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Research Edition 2014



ANNUAL RESEARCH EDITION
COLLABORATION: THE NEW (AND BETTER) NORMAL



Message from Dean Walz

Since becoming dean of the University of Kentucky College of Engineering two years ago, I have set my sights on UK becoming a top 50 college of engineering. An essential component that will determine whether we are successful is our ability to conduct groundbreaking research in areas that will transform our world. This annual research edition of *Kentucky Engineering Journal* is designed to highlight the areas where such revolutionary exploration is possible and where we are making substantial advances.

Over the last few years, we have seen a notable increase in the number of grant awards involving faculty members strategically collaborating across different departments, colleges and even universities. Eric Grulke, the college's associate dean for research and graduate studies, provides an overview of the interdisciplinary research efforts taking place within the college. His essay is followed by an infographic that highlights the five key research areas I believe are crucial to making a better world, as well as the key faculty members leading the way. Also in this research edition, we profile one of our most celebrated professors, Dibakar Bhattacharyya—better known as “DB.” His current grant portfolio is proof he simply gets better with age. In addition, we are featuring one of our exciting new hires, Director of Strategic Initiatives Tony Elam. Finally, we put our spotlight on mechanical engineering Ph.D. student Ann Whitney, who came to us after earning her undergraduate degree at Purdue University.

We are striving to be among the best colleges of engineering in the country and I hope this research edition demonstrates we have the strategic focus and talented personnel necessary to reach our goal.

Sincerely,

John Y. Walz
Dean

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FRONT COVER

Professor Hank Dietz, the James E Hardymon Chair in Networking (front) and student Matt Wiggins (rear) make adjustments to a cluster supercomputer housed in the state-of-the-art Davis Marksbury Building.

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COLLABORATION: THE NEW (AND BETTER) NORMAL

by Eric Grulke, Associate Dean for Research and Graduate Studies

Research collaboration, a way of life for many engineers, has been a major topic for funding agencies nationwide. Since 2010, there have been a number of new federal initiatives for science, engineering and technology—complex projects seeking real solutions. During the first decade of this century, nanotechnology was a major theme, involving over 20 federal agencies that were brought together by the National Nanotechnology Coordination Office. Today, new federal initiatives include:

- Big data¹
- Convergence² (research at the interfaces of life sciences, physical sciences and engineering)
- Advanced manufacturing³
- Materials genome⁴

Most of these initiatives involve multiple federal agencies providing funding for relevant and complicated technologies, offering high reward for the high-risk investment.

Because the University of Kentucky has Colleges of Medicine; Agriculture, Food and Environment; Engineering and Arts & Sciences on the same campus, we are particularly well-positioned to contribute to collaborative projects in these areas of national need. In fact, over the last few years, over 80% of our awards have been collaborative.

Research on big data within the college spans bioinformatics with our Markey Cancer Center and our Center for Clinical and Translational Sciences to archiving images for the W.T. Young Library. Research in convergence areas includes drug discovery with our College of Pharmacy, medical devices with our College of Medicine and a fundamental understanding of cancer, dental diseases and biological/biochemical processes.

We have recently teamed with researchers at the University of Michigan to win an advanced manufacturing award from the Department of Defense: the American Lightweight Materials Manufacturing Innovation Institute (ALMMII). The ALMMII collaborative will work in four areas: 1) rapidly maturing and demonstrating production scale-up of innovative lightweight alloys, 2) shortening the time for design and integration of new metals into new products, 3) developing more competitive automated manufacturing processes and 4) developing tools and training for the computational materials engineering workforce. This last element has a link to the materials genome effort and builds upon our long-term expertise in light metals.

More interdisciplinary research funding announcements are being made every month; we anticipate more funding success based on our ability to work across disciplinary lines. [KEJ](#)

¹Andrew McAfee and Erik Brynjolfsson, Big Data: the Management Revolution, Harvard Business Review, Oct. 2012.

²Phillip A. Sharp, et al., The Third Revolution: the Convergence of the Life Sciences, Physical Sciences and Engineering, MIT Press, Jan. 2012.

³PCAST, Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, Office of Science and Technology Policy, July 2012.

⁴John P. Holden, Materials Genome Initiative for Global Competitiveness, OSTP, June 2011.

STRATEGIC RESEARCH AREAS

ADVANCED MATERIALS & COMPONENTS

David Puleo, Biomedical Engineering

With support from the NIH, NSF, U.S. Army and private foundations, Puleo has organized cross-institutional research teams of engineers, scientists and clinicians to develop and test biomaterial-based strategies for regenerating tissues including bone, growth plate cartilage and muscle lost as a result of injury, degeneration and disease.

Haluk Karaca, Mechanical Engineering

Thanks to a NASA EPSCoR and two NSF awards, Karaca is developing environmentally-friendly, silent and multifunctional high temperature and magnetic shape memory alloys, as well as shape memory composites with tunable material properties to replace conventional actuators, sensors and dampers.

COMPUTATIONAL SYSTEMS & HARDWARE

Ruigang Yang, Computer Science

With NSF funding, Yang is engaged in two multidisciplinary projects with diverse objectives. One initiative involves the development of computational algorithms that can use low-cost 3D sensors to precisely monitor a patient's gait for health-related applications (such as physical therapy) and the other project is aimed at creating a robot that can perform welding operations remotely via human actions.

Robert Adams, Electrical & Computer Engineering

John Young, Electrical & Computer Engineering

Building on a decade of support from the Office of Naval Research, Adams and Young are working with colleagues to develop software tools that model electromagnetic signatures of naval vessels. Work that began with basic algorithmic development has progressed to ongoing development of production quality tools designed to help understand the electromagnetic properties of existing and future vessels.

INFRASTRUCTURE SYSTEMS

Sebastian Bryson, Hardin-Drnevich-Huang Professor in Geotechnical Engineering

Bryson recently completed a \$2.72 million multi-agency, multidisciplinary project for the National Institute for Hometown Security that researched how to best protect against waterside terrorist attacks on dams. The same agency has also granted him \$2 million to research methods that will enhance the resiliency of water distribution systems.

Kelly Pennell, Civil Engineering

Using cross-disciplinary collaboration between social science, public health and environmental engineering/science, Pennell's research investigates how contaminants move in the environment and develops techniques to reduce human health effects of environmental contamination. Her research team uses computational models, laboratory experiments and field data to bring relevant solutions to environmental challenges.

ENERGY, MANUFACTURING & SUSTAINABILITY

Sue Nokes, Biosystems & Agricultural Engineering

Thanks to a four-year \$6.9 million federal grant, Nokes is spearheading a multidisciplinary, multi-institutional team of researchers that is investigating ways to produce environmentally-friendly biofuels from post-harvest leftovers like wheat straw and corn stover, as well as crops grown specifically for fuel processing, including indigenous switchgrass and miscanthus.

Jeffrey Seay, Chemical Engineering

Seay's passion for sustainable energy has led him to the sub-Saharan African countries of Cameroon and Gabon, where he and his research team have developed a non-electronic biodiesel processor made from junked parts, discarded oil drums and scrap metal that uses indigenous, non-edible oils to make the biofuel.

HEALTH & THE HUMAN CONDITION

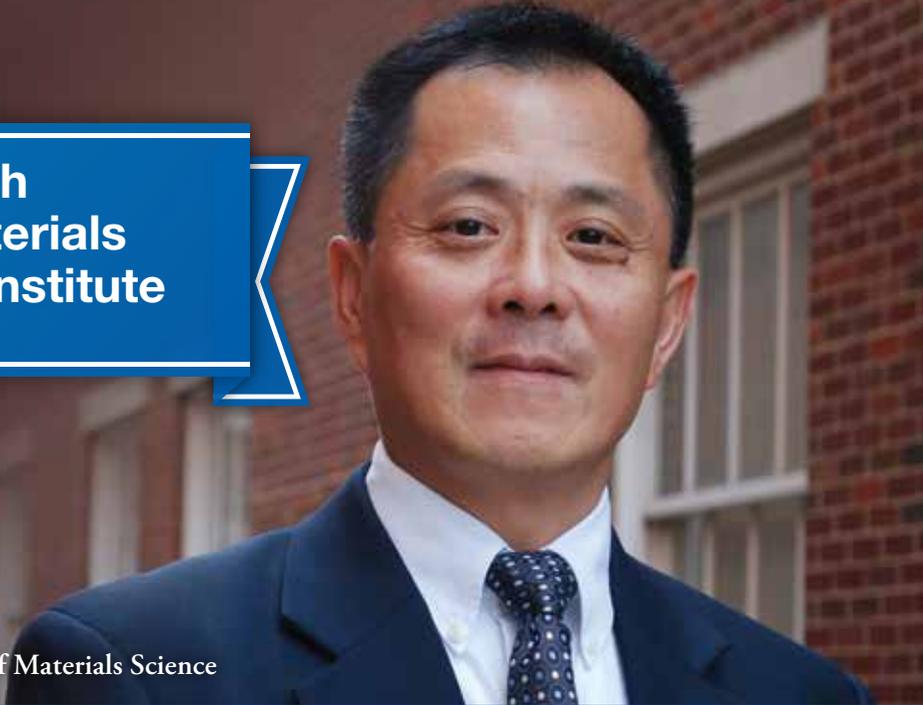
Dan Pack, Ashland Inc. Chair in Chemical Engineering

Pack's primary research focus is on the engineering of advanced drug delivery systems with an emphasis on human gene therapy for the prevention, control and treatment of disease. His research involves interdisciplinary partnerships between the Colleges of Engineering and Pharmacy in the area of biopharmaceutical engineering.

Tom Novak, Alliance Coal Chair in Mining Engineering

Chad Wedding, Mining Engineering

Novak and Wedding received \$670,000 from the Alpha Foundation and will receive \$1.25 million from CDC/NIOSH to design innovative scrubbers that remove respirable coal dust in underground mining. The scrubbers will protect coal workers from pneumoconiosis, a debilitating and irreversible lung disease tied to long-term overexposure to respirable coal dust.



UK Helps Launch Lightweight Materials Manufacturing Institute

by Keith Hautala, UKPR

Y.T. Cheng

Frank J. Derbyshire Professor of Materials Science

Kentucky is both benefiting from and making important contributions to Detroit's new \$148 million lightweight materials manufacturing institute, announced in late February by President Barack Obama. The American Lightweight Materials Manufacturing Innovation Institute (ALMMII) will receive \$70 million in Department of Defense funding, with \$78 million in matching support from a public-private consortium, including more than \$4 million from Kentucky.

ALMMII is charged with developing and deploying advanced lightweight materials manufacturing technologies and implementing education and training programs to prepare the workforce. The institute is one of three announced this year as part of the National Network of Manufacturing Innovation, a White House initiative founded to help U.S. manufacturers employ leading-edge technology to become more competitive.

According to John Walz, dean of the University of Kentucky College of Engineering, Kentucky, with its strong aluminum manufacturing base, also stands to benefit from education and training programs developed by the institute.

"This is a great opportunity for the college and for the university to be a significant partner in a project of this scale and of this importance," Walz says. "Our participation in ALMMII will produce dividends for the university, for the partnership and for the Commonwealth."

"UK will also contribute to, and benefit from, collaborative research and development projects through the institute," adds Y.T. Cheng, Frank J. Derbyshire Professor of Materials Science and one of the participating faculty members.

Faculty members will contribute to various projects that are vitally important to Kentucky, and to the United States as a whole, through the Center for Aluminum Technology, Institute for Sustainable Manufacturing and Department of Chemical and Materials Engineering. According to Cheng, these collaborative research projects will also help enhance UK's research and development capabilities in lightweight metals.

UK President Eli Capilouto says UK's participation would help to advance the university's mission in a number of ways.

"UK's partnership in this institute engages our human capital and intellectual curiosity in collaborative and creative scholarship. Our role will support research and development in ways that are significant to education we provide, industries we support in our state and the economic competitiveness of our nation."

UK is one of nine universities that has joined with 34 private companies and 17 other organizations in the public-private consortium.



UK Engineering Faculty Part of \$12.2 Million NIH Superfund Grant

by Carl Nathe, UKPR

Lindell Ormsbee

Raymond-Blythe Professor in Civil Engineering

In June, the University of Kentucky Superfund Research Center (UK-SRC) received a \$12.2 million grant (five year duration) from the National Institutes of Health to continue its work of better understanding and minimizing negative health and environmental impacts from hazardous waste sites.

The Nutrition and Superfund Chemical Toxicity grant funded through the NIH's National Institute of Environmental Health Sciences is administered through the UK College of Agriculture, Food and Environment. It supports the efforts of more than 50 scientists and students from 15 departments within the colleges of Agriculture, Food and Environment; Arts & Sciences; Engineering; Medicine and Public Health.

The grant sponsors five specific research projects, as well as five core areas of focus. Research project and core leaders (two out of the five projects) from the College of Engineering include the Department of Chemical and Materials Engineering's Dibakar Bhattacharyya, Thomas Dziubla and Zach Hilt, as well as the Department of Civil Engineering's Kelly Pennell and Lindell Ormsbee, who is also the UK-SRC's associate director.

UK Superfund Research Center's biomedical research focuses on the idea that nutrition can help reduce negative health effects from exposure to hazardous chemicals. Environmental science researchers at the center are working to develop new methods to detect hazardous

chemicals and clean up contaminated sites. Kentucky has rates of chronic diseases, such as cardiovascular disease, cancer, diabetes and hypertension, well above national averages. The state is also home to more than 200 federal Superfund sites, including 14 active sites that are on the National Priorities List, a list of the worst sites in the country. The U.S. Environmental Protection Agency defines Superfund sites as uncontrolled or abandoned places where hazardous waste is located.

In Kentucky, such sites include abandoned waste dumps and large industrial facilities. Many of these sites are contaminated with environmentally persistent chlorinated organic compounds—molecules which contain carbon and chlorine—such as polychlorinated biphenyls (PCBs) and trichloroethylene (TCE). Bhattacharyya's project deals with integration of membranes with iron particles for toxic organic remediation from water. Hilt's project investigates pollutant sensing and capture. These two projects will support four to five Ph.D. students per year in the College of Engineering.

"We are optimistic that the results from our environmental science research will help accelerate the clean-up of several Superfund sites in Kentucky, such as the Paducah Gaseous Diffusion Plant. Our research is likely to have other applications as well, including uses in treating drinking water and removing toxic metals from power plant water," says Ormsbee.

“DB is an energetic and innovative scientist internationally recognized for his pioneering research in the area of functionalized ligand membranes for high capacity adsorption of metal ions in water.”

– Norman Li, President of NL Chemical Technology,
Member of the National Academy of Engineering



GAME CHANGER

Iconic professor Dibakar Bhattacharyya is applying his profuse knowledge of membranes to the world of manufacturing.

Alumni Professor Dibakar Bhattacharyya—ubiquitously known as “DB”—has forged a successful 47-year career as a chemical engineering professor and researcher fueled by his serious interest in creating clean water through advanced membranes and other technologies. After spending nearly a half-century at the University of Kentucky, DB sports one of the most impressive resumes in the College of Engineering. His 180+ refereed journal articles, 21 book chapters, two books and nine U.S. patents in the area of functionalized membranes and water detoxification have made him a renowned authority in the fight against water pollution. In addition to being one of the PIs in the membrane and environment-related area for two recent large grants from the National Institutes of Health and the National Science Foundation, he has received continuous funding for over 30 years, and received over \$4 million in the last 10 years.

“Dr. Bhattacharyya is a natural in the pursuit of clever engineering solutions to problems based on the right science,” confirms longtime associate Subhas K. Sikdar of the United States Environmental Protection Agency’s National Risk Management Research Laboratory.

Yet it would be a mistake to think DB is coasting toward retirement; in fact, in the last two years, the recent President-elect of the North American Membrane Society has been the principal player in a collaborative water reuse technology development project that is pushing him to integrate nanoparticles in polymer membranes on a large scale.

A few years ago, Southern Company approached DB about collaborating on a new kind of water recycling technology dealing with coal-fired power water reuse; however, there was a crucial stipulation.

“They said our work would need to result in a fully scaled product down the road. It could not be a ‘research only’ project,” DB explains with a chuckle. “This was exciting for me. I knew I had to find a company that could help in the scale-up of the technology. This required collaborative work with a membrane company.”

ULTURA Co., is a membrane manufacturer based in Oceanside, Calif. As their senior visiting scientist, DB works with the technical team to scale-up pore-functionalized and positively-charged nanofiltration membranes to a level that will improve selective desalination to toxic metals removal and organic destruction from water. In the last year, UK has licensed eight functionalized membrane patents to ULTURA and one of the advanced nanofiltration membranes has led to a commercial product. They recently signed a research and development cooperation contract with Chevron to test functionalized membranes for produced water treatment. Recent work by DB and his Ph.D. students with other companies includes funded research projects with Compact Membranes, NEI Corp., Osmonics and Huber Corporation. DB also does collaborative membrane development work with Professor Rong Wang at the Singapore Membrane Technology Center and recently signed a memorandum of understanding to further enhance interactions.

DB says he draws much of his inspiration from nature and that the membranes were developed with the help of his team of talented graduate and undergraduate students.

“When thinking about using membranes to remove pollutants from water, you want materials that can change shape, can shrink and expand. Nature knows how to do this! While we can’t directly copy nature, we can learn from it and mimic some of its processes.” **KEJ**



MAKING CONNECTIONS

When it comes to research excellence, Anthony J. Elam has a proven history of getting the right people together.

In an academic system where specialization is inevitable, Tony Elam is what one might call a “deep generalist.” His lengthy career consists of ample experience in both industry and academia—a powerful combination that enables him to do what he does best: cross borders and create partnerships. As the college’s Director of Strategic Initiatives—a new position created by Dean John Walz—Elam’s diverse background will be a tremendous asset.

“I am a catalyst, a facilitator, an enabler,” Elam explains. “My role is to identify the research leaders within the college and then devise ways we can maximize their expertise through partnerships inside and outside the college.”

“There is so much potential for collaboration at UK and beyond,” says Walz. “What Tony brings to the table is the ability to scan not just the college, but also the university and corporate entities and understand where our engineering faculty can make a significant impact.”

After graduating from the University of Kentucky with a computer science degree in 1977, Elam embarked on a 20-year career at IBM where he worked on large, complex projects in conjunction with government

agencies and national labs. Seeking a change of pace in the mid-90s, Elam took a leave of absence from IBM to become the Executive Director for the Computer and Technology Institute at Rice University in Houston and assumed responsibility for cultivating strategic partnerships. Not only did Elam help the institute triple its industrial research funding, he discovered he enjoyed the academic atmosphere and left IBM for good. In 2000, Rice named him associate dean of research for the College of Engineering. Several years later, Elam accepted an offer from the highly-respected Baylor College of Medicine, where he focused on developing high-leverage partnerships between medicine and engineering as the college’s Director for Strategic Initiatives. Elam is excited to operate in a similar capacity here at UK.

“We have a unique opportunity in that we have medicine, pharmacy, engineering, computer science, public health and agriculture—all outstanding programs—right here on campus. Our faculty’s depth of knowledge in areas such as data mining, regenerative medicine, bioinformatics, imaging etc., opens up many different avenues for making new discoveries and creating new technologies. That’s where I come in, and that’s what I most enjoy.” **KEJ**



SEEING BLUE ((TOOTH))

After receiving her Bachelor of Science in mechanical engineering from Purdue University, Ann Whitney came to UK to earn a Ph.D. in mechanical engineering with a focus on wireless devices. Specifically, Ann is investigating radio frequency identification (RFID) and Bluetooth low energy and discovering new ways of estimating the location of a device based upon the return signal. Her research advisor is associate professor Johné Parker.

“What excites me most about my research is that Dr. Parker and I are continually discovering new methods. Our research is already on the cutting edge of wireless localization technology and there is serious potential for UK, and this research team in particular, to be seen as world leaders in this field,” says Ann.

Crucial to Ann’s success is the RFID research partnership Parker has forged with Lexington-based Lexmark International. Utilizing Lexmark’s world-class facilities enables Parker and her research group to employ equipment that would not otherwise be available to them.

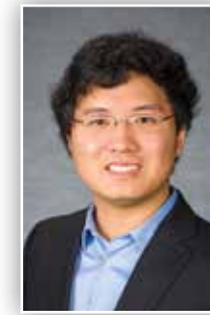
“This is a mutually beneficial partnership that maximizes the research capacity and quality of both parties,” articulates Parker. “We are uncovering very interesting basic research problems as well as solving some exciting applied problems as a result of this collaboration.”

When Ann completes her Ph.D., she plans to continue working with wireless devices, possibly deploying her expertise toward service projects in third world countries.



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