easier and his performance would improve remarkably.

"As a trooper, you have to track an awful lot of information," says Marks. "When you make a simple traffic stop, you need a record of time, location, and other pertinent information for evidentiary purposes."

"Although some cruisers are equipped with video cameras, none of them currently have the GPS information included," Marks continues. "A video recording can help, but it would be very time consuming to look through all the videotape to track down the information you need. Now, add the cover of darkness and perhaps a high-speed chase, and it becomes extremely difficult to sort it all out at the end of your shift."

According to Marks, the Highway Patrol in Minnesota is gearing up to provide all metro-area cruisers with video cameras, laptop computers, and GPS capabilities by the end of 2003. The technology for that system, however, is very expensive—running in the neighborhood of \$5,000 per vehicle

(not including the centralized 'parent' system)—and the GPS information is recorded at the dispatcher's end, not directly on the videotape. To synchronize the video and GPS information would require an additional step that is not currently in the plans.

To Holte, developing a economical system that could go the current technology one and maybe two or three better seemed an ideal project for his senior design class.

The inspiration.

"In classes like this, the professor usually ends up playing dual roles as project manager and customer," says Holte. In this case, we were able to have Ben Marks—a real State Trooper—play the role of the customer and I played the role of project manager."

As project manager, Holte would soon discover that he had quite the team under his direction.

"In the beginning, I suggested a system that incorporated solid state memory and could record GPS and voice," he explains. "I figured someone else could worry about the image capture. But they wanted to try to do that piece of it, too. Since they were deter-



mined to include video, I suggested using a digital camera, for simplicity's sake."

Again the students balked. They argued that, although any form of information capture would be subject to legal scrutiny, analog video images are more difficult to alter than those in a digital format. Holte disagreed, but when he checked with authorities, he was told that analog recordings would be preferable to digital.

"This was an exceptional group of students," Holte says. "Their initiative and ingenuity created a paradigm shift."

Since an ordinary videotape already has two audio tracks in order to create stereo sound, (in addition to the capability to record the video images), the students figured they could simply use one to record the GPS data and the other to record an audio track. (Troopers are already 'miked' and it was a simple matter to pick up the audio feed with their prototype.)

To control costs, the students adopted a modular approach that also afforded them both flexibility and adaptability. A key concept they incorporated early on was the use of micro-controllers instead of full-blown microprocessors. That way they could get the most bang for their buck, using architectures that gave them just the right amount of 'smarts' and memory. They also did an excellent job of searching the marketplace for economical, existing modules that fit the bill, according to Holte. For example, they found a reasonably priced VCR module already designed to run on direct current (through a typical 'cigarette lighter' hook-up).

"Because they incorporated existing products, they didn't have to reinvent the wheel each step of the way," says Holte.

By the end of the semester, the students had actually surpassed their original goals. Although their final "product" still has a few bugs to be worked out, Holte believes it's possible

Professor Emeritus **Jack Judy** has been elected a Fellow of the Institute for Electric and Electronic Engineering (IEEE) for "contributions to magnetic thin film media for longitudinal and perpendicular magnetic recording."

Associate Professor **Sachin Sapatnekar** and graduate student **Jiang Hu** (01) won the best paper award at the 2001 ACM/IEEE Design Automation Conference for "A Practical Methodology for Early Buffer and Wire Resource Allocation."

Professors **Nikolaos Sidiropoulos** and **Georgios Giannakis**, along with colleague R. Bro of Denmark received a 2001 Best Paper Award from the IEEE Signal Processing Society for their paper entitled "Parallel factor analysis in sensor array processing," published in the IEEE Transactions on Signal Processing, August 2000.

Assistant Professor **Bethanie J. H. Stadler** received a prestigious National Science Foundation (NSF) Career Award. She will use the NSF award to help support her research in advanced materials for photonics.

Assistant Professor **Joey Talghader** received a 3M Non-Tenured Faculty Award.

Randall Victora has been promoted from associate professor to professor.

Professor **Bruce Wollenberg** received the Outstanding Power Engineering Educator Award from the Power Engineering Society of IEEE.

The following faculty members have been appointed to chairs and professorships by the Dean of the Institute of Technology:

Tryphon Georgiou, Vincentine Hermes-Luh Chair in EE
Georgios Giannakis, ADC Chair in Wireless Communications
Anand Gopinath, Sanford P. Bordeau Chair in ECE
Mos Kaveh, Centennial Chair in EE
Richard Kiehl, Louis John Schnell Professorship in ECE

that they could ultimately come up with a system that provides the basic functionality they targeted for about \$1,000 per vehicle. Furthermore, because they adopted a modular approach to begin with, they could offer variations on the basic system that included add-ons such as a flat-screen video display monitor, or the capability to superimpose the GPS data on local street maps so that users could track their position in real-time.

The students are continuing the project on their own, refining some of the more mundane components such as the various cables and connections that would be necessary to produce a "plug-in-and-go" system, and arranging to fabricate a printed circuit board. Ultimately, they hope to find a way to produce their system commercially.

"The design class was a tremendous experience for me," says Jeremy Mattke, and ECE senior from Eden Prairie, Minnesota. "We set it up so that it was similar to the way a corporate project team might tackle a design problem."

In addition to Mattke, the project team included fellow seniors Chad Peters, Kenneth Sturgis, Thomas A. Stavsvick, Ryan O'Leary, and Michael Miller.

"I don't think I've ever had a group of students do such a good job," says Holte. "Each one of them picked up a piece and ran with it. I was amazed by what they accomplished in just 15 weeks."

Roychowdhury Bolsters Department's Strength in RF Circuit Design, Theory

Joining the faculty of a top research institution had always been among the goals of Associate Professor Jaijeet Roychowdhury. At the time he completed his Ph.D. work in 1993, however, the academic market was a bit down and Roychowdhury wasn't particularly intrigued by the job offers he received from the academic community. When the prestigious AT & T Bell Laboratories offered him a research position, he decided to take a small detour from his original career plan and spend some time working in the private sector.

"Bell Labs offered me the opportunity to pursue a number of my research interests—including numerical algorithms for circuits and RF circuit design—while working in their Communication Sciences Research Division," says Roychowdhury. "Things were good at Bell Labs and, although I had at least three other opportunities to move to the academic side of things, I didn't want to leave such a positive environment."

Bell Labs began to struggle in late 2000, and Roychowdhury realized it was time to move on. After a brief stint with a start-up optical networking company, he made the move to academia, joining the ECE Department faculty in the fall of 2001.

"I had a few other offers, but there were a number of things that impressed me about the ECE Department at the University of Minnesota," he says. "Starting with the department head on down, the faculty here includes a lot of very bright people doing research in a number of areas that interest me. And an aspect that is very important to me is the friendly and supportive atmosphere they have created." Roychowdhury also cited the newly formed Digital Technology Center and its director, Andrew Odlyzko, as other factors that attracted him to Minnesota.



Jaijeet Roychowdhury

A native of India, Roychowdhury received a bachelor's degree in electrical engineering from the Indian Institute of Technology, Kanpur in 1987. He earned his master's and doctoral degrees in electrical engineering and computer science from the University of California, Berkeley in 1989 and 1993, respectively.

Roychowdhury's research interests should provide a stimulating complement to a department already strong in RF circuit and system design and theory. His primary research interest is in the development of computer-aided design (CAD) tools for designing RF circuits and systems. His secondary research interests include the design and verification of techniques for optical communications and integrated electro-optics, as well as novel optoelectronic systems and communication schemes.

"There is a great need for computer-aided design tools for use in RF circuit design," Roychowdhury explains. "The analog circuits used in RF systems are much more complicated than typical digital circuits. Where once these circuits consisted of tens of transistors, they now require thousands of transistors." The wireless explosion—most evident in the proliferation of cell phones—has created huge competitive and price pressures on chip design, he adds.

"This demand has created a paradigm shift in the design of RF circuits," Roychowdhury explains. "The old design methods—which relied on the skills of a few highly trained individuals—are no longer practical. New computer-aided design tools are essential if we are to meet the demands of the market."

Jacobs Adds to U's Strength in Micro- & Nano-technology

"The offer to join the faculty here was very much appreciated," says Assistant Professor Heiko Jacobs who joined the Electrical and Computer Engineering (ECE) Department last fall. "The research environment here is very exciting. There's a group that is very active in micro and nano-technology and there are also many opportunities for interdisciplinary collaboration in my research areas."

Collaboration across disciplines has been a part of Jacobs' approach to research almost from day one. A native of Cologne, Germany, Jacobs earned his bachelor's and master's degrees in electrical engineering from the University of Wuppertal, Germany in 1993 and 1995 respectively. He completed his Dr. Sc. Techn. degree in mechanical engineering in the area of Nanotechnology at the Swiss Federal Institute of Technology. In his doctoral research Jacobs demonstrated the use of Atomic Force Microscopes to pattern and visualize charge with 100 nm resolution. "I think the borders or the interface between existing fields provide some of the best opportunities for research," Jacobs explains. "To date, my research has gone back and forth among several disciplines, including chemistry, applied physics, mechanical engineering, and electrical engineering."

Prior to joining ECE faculty, Jacobs completed a postdoctoral stint at Harvard University where he worked with renowned Chemistry Professor



Heiko Jacobs

George M. Whitesides. In one project, Jacobs developed a conductive flexible stamp to form multiple nanometer-sized contacts to a rigid surface. (See H. O. Jacobs and G. M. Whitesides, "Sub-Micron Patterning of Charge in Thin Film Electrets," *Science* 291, 1763; 2001.)

"These stamps are a crucial part of my current research because they allow us to parallel inject charges into dielectric thin films at very high resolution."

"In one of my research projects, we're now exploring ways to use such charges to attract particles as part of a process of nanometer-scale, charge-based, xerographic printing," Jacobs says. In some of his first experiments, Jacobs' research group was able to achieve resolution of 1.5 micrometers—about 75 times the resolution of the best xerographic printer. Currently, Jacobs is pursuing two additional areas of research: non-traditional nanofabrication and self-assembly-based device fabrication.

His work in non-traditional nanofabrication has concentrated on the development of scanning-probe microscopy and scanning-probe lithography to study and modify electrical properties on a nanometer scale. Such technology is currently used to fabricate prototypes of devices such as a single-electron transistor. Instead of using the serial approach this typically involves, Jacobs

is proposing the use of a parallel strategy that would be five orders of magnitude faster.

The work he is doing in self-assembly is directed towards using self-assembly as a manufacturing strategy. For the most part, other research in the area of self-assembly has examined the process at the atomic and molecular level. Jacobs hopes to develop, study, and exploit self-assembly processes at what might be considered the Meso scale (from 10 nanometers to a millimeter) to assemble and package functional hybrid devices in two and three dimensions. "I gained a tremendous amount of knowledge by working with George Whitesides who is an expert in self-assembly," he says. "Self-assembly is well known in chemistry, however, I am convinced that it will become an important tool to fabricate functional devices in the future." Jacobs recently demonstrated the fabrication of cylindrical display using surface tension driven self-assembly of liquid solder. (See H. O. Jacobs, et al., "Fabrication of a Cylindrical Display by Patterned Assembly," *Science* 296, 323; 2002.)

"My research has taken me into many novel areas and a multitude of disciplines," says Jacobs, "but my current efforts seem to have brought me back a little closer to my roots in electrical engineering. However, I still intend to collaborate with my colleagues at the University of Minnesota in mechanical and chemical engineering."

Within the next few years, Jacobs also hopes to develop a class for ECE students that will address new developments in micro and nanotechnology.

"There's so much happening in these areas," Jacobs says. "I think it would be very gratifying to introduce more students to the potential this research area offers."

The home page for Jacobs' research group is <http://www.ece.umn.edu/users/hjacobs/>



Bethanie J. H. Stadler

Stadler Moves to Tenure Track, Wins NSF Award

Bethanie J. H. Stadler first came to the Electrical and Computer Engineering Department as an adjunct professor in the Spring of 1997. Last summer she was promoted to an assistant professor, tenure track—a position she won the old fashioned way: she earned it.

"I was able to secure some research funding, chair a couple of symposia, and publish a few papers during my time as an adjunct professor," says Stadler. "I think those achievements helped turn the corner when it came time to interview for my new position as a tenure track faculty member." Her new job status is not the only reward she received for her work ethic. In February, she received a prestigious National Science Foundation (NSF) Career Award.

"The NSF award will help support my research in advanced materials for photonics," she says.

A native of Chardon, Ohio—a small town in the heart of Amish Country not far from Cleveland—Stadler earned a bachelor's degree in materials science and engineering from Case Western Reserve University in 1990. She earned her Ph.D. degree—also in materials sci-

ence and engineering—from the Massachusetts Institute of Technology in 1994.

That same year she was awarded a National Research Council postdoctoral fellowship. Working at the Air Force Research Laboratory, Stadler spent two and a half years studying ways to incorporate magneto-optic structures onto Class III-V semiconductor materials. It was relatively easy, Stadler says, to grow transition-metal and rare-earth-doped indium phosphide on top of a III-V substrate, but the magneto-optic properties of doped indium phosphide are so weak that the devices were impractical.

Around the time she came to the University of Minnesota, she shifted her research efforts to focus on fabricating magneto-optic devices from garnet.

“Finding a way to put garnet onto semiconductors will give us devices that are hundreds of times better in terms of their magneto-optic properties,” says Stadler. “The problem is, garnet is much harder to integrate with these other materials.”

Stadler’s research group—named AIMD, an acronym for Advancing the Integration of Materials & Devices—is conducting a number of current research projects “AIMD” at finding ways to incorporate and optimize photonic and magnetic devices. These include projects that are:

- using thin-film technologies to fabricate integrated magneto-optic devices on semiconducting substrates,
- developing integrated thin film permanent magnets that are critical to advances in magnetic recording media, microelectromechanical systems, photonic integrated circuits, and other arenas; and
- growing self-organizing nanostructures in aluminum oxide for novel photonics and magnetic applications.

“Eventually, we hope to use the aluminum oxide structures as a mask to pattern those same nanostructures into garnet film for applications as photonics crystals,” Stadler says.

Along with her research, Stadler has been busy developing new classes, incorporating new methods—such as team-based classroom competitions—and creating more research opportunities for students both at the undergraduate and graduate level.

Lee Retires from Teaching, But Not Research

After 46 years at the University of Minnesota—first as a student and teaching assistant, then as an instructor, and finally as a member of the Electrical and Computer Engineering (ECE) faculty—it’s hardly surprising that Associate Professor T. S. Lee decided to retire from teaching as of last July. What might perhaps be surprising to some is the reason he decided to give up teaching: so he could have more time to pursue his research interests.

“Much of my research—especially in the area of electrostatics—has uncovered some unexplained phenomena that I want to spend more time on,” says Lee.

So much of his life has been devoted to the world of academia and research, according to Lee, that it would be difficult to pursue any other course of action.

Born in China, Lee grew up in the Yunnan Plateau in Western China, before going off to college in Taipei, Taiwan, where he earned his bachelor’s degree in electrical engineering from the National Taiwan University in 1955. A series of rather unlikely coincidences helped him land at the University of Minnesota.

“Rather early on, I had planned to go to graduate school,” Lee recalls. “One day I came across a catalog from

the University of Minnesota. My only association with Minnesota came from a Benedictine nun—Sister Renee—who had been one of my teachers growing up. I had very fond memories of Sister Renee and decided that anyplace that had produced a person as fine as her couldn’t be all bad.”

Lee wrote a letter to Henry Hartig, who was then chair of the department. Within two weeks he had received a reply, which impressed Lee a great deal, given his experience in dealing with the bureaucratic behavior he had encountered in Taiwan. When Hartig described the environment in Minnesota, Lee was sold.

“I found the Institute of Technology to be very attractive for my interests,” he explains. “Along with engineering, mathematics and physics were an integral part of the institute, which I liked. That was not commonly the case at other universities.”

The combination of disciplines was ideal for Lee, whose interest was not limited to electrical engineering, but ranged through all of what one might consider the physical sciences. It proved to be a good fit. Lee earned his master’s degree in electrical engineering from the University in 1957 and his Ph.D. degree in electrical engineering in 1962. And, when he completed his education, he joined the faculty as an assistant professor.

A brief recap of his research career confirms that his interests continued to be wide ranging. Early on, he did a good deal of work for the U.S. Naval Research Laboratory in Washington, D.C. From 1965-73, Lee worked in three different divisions at the laboratory: Radar, Applications Research, and Plasma Physics. Among his research projects, one focused on characterizing the electromagnetic properties of rocket exhaust; another looked at the concept of using pulsed power generation.

From 1983-87, Lee did a good deal of research for the Lightning and Transient Research Institute in St. Paul, looking at ways to protect aircraft from lightning strikes. In 1984-85, Lee was invited to participate on one of 20 investigative teams trying to discover the cause of the infamous Pershing II accident in Heilbronn, Germany. The Pershing was a U.S. made solid-fuel ICBM. In 1983, a Pershing II missile exploded killing a number of people and the Army didn't know why it had exploded.

These and other projects comprised a productive research career that enticed Lee to pursue studies in everything from solar-terrestrial relations, gaseous discharges, wave phenomena, electromagnetic fields, compressive flow, electrostatics, and electro hydrodynamics (EHD). On the teaching side of things, Lee taught courses in fields and circuits, as well as courses on the fundamentals of acoustics and electromagnetism.

With his retirement from teaching, Lee is now able to focus more directly on a number of intriguing problems. Currently, he is active in two separate research projects. One finds him collaborating with French and Canadian colleagues on field-related EHD phenomena. The other reconnected him with his native China. He is working with an electrical engineering group from China's Tsinghua University in studies on problems related to pulsed-power generation.

"Hobbies hold little interest for me," he says. "But I still have an avid interest in these research problems. After a life dedicated to research, it would be difficult, now, to do anything else."

Cymer Professorship Energizes Leger's Laser Resonator Research

When Cymer, Inc.—a San Diego firm that is the world's leading developer and producer of excimer lasers for use in photolithography—went looking to establish a couple of professorships, the Electrical and Computer Engineering (ECE) Department at the University of Minnesota seemed like a natural candidate. Through nearly 17 years of research and development, ECE Professor Jim Leger has established a reputation for excellence in research and development of laser resonators. (The resonator is the "part that uses mirrors to bounce the light back and forth," Leger explains for the layman.) After visiting with Leger, representatives of Cymer agreed last fall to provide the department with half a million dollars to endow the professorship. Leger was named to the position, which is officially titled: the *Cymer Professorship in Advanced Optical Systems, Metrology, and Lasers*.

"I think that they believe professorships such as this are critically important to the United States and they want to plant seeds that will come to fruition in the future," says Leger.

"The majority of the funds that come along with the professorship will be used to support additional graduate students," Leger says. "But Cymer also wants to ensure that instruction in this kind of laser physics remains alive and well at the University of Minnesota."

According to Leger, many U.S. universities tend to migrate away from research areas such as laser resonators once they become well established in industry. The expectation is that the industries themselves will continue the "R & D" in these areas, but that is often not the case.

"Much of the research in laser resonators has moved to universities in Europe and Japan," he explains. "They seem to get more funding for this kind



Jim Leger

of research than U.S. universities. Recently, however, there has been a revolution in optics that has opened new doors."

Fortunately, Leger has kept the flame burning, so to speak, with his resonator research.

He believes that the increased level of interaction with the industry leader will revitalize his efforts.

"Obviously, Cymer hopes to benefit by ensuring that they can get access to potential employees with the right kind of training—and by fostering research that may one day lead to breakthroughs in product development," says Leger. "But we benefit enormously, too. It goes well beyond the financial support. By interacting with the industry leader, and learning about the problems they face, we get new ideas to guide our research."

"In creating this professorship and another at the University of California-San Diego, Cymer has proven it is a very forward-looking company," says Leger. "Ultimately, many companies—including some of Cymer's competitors—will benefit from these professorships. I think that kind of corporate enlightenment and generosity is amazing."

2001-2002

SCHOLARSHIPS

Hyverinen Scholarship Fund

Brent R. Nelson

Hackborn Scholarship

Matthew M. Dummer

Hartig Fund

Yeetin Chau
Paul (Yang) Cheng
Derwin Halim
Pedro Leiva
Mark J. Lodermeier
July Mulia
Apisek Tewinpagti

Roger M. Nordby Scholarship Fund

Jamin M. Arvig
Michael R. Burr
Daniel Thomas Kollmann
Jesse Ryan Prusi
Justin Tungjunyatham

Oscar A. Schott Scholarship Fund

Jared L. Hawkinson
Eric Paul Ostby
Charles W. Steidl

HKN Scholarship Fund

Yeetin Chau
Matthew M. Dummer
Derwin Halim
Mark J. Lodermeier
Apisek Tewinpagti

Wendell Johnson Scholarship Fund

Matthew M. Dummer

3M Scholarship

Justin Tungjunyatham

FELLOWSHIPS

IBM Fellowship

Mahesh Ketkar

Semiconductor Research Corporation

Noel Hoilien
Kavita Nair

Department Fellowship

Yongru Gu
Karthik Ranganathan

National Science Foundation Fellowship

Ryan Supino

Guidant Corporation Fellowship

Michael Sutton

Graduate School Fellowship

Ryan Cobian

Dissertation Fellowship

Zhengdao Wang

RECENT GIFTS

We would like to thank the following companies for their support during the past academic year.

B H Electronics
Braemar Corp.
Brocade
Cadence
Cray
Cymer Inc.
Dupont Corporation
Envoda
Exxon
Firesummit Inc.
Ford Motor Co.
General Dynamics
Guidant
Honeywell, Inc.
Intel
IBM
Kuck & Associates Inc.
LSI Logic
Microsoft
Minnesota Mining & Manufacturing
National Storage Industry Consortium
Nordby, Roger M. (1940) and Ruth;
\$500,000 to the Nordby Scholarship Fund
Rosemount Engineering Inc.
Samsung
Seagate Technology
Semiconductor Research Corporation
SemiCube, Inc.
Statkraft
StorageTek
Sun Microsystems

Electrical and Computer Engineering

University of Minnesota
200 Union Street S.E.
Minneapolis, MN 55455

ADDRESS SERVICE REQUESTED

Nonprofit Org. U.S. Postage PAID Minneapolis, MN Permit No. 155
