Dear Colleagues,

I’m happy to share with you, in this second annual research report from SDSU’s College of Engineering, profiles of growth and progress little affected by the country’s slow economic recovery. In keeping with a university focus on team research, we report here on several major research teams within our college, as well as some that cross university and even national boundaries.

Many funding organizations increasingly encourage cross-disciplinary research in the belief that new cutting-edge technology lies at the intersection of traditional disciplines. The teams described in this volume engage in such boundary-spanning research. Our Convergent Computing Research team is working with computer scientists, electrical engineers and medical doctors at home and abroad to develop new technology for breast cancer imaging. The college’s team of mathematicians and statisticians apply their analytical expertise to answering questions and solving problems for researchers across the campus, as well as regional industries. We also feature a cross-disciplinary team of faculty engaged in training future researchers—undergraduates from across the country who aspire to be scientists and engineers.

Regrettably, this increase in activity among our teams of scientists has not been accompanied by an increase in the college’s external funding. Because the lion’s share of our funding comes from the federal government, the steady tightening of federal budgets makes it progressively more difficult to secure funding. This difficulty is compounded by the fact that two of our large DOD projects are approaching the end of their lifecycles.

As the accompanying charts indicate, both external funding and expenditures decreased during the past fiscal year. This decline was largely due to decreases in the funding of earmark-related projects. However, it is encouraging to note that our grant proposals and awards both increased in number this year. Furthermore, our reliance on the federal government for external funding shrank from 93 percent to 87 percent. Of that federal funding, about 45 percent came from the Department of Defense, while NSF and NASA dollars accounted for approximately 25 percent of expenditures. I can also report that, at the departmental level, electrical engineering and computer science generated 55 percent of expenditures, mechanical engineering 12 percent, and the remaining departments roughly 6 percent each. While the data indicate lower numbers overall, the greater diversification of funding sources is promising.

Despite the decline in funding, our optimism and confidence remain strong, buoyed by substantial increases in the college’s research infrastructure. The research
One of the newer research teams in the College of Engineering, housed in our Mathematics and Statistics Department, extends its influence beyond both the department and the college to meet the needs of the SDSU research community and many parts of the private sector for mathematical and statistical analyses, computational science, predictive analytics and bioinformatics. This young team, nearly all of whom are assistant professors, includes Drs. Matt Biesecker, Tom Brandenburger, Gemechis Djira, Xijin Ge, Gary Hatfield, Dong He, Jung-Han Kimn, Maurice Ling, Yunpeng Pan and Chris Saunders. Department head Kurt Cogswell is also an active member of the group.

The team’s equation for success adds skills in mathematics, statistics, and computational science to knowledge of applied discipline ‘X’; the result equals a better understanding of how systems work in these disciplines. Over the past five years, team members have demonstrated a remarkable ability to join a project in a discipline that is new to them and to quickly come up to speed and make a significant contribution. They have worked on an impressively diverse array of projects, including mathematical, statistical and computational modeling of agricultural commodity futures prices, Board of Regents student data, bone density degradation, DNA in cancer cells, electrical charge transport in solar cells, fish populations in northeastern South Dakota lakes, forensic handwriting identification, grape genetics, long-term preservation of online scientific databases, neutrino oscillations, OSHA workplace safety program success rates, pharmaceutical effectiveness, prairie cordgrass root structure and regional financial organization profitability and risk management.

In addition to supporting many other research teams, these faculty members also run their own research projects. For example, Dr. Ge has funding from the National Institutes of Health to investigate subtle differences in the DNA of normal and cancerous cells, leading to better and earlier detection of breast and other cancers. Dr. Saunders has funding from the National Institute of Justice to develop sophisticated statistical models for use in forensic handwriting identification procedures.

The work of this team fills a unique support role to both the college and the university by providing the mathematical, statistical or computational element that is often critical to many research proposals. The team is now grappling with a surging demand from the financial industry for assistance in making sense of newly created databases of client transactions. Our skilled researchers use existing algorithms and develop new ones to mine meaningful, business-actionable information from the terabytes of data collected in various forms. There is more work out there than there are faculty and students to perform it. If you are looking for support for your next project, you had better get in the queue quickly!
Meeting Needs through Service, Education and Fundamental Research

July 2, 2012, marked the 150th anniversary of the Morrill Act, the federal legislation that created the land-grant system. As a land-grant institution, SDSU strives to meet the needs of the state and the region. The contribution of SDSU’s Water and Environmental Engineering Research Center (WEERC) to meeting that mission is more than just a drop in the bucket. Since 1990, WEERC has been engineering solutions to water resource and environmental issues of local, state, regional and national interest.

Exiting WEERC Director Professor DeBoer summed up the world of water in three words: “Water is life.” This simple statement frames a very complex area of study. While water research is often perceived as a single, uniform field, diving beneath the surface reveals a wide variety of distinct areas of research. SDSU’s water research team brings together a broad range of specializations that produce both fundamental understanding and applied solutions for municipalities and industry.

**Clean Water.** One of the primary interests of WEERC researchers is ensuring a sustained supply of quality drinking water. South Dakota has one of the world’s largest networks of regional water systems. Professor Chris Schmit, new WEERC director, and DeBoer have trained nearly 500 advanced water and waste-water operators throughout the state. These technicians have adopted and implemented the training in their service areas to improve operations that affect the water quality and environment of all South Dakotans. WEERC has a profound impact on how rural water systems are currently being operated in the state. One innovation that emerged from a recent study was the development of a satellite-based system to read water meters in remote locations. In Schmit’s words, this is just one example of “a little ripple making a great impact.”

**Waste Water.** Water is a surprisingly scarce resource; only 3 percent of the water that covers our planet is potable. Given its increasing scarcity, researchers like Schmit are working hard to find more efficient ways to reuse it. Waste water, or water that is no longer used for its intended purposes, is discharged through a pipe into the environment. This water can be treated and reused for something else (such as watering a golf course) or discharged into ground water for eventual use. Waste water can also be viewed not simply as something to be treated but as a resource that can be harvested. Researchers are exploring new ways to extract energy from the organic molecules and heat contained in waste water and to convert that energy into a useful form like electricity or biofuel. As Schmit says, “we study water as it moves through the cycle and manipulate the cycle to benefit public health and make the system as sustainable as possible.”

**Water and the Natural Environment.** WEERC researchers are also studying interactions between surface and ground water systems, contaminant transport, bioindicators and metals in water. In a project funded by the National Science Foundation, WEERC researcher Professor Berdanier, head of the Department of Civil and Environmental Engineering, is working with Tribal Colleges in South Dakota to develop a pre-engineering curriculum that engages students in research. In the process, the primary research interests that have emerged among the Native American students are the environmental impact of metals in soils, plants and water.

**Water and the Built Environment.** The physical impact of water both inland and in coastal regions is another area of study. Professor Ting describes his National Science Foundation-funded research on sediment suspension in breaking waves as an effort to “improve the knowledge base at a fundamental level.” His research using computer simulation models has a goal of predicting what will happen when a storm or weather system hits a coastline. This fundamental understanding can also be used by transportation officials to interpret the physical impact of water on bridges, dams, highways, and other infrastructure. Ting’s basic research on bridge scour contributed to a Department of Transportation manual for highway maintenance.

Although their areas of interest are quite disparate, SDSU’s water researchers seek out opportunities to collaborate with one another. They have found multiple occasions to support each other in developing grant proposals, conducting studies, writing journal articles, and providing service. They aspire to grow SDSU’s water research program and develop a critical mass of people to enable more collaboration with each other and with peer institutions.
PHOTOVOLTAICS TEAM
Developing, Delivering and Promoting Solar Energy

Solar energy currently provides less than 1 percent of the world’s total energy, though it has the potential to provide much more. Barriers to widespread solar power generation include fabricating cells that efficiently capture the sun’s energy, converting the energy to useful forms, then storing and distributing it for use. SDSU’s photovoltaics (PV) team is strategically positioned to address these concerns with proficiency in solar cell efficiency and systems integration. The work of this team ranges from nanoscale devices to entire renewable energy systems.

A Hybrid Cell. Among PV programs in universities across the nation, SDSU is unique in combining expertise in organic materials, inorganic materials, and nanocharacterization. The team is currently focused on developing a high efficiency broadband hybrid (organic and inorganic) multijunction solar cell. They aspire to combine the stability of high bandgap inorganic material with the absorption characteristics of low bandgap organic material in a self-sealing device. Assistant Professors He and Yan are concentrating on the organic layer of the cell, with He pursuing the most efficient organic dyes that can absorb light in the visible to near infrared regions, while Yan assembles sandwich-type phthalocyanine nanostructures with low energy bandgap optimized for the longer wavelengths of the solar spectrum.

Associate Professor Fan is designing the stable, inorganic top layer of the hybrid cell. He is manipulating silicon to find the optimal nanoparticle size for broadband absorption, wrestling with the challenges of forming controllable-size nanoparticles and putting them in a matrix that can hold the nanoparticles uniformly dispersed. Fan is using the new technique of plasma electrolysis to create the silicon nanoparticles as well as a light-trapping textured surface on crystalline silicon for the antireflective layer that will be part of the cell.

Assistant Professor Qiao is working on the third piece of the puzzle, what he calls “morphology engineering of organic/inorganic hybrid materials.” Qiao is investigating different materials at the interface to maximize charge separation and transport, and experimenting with composites and surface treatments to chemically link the organic with the inorganic layers of the cell.

Assistant Professor Baroughi is combining modeling and simulation to investigate the electronic properties and transport of energy carrying particles in the nanostructured interfaces throughout the hybrid devices. Baroughi’s work targets high throughput, stable, and reliable solar cells that utilize low-cost electronic materials.

A Delivery System. In the pursuit of renewable energy, developing stable, efficient solar cells, though important, is only the beginning. Professor Galipeau explains that “the driver of the PV system is not the cell.” Solar cells only account for approximately 25 percent of system cost. The major costs tend to be the system’s structure, wiring and electronics. The primary challenge is how to integrate the systems and use resources effectively. Members of the PV team are exploring the system design and management necessary to effectively integrate solar energy and connect it to the grid.

Assistant Professor Tonkoski has found that utility companies “don’t trust renewable energy because they believe it is unreliable, they can’t control it, and they don’t want to add another variable to their system.” Tonkoski would like to provide services to utilities that reduce power system distribution loss and provide voltage support for feeders by supplying reactive power and voltage regulation, making the system responsive to problems. “We need distributed control to make PV systems operate together to meet the needs of the utility companies.” Tonkoski envisions cooperative microgrid technology neighborhood systems with controlled loads and dispatchable resources. Such an infrastructure would enable neighborhoods to participate in the energy market and reap the benefits of renewables.

PV team members Baroughi, Tonkoski and Galipeau are collaborating with researchers throughout the college in the use of image processing and distributed sensing to develop short- and medium-term solar irradiance forecasts. With a forecasting structure, the neighborhood microgrid could use controllable loads to reduce demand during peak hours when utility companies need excess power. This system would lower uncertainty, increase the price utility companies will pay for the energy generated, and mitigate distrust of renewable energy.
Research experience is one of the most effective means of preparing students for careers in science and engineering. Engaging undergraduates in research further serves to both attract students to and retain them in STEM disciplines. Assistant Professors Jung-Han Kim (PI, Mathematics and Statistics) and Stephen Gent (Co-PI, Mechanical Engineering) received funding from the National Science Foundation to launch a Research Experiences for Undergraduates (REU) Site program in summer 2012. From a pool of more than 90 applicants (representing 30 states and three countries) ten students were selected to engage in an intensive eight-week program of computational simulation and analysis of engineered systems.

These students learned about both the theory and application of simulations as they engaged in the generation and validation of realistic physical models, the estimation of model parameters, and the prediction of salient physical phenomena. The students gained first-hand knowledge of how simulation methods are selected and implemented, and how simulation results are analyzed and interpreted. Guided by faculty mentors and graduate student assistants, the REU students selected and conducted research projects in the areas of computational fluid dynamics, computational science, photovoltaics and statistics.

**Computational Fluid Dynamics (CFD)** (Primary faculty mentor: Dr. Stephen Gent). One application of CFD is in the design and analysis of photobioreactors for algae production. A photobioreactor (PBR) is a controlled system, similar to a bubble column or air lift reactor, that manages light, carbon dioxide and additional nutrients. Students who selected this research area used CFD tools to reveal bubble and water-flow patterns, heat-transfer effects, light effects and nutrient management within PBRs in an effort to improve PBR designs to enhance microalgae production for biofuels and bioproducts. A second application in CFD...
principles is modeling the effects of grain drying, in which hot air is forced through a packed bed of grain. Students on this project developed a stand-alone computer application to predict the drying characteristics of grain.

**Computational Science (Primary faculty mentors: Drs. Matt Biesecker and Jung-Han Kimn).** In collaboration with faculty researchers, students working in this area focused on mathematical analysis for computational or theoretical improvement during numerical implementation for mathematical models of physical phenomena. Emphasis was placed on understanding the theoretical foundations of underlying physical or mathematical models, selection and implementation of appropriate computational methodology, and interpretation and validation of results.

**Photovoltaics (Primary faculty mentor: Dr. Venkateswara Bommiisetty).** Organic photovoltaics, a potential alternative to conventional inorganic solar cells, may significantly reduce the cost of power consumption and offer new flexible device designs. Research in this field focused on improvements to the absorption characteristics of the active layer of bulk heterojunction (BHJ) solar cells, and the engineering of charge transport processes within the active layer and at the interfaces. Student research projects included the use of a hybrid Monte Carlo Poisson-based method to simulate charge transport processes, generation of 2D and 3D meshes to simulate BHJ cells, and simulation of photocarrier generation and dissociation in BHJ cells.

**Statistics (Primary faculty mentor: Dr. Gemechis Djira).** Students who selected this focus were introduced to contemporary graphical and numerical descriptive statistics as well as inferential statistics based on real-world data and Monte Carlo simulations. Participants learned to construct research hypotheses, apply appropriate descriptive and inferential statistical methods, interpret results, and transform voluminous data into information useful for decision-making. Projects included analysis of real cross-sectional or panel data; nonlinear regression involving numerical optimization and model assessment via bootstrap sampling; and simulation of average sample number, type-I, and type-II error rates in group sequential analysis of clinical trials data.

In addition to conducting state-of-the-art multidisciplinary research, the REU students benefited from a variety of professional development and enrichment opportunities. They participated in a series of seminars on the responsible and ethical conduct of research, led by Norm Braaten, SDSU research compliance coordinator. They enjoyed a detailed presentation on SDSU’s high performance computing center. They toured POET, a biorefinery that produces ethanol, high protein animal feed, bio-based oils and lubricants. They visited the Earth Resources Observation and Science Center, a data management, systems development and research field center for remote sensing operated by the U.S. Geological Survey. And they learned about professional presentation and publication of research results with some of them preparing to present at regional and national academic conferences.

REU program directors Kimn and Gent were very pleased with the results of the first year of their three-year program. Independent evaluator Assistant Professor Ken Emo collected both formative and summative evaluation data from participants that will be used to refine subsequent iterations. Their experience working with undergraduate researchers reinforced for Kimn and Gent the need to relate complicated material back to what students already know, the importance of capitalizing on the variety of ways students learn (from peers, graduate students and faculty members), and the delight of watching exceptional students make tremendous progress each day.
Sung Shin, professor of computer science, is the director of the Convergent Computing Laboratory, one of the newest laboratories in the College of Engineering. Collaborating with researchers both at home and abroad, Shin is part of an international team developing a microwave tomography (MT) imaging approach to the detection of breast cancer.

At SDSU, Shin is supported by coinvestigator Wei Wang, assistant professor of computer science, who directs six graduate students working on the project. Carrie Hruska, an SDSU electrical engineering graduate who recently completed a Ph.D. in the biophysics program at Mayo Clinic, brings the practitioner’s perspective to assist with translating this technology from the bench to the clinic.

Abroad, Shin is partnering with South Korea’s leading breast cancer researcher, Dr. Wu-Kyung Moon, M.D., of Seoul National University, Dr. Soon-Ik Jeon at the Electronics and Telecommunications Research Institute, and Dr. Hyung-Do Choi from our sister university, Chung Nam University, (both in Daejeon, South Korea).

While his counterparts in South Korea focus on the development of the instrument, Shin and his domestic colleagues are tackling the four-part image processing task. The first stage in this undertaking is the use of an edge detection approach to locate cancer tissue with an MT image. This is followed by the development of an algorithm that will segment the breast cancer tissue portion of the image from the normal tissue. One of the toughest steps is making the cancer tissue identification process independent of orientation in the image. The last major phase is the comparison of the extracted MT cancer image to imagery obtained through standard magnetic resonance imaging (MRI) methods. This step capitalizes on the wealth of breast cancer information that already exists in MRI databases.

The significance of this project lies in the fact that it provides a method of cancer detection that achieves the necessary balance between accuracy and cost. Normal breast cancer screening methods rely on mammography, an approach that, while relatively inexpensive, is limited in its ability to detect cancer in dense breast tissue (where cancer progresses faster). Conversely, MRI is a very accurate but extremely expensive procedure that is not normally used for cancer detection. The tremendous advantage of MTI is that it has the potential to detect breast cancer with greater accuracy than mammograms, while doing so at a similar cost.

Since its inception, Shin’s project has relied upon simulated MT imagery because MTI has not been approved for use on human subjects. However, in the summer of 2012, Seoul National University obtained MTI prototype imagery from its first human subject. Shin and Wang are eager to perfect their algorithms using real human images during the 2012-2013 academic year. This project will likely continue at SDSU through 2015. If successful, this research will lead to earlier and more accurate breast cancer detection, impacting the health of thousands of women and men throughout the world.
In 1990, Dr. Dennis Helder, Distinguished Professor of electrical engineering and associate dean for research, made a cold phone call to USGS EROS to inquire about opportunities for collaboration. This call marked the founding of SDSU’s Image Processing Laboratory, the oldest research lab in the college, and led to an on-going relationship with EROS, a major supporter of the lab. Today the laboratory has 15 students and staff working on a variety of projects related to the calibration of optical remote sensing satellite systems.

The laboratory is organized into teams with staff leaders who represent a diverse set of educational backgrounds and science expertise.

Dave Aaron, assistant professor of physics, leads a team that focuses on the development of pseudo invariant calibration sites, or PICS. These sites are extremely stable locations on the Earth’s surface (generally found in desert regions) that can be used to monitor the calibration of remote sensing satellites. Because these sites do not change over time, researchers can safely assume that any changes noted in satellite imagery of PICS must be due to the instrument and not the subject. Thus, PICS have become a preferred method for measuring small changes (on the order of 1-2 percent) in satellite responsivity. Aaron and Larry Leigh (below), also lead a team performing absolute calibration of on-orbit satellite sensors based on direct ground measurements of a calibration site located near Brookings.

Leigh, whose background is in mechanical engineering, leads a group endeavoring to compensate for atmospheric distortions in satellite imagery. This project represents a key step towards achieving the land remote sensing goal of observing what is occurring on the Earth’s surface. Leigh’s team has assembled information from a variety of databases collected by satellites and other sensors during the past 40 years to develop the ability to estimate atmospheric effects at any time and in any location since the launch of the first earth remote sensing satellite in 1972.

Assistant Professor Michele Kuester leads a team that is focused on supporting the calibration of a new set of sensors being developed by NASA that will be launched in early 2013. The Landsat Data Continuity Mission will put into orbit the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS), two sensors that will provide far more accurate imagery with respect to radiometric resolution and signal-to-noise ratio. Kuester’s doctoral work was in atmospheric physics, and she designed some of the laboratory testing for the OLI when she worked at Ball Aerospace. Her team will be particularly busy for the first 90 days following the launch as they participate in the on-orbit initial verification of the new satellite.

Working closely with EROS is a major part of Josh Mann’s activities as a team leader. Mann, who is also trained as a mechanical engineer, heads the team that supports development of the Image Assessment System (IAS) at USGS EROS. The IAS is part of the ground processing system that strips calibration and quality information from every image downloaded from Landsat satellites to assess the performance of the spaceborne sensors. Thanks to the work of this team and the IAS, many small anomalies in data collected from the Landsats series from 1972 through the present have been identified and corrected. Improving imagery collected from sensors decades ago provides the most accurate space-based record of changes that have occurred on the Earth’s surface during our lifetime.

The SDSU Image Processing Laboratory is an excellent example of team research in the College of Engineering. With an international reputation as a leader in optical remote sensing satellite calibration, the lab regularly hosts international interns and is currently hosting a visiting scientist from Thailand. Future goals of the lab include developing a calibration capability that not only supports U.S. satellites, but extends to all satellites worldwide to maximize the utility of remote sensing imagery.
ENGINEERING AWARDS

2011 Grantswinship Awards

Beginning with fiscal year 2011, the College of Engineering has instituted an award program that recognizes all faculty who have developed a substantial amount of research and external funding activity. The criteria for receiving one of these annual awards is that the faculty member must have received, or had expenditures of, external funding in the amount of $100,000 or more during the fiscal year. This year we were delighted to make these awards to 18 individuals from all departments within our college. Our congratulations go to each of them, and we hope to present the same award to them next year, as well as to additional faculty members.
Dr. Delvin DeBoer 2011 Researcher of the Year
DIRECTOR, WATER & ENVIRONMENTAL ENGINEERING RESEARCH CENTER
PROFESSOR, CIVIL & ENVIRONMENTAL ENGINEERING

Dr. DeBoer’s research program has focused primarily on water quality, water treatment and water distribution related to municipal and industrial systems. He has been the principal or coprincipal investigator of 33 projects resulting in external grant funding of $5.5 million. His research projects, focusing on finding practical solutions to problems faced by water supply systems, have enabled 64 master’s-level graduate students to accomplish their requirements for a thesis or design project. Outreach activities from these projects frequently included on-site operator training and local/regional conference and seminar presentations. Dr. DeBoer has authored/co-authored 10 published articles and has provided 70 presentations at local, regional, national and international conferences. As director of the Water and Environmental Engineering Research Center, Dr. DeBoer was instrumental in developing the Regional Water System Research Consortium. This consortium conducts research and development projects to support the sustainability, management and operations of South Dakota’s regional rural water systems with funding from stakeholders as well as federal and state agencies. Dr. DeBoer served as the vice chair, chair, past chair, and director of the South Dakota Section of the American Water Works Association. In recognition of his service, he was awarded the George Warren Fuller Award by the South Dakota Section in 1992 and became a Life Member of AWWA in 2011. He serves as the chair of the South Dakota DENR Operator Certification Board, to which he has been an appointed member for the past 21 years. Dr. DeBoer also served as a director of the South Dakota Water and Wastewater Association from 2008 through 2010. Despite his many impressive accomplishments, Dr. DeBoer is most proud of his work with his graduate research assistants who have, in his words, “gone on to distinguished careers, designing and managing projects that solve environmental problems, renewing the water environment infrastructure, and building the quality of life. Their professional lives are the final outcome.”

Dr. Qiquan Qiao 2011 Young Investigator of the Year
ASSISTANT PROFESSOR, ELECTRICAL ENGINEERING

Dr. Qiao’s research of next generation cost-effective solar cells focuses on new approaches to enduring challenges in photovoltaic technologies. Specifically, his team is working on (1) increasing light absorption through the design and synthesis of new organic semiconductors, including broadband polymers; (2) enhancing charge transport through the growth and optimization of inorganic nanostructures with high carrier mobility, such as ZnO and CdSe nanorods; (3) maximizing power output by engineering donor/acceptor morphology; and (4) fabricating and testing high efficiency single- and multijunction solar cells.

Dr. Qiao has published more than 20 peer-reviewed papers in leading journals on organic solar cells and dye-sensitized solar cells. Two of his papers, published in Energy and Environmental Science, were among the journal’s ten most-read articles in July and August 2010. Another of his papers, published in the Journal of Photochemistry and Photobiology A: Chemistry, was one of that journal’s most downloaded articles. Dr. Qiao has filed one patent and submitted several other invention disclosures to SDSU’s Technology Transfer Office. He also established SDSU’s Organic Electronics Laboratory, a teaching and research lab devoted to studying organic electronic materials and devices for photovoltaics.

In addition to his recent receipt of the 2012 College of Engineering Young Investigator Award and one of the 2012 College of Engineering Grantsmanship awards, Dr. Qiao was also a recipient of the 2010 Excellence in Research Award from the College’s EECS department. In 2010, Dr. Qiao was granted an Early Career Award from the National Science Foundation, and in 2009 he received the Bergmann Memorial Award from the US-Israel Binational Science Foundation. During his graduate study, Dr. Qiao received the 2006 American Society of Mechanical Engineers Solar Energy Division Graduate Student Research Award and the 2006 Chinese Government Award for Outstanding Students Abroad.

3M Non-Tenured Faculty Grant

Dr. Qiquan Qiao is the first member of the Electrical Engineering faculty to be awarded the 3M Non-Tenured Faculty Grant, an unrestricted annual award of $15,000 for up to three years. These grants from the 3M Foundation provide financial support to new faculty members while encouraging them to remain in academia, teaching and conducting research of general interest to 3M, and to develop an awareness of science in an industrial setting.

Dr. Qiao’s award will support his efforts to invent new polymers and novel nanostructures and integrate them with 3M tapes for next generation flexible electronics. According to Dr. Qiao, “The key innovation of this project lies in the invention of novel polymers and nanostructures with potentially variable bandgaps, controllable energy levels and high carrier mobilities that are significantly superior to existing materials.”
All departments in SDSU’s College of Engineering are making contributions to grand challenge research areas as shown in this matrix.

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