Innovative Self-Powered Sensor Ready for the Marketplace

Taking an invention from conception to commercialization is no easy task. Just ask ECE associate professor Shantanu Chakrabartty. He currently is working on commercial applications for a piezo-floating gate self-powered sensor, which won the 2012 Technology of the Year Award from MSU Technologies.

“The basic technology proves that the sensor works and that the sensor can achieve energy efficiencies that are far better than what is out there now,” says Chakrabartty. “Now we are working on building a complete system that fits various commercial uses.”

It all started soon after Chakrabartty arrived at MSU in 2004. Over several lunch meetings Chakrabartty and another new faculty member discussed ideas for useful inventions. One idea was a sensor that could be embedded in concrete, but the stumbling block was how to make the power to the sensor last as long as the life of the structure. At the time, the available sensors lasted only for a few months if the entire functionality of the sensor was used. Structures, such as buildings and bridges, on the other hand, have life spans of 20 to 40 years.

“My expertise is in ultra-low power integrated circuits, so we started talking about power that can be harvested inside the structure, which should be barely enough to sense, calculate, and store useful information. This information could then be used for preventative maintenance,” Chakrabartty explains.

For example, the Washington Monument in Washington, D.C., was damaged by an earthquake in August 2011. The facility had to be shut down to figure out what part of the building was damaged and is still closed while repairs are being made. Workers had to manually inspect all the parts of the building.

“If these sensors were already embedded in the building, you could just scan the contents of sensors like a bar code to figure out which parts of the structure incurred damage and focus very quickly on those parts,” says Chakrabartty.

So using his research expertise, Chakrabartty came up with the idea of combining piezoelectrics with a non-volatile memory, like the kind found on a flash drive. Piezoelectricity is the charge that accumulates in certain solid materials in response to applied mechanical stress.

“So I figured that if I could directly combine the physics of certain piezoelectric material with the physics of the non-volatile memory, then you could probably push down the energy consumption to fundamental limits. That’s the science part of it. Piezoelectrics can generate enough

Technology Transfer and Commercialization at MSU

MSU Technologies is the university’s technology transfer and commercialization office. This office facilitates the commercial development and public use of technologies and copyrightable materials developed by MSU faculty and staff. The goal is to move MSU’s technologies from the lab to the marketplace. To accomplish that goal, MSU Technologies:

• manages the university’s extensive intellectual property portfolio, evaluating the commercial potential of each invention;
• works with MSU researchers on the invention disclosure and technology transfer process;
• protects inventions by filing patent applications;
• markets and licenses commercially viable technologies to large corporations and small to mid-sized businesses;
• works with Spartan Innovations to launch start-up companies based around MSU technologies;
• facilitates confidential disclosure and material transfer agreements.

More information about this organization is available at www.technologies.msu.edu
I extend my greetings to all the alumni and friends of the Department of Electrical and Computer Engineering.

The ECE Department has students, alumni and faculty that are making important contributions to education, technology development, commercialization of technology, and leadership in companies. A sample of these contributions is certainly found in this newsletter. Two technologies developed by faculty and the students working in their laboratories are described in this newsletter. The work of Prof. Chakrabartty on self-powered sensors is starting the commercialization process. The work of Prof. Mukkamala on cardiovascular monitoring is advancing in commercialization to Series A venture capital funding. Both are clear examples of technology developed in ECE being on the commercialization path to products that can benefit society. The innovation of Prof. Aslam in developing tools and concepts for engineering education that extend across an age range from grade school to graduate school is also highlighted in this newsletter.

Examples of alumni accomplishments in leading education institutions, leading technology groups and companies, and forming companies are also found in this newsletter. I am always impressed by the accomplishments of so many of our alumni. The accomplishments of you the alumni serve as evidence and reminders for our students of the things they can accomplish using their ECE degree as one of the building blocks of their career.

I invite you to stay in contact with us. Your collective ideas can help to continue to build and strengthen the ECE department.

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Asif Naseem (MS ’80, PhD ’84) received the 2012 John D. Ryder Electrical and Computer Engineering Alumni Award at the annual College of Engineering Alumni Awards Banquet in May. Established in 2004, this award commemorates the outstanding professional contributions of John D. Ryder, former dean of the College of Engineering and a professor in the department.

Naseem serves as vice president of the Global Communications Business Unit of Oracle Corporation. Until recently, he served as president and chief operating officer of GoAhead Software, a privately held company that develops and markets high availability and embedded management infrastructure software for telecommunications and the aerospace and defense industries. Under his leadership, GoAhead Software, Inc., grew to become the market leader and the most prestigious company in its category culminating in its recent acquisition by Oracle Corporation.

Naseem began his career with AT&T Bell Laboratories, where he held various technical and management positions including growing and leading the LifeKeeper family of products. Subsequently, LifeKeeper was successfully spun out as an independent business. He then served as general manager of the Internet & Connectivity Solutions Division of Motorola, based in the UK, and was responsible for EMEA (Europe, Middle East, and Africa), where he started and ran a successful wireless applications business for Motorola.

Just prior to GoAhead, Naseem was the chief operating officer of Iospan Wireless, Inc., a broadband wireless company that pioneered the development of smart antenna technologies employing MIMO (multiple input multiple output) for high-speed broadband communication. Iospan Wireless was acquired by Intel Corporation and L3 Communications.

For the past 20 years, Naseem has been actively engaged in key international consortia, driving and promoting standards for the computing and telecommunications industries. He has served on the steering committees of the System Performance Evaluation Cooperative, the Transaction Processing Council, and most recently as president of the Service Availability Forum. He serves on the advisory boards of several telecommunications-related conferences. He is also a frequent author of technical and business papers, and regularly speaks at industry and academic events.

Since graduation, Naseem has regularly visited MSU’s ECE department as an invited speaker, giving seminars to the faculty and students on a variety of topics. He lives in both Naperville, Ill., and Seattle, Wash., with his wife, Deborah Farwell, and their two sons—Armande (age 9) and Amani (age 7). Naseem enjoys flying and playing tennis and is an avid painter in oil and watercolor.
Innovative Self-Powered Sensor (continued from page 1)

Energetic electrons that can then be harvested to write a flash memory.

All of that is what uniquely distinguishes this sensor from any competing technology. The stored statistics on the flash memory can be remotely retrieved and used to predict the onset of mechanical failure or spot where a failure has occurred.

In addition to uses in buildings and bridges, there are numerous other applications for this sensor. One project that Chakrabartty is working on is smart armor. “If a bullet strikes a part of the armor, it leaves a signature,” says Chakrabartty. “So we look at what kind of signature was left, how fast the bullet struck the armor. The impact powers the device itself, so the sensor can compute the statistics and store it in a non-volatile memory. Later, the memory can be scanned, like a bar code, to see which part of the armor may have failed.”

The sensor could be packaged in a variety of different ways. For example, where the orientation of the sensor doesn’t matter, the sensor might be packaged as a ball or sphere that could be thrown into concrete as it is being laid. In biomedical uses, such as hip implants, the size has to be small, so the packaging has to be application-specific. Sensors could also be used in helicopter blades, airplane fuselages, and in a variety of other ways.

Recently, MSU Technologies helped Chakrabartty with this project, especially in obtaining patents and in linking the researcher with interested business partners.

“The innovation with this sensor is from how small of a strain you can harvest the power,” says Chakrabartty. “With this sensor it takes only a small movement to sense, calculate, and store the useful information. A lot of existing technologies cannot match that.”

— Jane L. DePriest

Cardiovascular Monitor Receives $7 Million in Funding

A nother device invented by an ECE faculty member also is making major progress in the marketplace. ECE associate professor Ramakrishna Mukkamala invented a cardiovascular monitor that has the potential to significantly improve critical care for high-risk patients. Now the company doing further development on the device received $7 million in Series A funding from a group of investors led by the Pritzker/ Vlock family office. The company is Retia Medical, an MSU spin-off, headquartered in the East Lansing, Mich., Technology Innovation Center.

Retia, co-founded by Mukkamala and Marc Zemel, Retia’s chief executive officer, will use the new funding to complete product development, submit regulatory filings for Food and Drug Administration approval, and market the monitor.

The monitor is designed to provide an alternative to the more invasive pulmonary artery (PA) catheter, currently considered the most reliable method for tracking cardiac output (i.e., total blood flow). Because organs can die within minutes without oxygen, cardiac output is considered a key metric for monitoring high-risk patients. Though less-invasive technologies than the pulmonary artery catheter exist, they are often inaccurate.

In a recent survey of more than 400 American and European anesthesiologists, 90 percent agreed that cardiac output is a major determinant of oxygen delivery and that oxygen delivery is of major importance for high-risk patients, yet at least 50 percent indicated that they do not use current cardiac output monitoring systems because they are too invasive and unreliable.

“The literature is rife with case studies showing how current, less-invasive technologies fail when significant changes in cardiac output or blood pressure occur. This is exactly when accurate monitoring is of greatest need,” says Mukkamala. “We performed competitive testing during similar hemodynamically unstable conditions and showed dramatic improvements in accuracy with Retia’s monitor that can lead to better clinical decision making.”

Currently, at least 15 million surgical patients and 3 million intensive care patients worldwide could benefit from accurate, less-invasive cardiac output monitoring. “Our vision is to enable physicians to achieve better patient outcomes via improved monitoring,” says Zemel. “Retia’s cardiac output monitor can help clinicians detect when patients go into shock, make faster diagnoses, and optimize fluid and vasoactive drug administration. With this technology, we have the potential to develop advanced monitoring of heart failure and hypertension patients in the hospital and at home.”

More information about Retia Medical is available at www.retiamedical.com.
**Faculty & Staff Networks**

**2012 DARPA Young Faculty Award**

Assistant professor Prem Chahal is the recipient of a 2012 Young Faculty Award (YFA) from the Defense Advanced Research Projects Agency (DARPA). The objective of the DARPA Young Faculty Award (YFA) program is to identify and engage rising research stars in junior faculty positions at U.S. academic institutions and expose them to Department of Defense (DoD) needs as well as DARPA's program development process.

The YFA program provides funding, mentoring, and industry and DoD contacts to awardees early in their careers so they may develop their research ideas in the context of DoD needs. The long-term goal of the YFA program is to develop the next generation of academic scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their career on DoD and national security issues.

Chahal received the funding for his research proposal, titled “Heterogeneous Integration of Nano-Devices for Terahertz Circuit Applications.” The objective of this research is to develop terahertz circuits by integrating nano-devices on silicon substrate. Terahertz (THz) is one of the least explored regions of the electromagnetic spectrum. This is largely because of lack of availability of devices operating at these frequencies. Chahal and researchers in the Terahertz Systems Lab see this project as an exciting opportunity to apply recent scientific advances in nano-devices and introduce practical circuits operating at THz for imaging applications.

Terahertz holds potential for use in high-bandwidth communications, medical imaging, security, spectroscopy, drug discovery, environment monitoring, and quality control, to name a few. Applications for terahertz imaging that are envisioned include detection of skin cancer without biopsies and analysis of wounds under an intact dressing or bandage. In addition, firefighters could analyze gas plumes for hazardous materials from a distance, and security personnel may be able to image through clothing or packaging materials.

Chahal received his PhD from Georgia Institute of Technology in 1999. He joined the MSU ECE department in 2009. He worked as a research scientist at Raytheon and Abbott Laboratories prior to coming to MSU. Terahertz and millimeter-wave electronics are the focus of much of Chahal’s research.

**Frontiers of Engineering Education Symposium**

Professor Dean Aslam was one of a select group of engineering educators who participated in the National Academy of Engineering’s fourth Frontiers of Engineering Education (FOEE) Symposium, held in October in Irvine, Calif. Faculty members from across the country who are developing and implementing innovative educational approaches in a variety of engineering disciplines were selected to participated in the 2-1/2-day event. The goal of the symposium was to share ideas, learn from research and best practice in education, and leave with a charter to bring about improvement in their home institution. The attendees were nominated by fellow engineers or deans and chosen from a highly competitive pool of applicants.

“The Frontiers of Engineering Education program creates a unique venue for engineering faculty members to share and explore interesting and effective innovations in teaching and learning,” says National Academy of Engineering (NAE) president Charles M. Vest. “We want FOEE to become a major force in identifying, recognizing, and promulgating advances and innovations in order to build a strong intellectual infrastructure and commitment to 21st-century engineering education.”

The program focused on innovations in the context, curriculum, and delivery of engineering education. “It is absolutely critical that U.S. engineering educators learn how to become more effective in the classroom, utilizing technology and pedagogy in creative ways in order to produce more innovative graduates who have the ability to address the complex problems of the 21st century,” says Larry Shuman, senior associate dean for academic affairs and distinguished service professor of Industrial Engineering at the University of Pittsburgh, and chair of the FOEE planning committee. “To do otherwise will cede the nation’s place as an educational leader to other, more aggressive countries. At FOEE these outstanding faculty learned about the newest educational developments ranging from MOOCs (massive, open, online, courses) to online publishing.”

The symposium featured informal presentations from the participants on educational tools or curriculum. Aslam’s presentation was on innovative functionalized bricks with embedded intelligence (FBEI). “Hands-on and
open-design FBEI were created, using custom-made LEGO-compatible bricks containing electronic circuits, to spark the interest of learners with different backgrounds and preparation levels—from kindergarten to PhD," says Aslam.

From 2001 to 2012, more than 2,000 learners around the world benefited from FBEI modules. By allowing user-designs, FBEIs made research-oriented and entrepreneurial learning unique and fun. FBEI kits for hands-on national and international courses (K-12, UG and graduate) can promote the FOEE mission in particular and NAE in general.

FBEI modules stimulate extremely simple to extremely complex multidisciplinary engineering learning as evident from design, creation, and testing of Maple-Seed Robotic Fliers (MRF). One-wing MRFs, made using paper and LEGO pieces, can evolve into multi-wing MRFs with on-board microcontrollers, nanosensors, and wireless interfaces—mimicking future drones. New FBEIs being developed include mind-controlled games/robots and DNA Inspired Active Network Arrays (DIANA) for sparking interest in neural and computer engineering areas, respectively.

Aslam, along with Jon Sticklen, director of the college’s Center for Engineering Education Research and the Applied Engineering Sciences program, were among the 72 engineering educators who participated in the event. ECE professor and NAE member Percy Pierre nominated both Aslam and Sticklen.

The 2012 Frontiers of Engineering Education symposium is sponsored by John McDonnell and the McDonnell Family Foundation.

**In Memoriam—Faculty**

Gerald (Jerry) Park, who was an ECE professor for more than 30 years, died April 15, 2012, at the age of 79. After serving in the U.S. Air Force, he graduated from Stanford University with a master’s degree in engineering and earned his PhD at the University of Minnesota. At Stanford, his lifelong hobby of amateur radio qualified him to work at Stanford’s Radio Lab where he set up receiving stations to monitor the very first satellite—Sputnik.

His research interests evolved to focus on electrical systems engineering, including investigations into the first wind power systems, electric vehicles, and power quality monitoring.

He served on the East Lansing School Board, including a term as president for more than 10 years. He coupled his interests in ham radios and education to serve for 15 years as the trustee and adviser for the MSU amateur radio station W8SH and was the “electrical expert” for a WKAR radio call-in show.

Park and his wife, Lois, established the Gerald and Lois Park Amateur Radio Endowed Scholarship Fund at MSU to aid electrical engineering students who are radio operators.

He is survived by his wife of 55 years, Lois; sons Stephen (Carol), Thomas (Jane), and David (Lisa); six grandchildren; two sisters; and many nieces and nephews.

**II-VI Foundation Block-Gift Program**

For the third year in a row, the ECE department has received funding through the II-VI Foundation’s Block-Gift Program.

This year the MSU funding is for “High Temperature Power Converters for Applications in Harsh Environments” with professor Fang Peng as the principal investigator, and for “Synthesis of Diamond Film Material for Electronic Applications” with professors Jes Asmussen and Timothy Grotjohn as the principal investigators.

The mission of the II-VI Foundation is to “encourage and enable students to pursue careers in engineering, science, and mathematics. The company (pronounced “two-six”) was founded in 1971 by Carl Johnson. The name refers to groups II and VI on the periodic table of elements, the two groups of elements serving as the basis for many of the components and materials made by the company, which develops and manufactures optical and optoelectronic devices used in laser and sensor systems.

The foundation reaches out to selected universities across the country and asks researchers to submit “white papers” on scientific topics of interest and importance, such as those from the ECE department that received funding this year. The research proposals include the use of graduate and/or undergraduate student assistance. The resulting proposals are reviewed based on scientific approach, educational potential, and budgetary realism. The campuses and laboratories are visited and then a selection committee awards the block-gifts.

Seven schools were awarded funding for their research during the first year of the program, 2008-2009; 14 schools in 2009-2010; 17 schools in 2010-2011; 19 in 2011-2012; and 21 in 2012-2013.
Alumni Networks

Michael Driscoll (BS ’83, MS ’85, PhD ’88) has been named president of the Indiana University of Pennsylvania, effective July 1, 2012. He left his post as provost and executive vice chancellor of the University of Alaska Anchorage, where he served since 2006. Previously, Driscoll was at Portland State University in Oregon.

Indiana University, about 60 miles northeast of Pittsburgh, is one of 14 state-owned colleges in Pennsylvania; it serves more than 15,000 students. Driscoll replaces interim president David Werner, who has led Indiana since August 2010.

Dave Marutiak (BS ’76, MS ’78) was appointed managing director of Scanbuy in the UK in 2011, after working at Vodafone Global on the Vodafone 360 service.

In London for the past three years, Marutiak returned to the United States this summer now that the local Scanbuy subsidiary is fully operational. Scanbuy, a market-leading barcode services and technology company based in New York City, was the exclusive supplier for the London 2012 Olympics.

Marutiak has held positions in technology planning and implementation with AT&T Bell Laboratories, Lucent Bell Laboratories, RCA Network Services, Wink Communications, Microsoft, Vodafone, and now Scanbuy. For the last 16 years his focus has been on mobile phone software architectures and services and he has worked on business development and service concepts with mobile operators globally.

Jit Saxena (MS ’68), the CEO and founder of Netezza prior to its acquisition by IBM, has joined the board of directors at uTest, the leading provider of in-the-wild software testing. A tech industry veteran with more than 35 years experience, Saxena also serves on the boards for Demandware, Actifio, AppTegic and TIE-Boston.

Most recently, Saxena served as CEO and then chairman of Netezza Corporation, which he founded in 2000. Netezza successfully pioneered the development of data warehousing appliances and remains a leading provider of data warehousing and analytics products for online businesses, retail, telecommunications, financial services and government markets worldwide. Under Saxena’s leadership, Netezza emerged a fast-growing public company and was eventually acquired by IBM in 2009.

Prior to Netezza, Saxena was CEO and founder of Applix Inc, which pioneered decision support applications for open environments. Applix went public in 1994 and later was acquired by Cognos/IBM.

uTest provides in-the-wild testing services that span the entire software development lifecycle—including functional, security, load, localization, and usability testing. The company’s community of more than 50,000 professional testers from 188 countries put web, mobile, and desktop applications through their paces by testing on real devices under real-world conditions. Thousands of companies—from startups to global brands—rely on uTest as a critical component of their product launches for fast, reliable, and cost-effective testing results.

Jill (Elam) Schaumloeffel (BS ’81) has accepted a position at Potomac State College of West Virginia University (WVU) as a visiting professor of information technology. She will teach classes in computer maintenance and repair, networking fundamentals, web design, multimedia creation, and the Adobe Suite of Graphic Applications, as well as advise students.

Prior to accepting this appointment, Schaumloeffel served as an instructor at Garrett College in McHenry, Md.; was a network engineer at Garrett Container Systems, Inc.; and owned her own business, Backbone Enterprises, LLC, where she managed a full-service computer consulting firm, which included customers from Vermont to Georgia.

She and her husband, Art, currently reside in Eglon, W.Va.

In Memoriam—Alumni

Robert “Bob” Edward Bannick (BS EE ’57), 83, of La Habra, Calif., died August 6, 2012. He was born in Flint, Michigan, February 2, 1929, the eldest son of Edward and Sophie Bannick. After graduating from Flint Northern High School in 1946, he was drafted into the U.S. Army and was stationed in Japan during the Korean Conflict. Upon returning from military duty, Bob took advantage of the GI Bill to attend MSU.

After graduation, Bannick moved to northern California, where he began his long career in electrical engineering. He was most proud of the work he did on the Mars Viking space probe. He enjoyed travel and weekend trips to Las Vegas. He was also an avid gardener, and an astute businessman and property owner.

Bannick was preceded in death by his beloved wife, Virginia Gail Bannick. He is survived by his six children: Nicholas (Teresa) Bannick of Richmond, Texas; Elena (Ben) Ross of Reno, Nev.; Elizabeth (Dave) Sullivan of Tucker, Ga.; Karl Keil of Fullerton, Calif.; Sharon (Delton) Quillin of Ruckersville, Va.; and Rick (Kathy) Wardlaw of Charleston, Ind.; nine grandchildren; and three great-grandchildren.

David W. L. Hedding (BS EE ’91) died at the age of 43 on August 19, 2012, at Genesys Hospice in Goodrich, Mich.


An avid sports fan, Hedding belonged to several bowling leagues and participated in many tournaments. He had season tickets to the Detroit Lions and Pistons, collected sport cards of all kinds, and played fantasy football. Hedding was a member of the Grand Blanc United Methodist Church where he played in the hand bell choir and was active in the Methodist Youth Fellowship. He participated in many CROP walks and a trip to the Appalachia Service Project in Kentucky to do home repairs.

Hedding is survived by his wife, Kelli; daughter, Grace; and parents, Dale and Donna Hedding, all of Grand Blanc; two sisters, Deborah Caplan (Kevin Roach) of Palm Beach Gardens, Fla., and Dawn Hellmich (James) of Menands, N.Y., and other family members, special friends, and co-workers.
International Corporate Tour

ECE sophomore Angelica Minissale participated in an intensive two-week tour held in May 2012. The tour gave 10 MSU College of Engineering and Eli Broad College of Business students a firsthand look at international corporations and the global marketplace. Stops on the International Corporate Tour (ICT) included BP (Sunbury, UK), Alcoa (Birmingham, UK), Whirlpool (Como, Italy), Alpine Convention (Bolzano-Bozen, Italy), Bosch Corporation (Stuttgart, Germany), Eaton Corporation (Rastatt, Germany), and Rampa (Hamburg, Germany).

Along with unique perspectives into their organizations, host employers engaged students in project simulations. Examples included “The Trading Game,” presented by BP in Sunbury, England; lunch on the factory floor at Ramp (an MSU alumni-owned engineering firm) that manufactures screws, inserts and other fasteners; and problem solving with representatives of the Alpine Convention, which is an agreement between various countries for the protection and sustainable development of the Alpine Region.

“The students embraced the opportunity to understand other cultures both from a social perspective as well as a corporate perspective,” says Bernadette Friedrich, director of student engagement for the Center for Spartan Engineering. “They saw companies that they are familiar with in an unfamiliar environment and learned that even large corporations have to prepare for and react to local culture while having a global presence.”

Minissale says she did not know what to expect when she stepped on the plane headed for Europe. “I had applied to participate in the tour as a freshman who didn’t know anyone, wasn’t really involved in many engineering activities, and had no clue how to talk with company representatives,” says Minissale. The tour, however, proved very worthwhile for her. “I gained confidence in myself to be able to talk with peers and professionals. The experience of meeting so many people will help me as I start looking for jobs because I will know more about what to say. The tour also expanded my knowledge of what companies do around the world.” She is from Novi, Mich., and is the daughter of Carla and Ernie Minissale.

Not only did the students benefit from the tour, which is in its first year, but several companies on the tour expressed an interest in working with the College of Engineering and Eli Broad College of Business to provide internship opportunities for MSU students, both domestically and internationally.

Participants were selected based on not having been abroad before; having a solid GPA (at least a 3.0); being involved in extracurricular activities; and balancing a work/school schedule. There were four other College of Engineering students on the tour in addition to Minissale: Britney Heatherington, mechanical engineering; Erin Hoffman, computer science; Alexa Jones, biosystems engineering; and Sara Mozdrzech, civil engineering.

The ICT was coordinated and led by the Center for Spartan Engineering and the Lear Career Center.

ACEC Student Paper Competition

ECE doctoral student Andrew Pray won first place in the student paper competition at the 2012 Applied Computational Electromagnetics Conference for his paper entitled “A Stable Higher Order Time Domain Electric Field Integral Equation Solver.” ECE professor Shanker Balasubramaniam and visiting research associate Naveen Nair also contributed to the paper.

The paper describes a method for stabilizing solutions to time domain integral equations (TDIEs) in Electromagnetics. Instability of TDIEs has been an open problem since the 1960s and while schemes exist that yield stable solutions, they are only applicable to geometries discretized using first order (flat) elements, which limits their accuracy. This method yields stable solutions and can be extended to geometries discretized using higher order (curvilinear) elements.

Pray received his undergraduate degree in ECE from MSU in 2009. His thesis adviser is Balasubramaniam.
Gold Club

The College of Engineering’s Fourteenth Annual GOLD Club (Graduates of Lasting Distinction) Reunion was held June 7, 2012. Two ECE graduates, Seward Ford and John Forsyth, were among those honored. More than 60 alumni, guests, and faculty and staff attended the celebration luncheon at the MSU Kellogg Hotel and Conference Center in honor of alumni who graduated 50 or more years ago from the college.

Members of the class of 1962 received 50-year pins in honor of their membership in the GOLD Club.

College of Engineering class of 1962 with Dean Satish Udpa (left to right): Seward Ford (electrical engineering); John Forsyth (electrical engineering); Satish Udpa, dean of the MSU College of Engineering; Robert Fawley (metallurgical engineering); and Frank Margrif (agricultural engineering). Not in photo: Joe Day (mechanical engineering).