BIOMEDICAL ENGINEERING
UNIVERSITY OF MICHIGAN

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Photographer: Amy Blatt. Light painter: Daniel Clough

Message from the Chair

Lonnie Shea. Photo: Joseph Xu.

It is wonderful to be back at U-M! I'm deeply grateful for the warm welcome I've received. In this, my first chair's message, it seemed natural to share more broadly what many have asked in person: What drove my decision to sign on as BME chair? To explain, I thought I'd relate a short but seminal story from my early career.

After completing my PhD and postdoc at U-M, I joined the faculty at Northwestern University. Shortly after arriving, I gave a talk at the cancer center about my work in tissue engineering. What happened next was like ripples in a pond: one seemingly small act with far-reaching consequences.

Soon after my talk, the head of the cancer center encountered a young girl with lymphoma. He knew the chemotherapy they had planned would give her a great chance at survival – but unfortunately she'd be infertile, and he had nothing to offer her. He asked a colleague to see if my lab could do anything to help.

What struck me immediately was how vital this single act of outreach was. This problem was obvious to clinicians, but those of us in the lab generally knew nothing about it.

We took on the problem, assembled a research team with expertise across engineering and reproductive biology, and launched a project in ovarian follicle maturation that's been underway for 13 years. One of our early results, reported as a breakthrough in Nature Medicine in 2008, involved harvesting ovarian follicles from mice, maturing them in a 3D culture, fertilizing the eggs, and implanting them to yield successful live births.
Since then, we've taken the science further, maturing human follicles to a stage appropriate for fertilization, and we've shown in mice that we could get live births after harvesting and then reimplanting still-immature ovarian follicles – the very treatment that, if translated to humans, may have helped the young patient who originally catalyzed this research.

As hopeful as we are about the science, we are just as encouraged by another breakthrough this work has made possible. Before our results gained prominence, it was uncommon for doctors to delve into the fertility ramifications of chemotherapy with their patients – after all, they had no real alternatives to offer. But our findings raised awareness of the problem, which led to conversations between reproductive endocrinologists and medical oncologists, and new approaches began bubbling to the surface. Cancer patients are now routinely counseled about their fertility, women can receive interventional IVF to freeze their eggs and embryos, and our sights are set on *providing additional options to these women and generating viable options for the pediatric population.*

What does this have to do with U-M BME? Everything. When I left Northwestern, I had a lab in the medical school and another in engineering. U-M BME is now a joint department of these very entities. Both are top 10 in their fields. Both have a long and deep history of collaboration. And the breadth of research and expertise here is unparalleled. What drew me here is the opportunity to contribute the very thing that launched my own career – connections. I have been overwhelmed by both the research progress and the unexpected change in clinical practice a single connection set in motion.

FOSTERING CLINICAL-RESEARCH CONNECTIONS

The expansive expertise here means that the sky's the limit in terms of potential synergies; the challenge is ensuring those with the clinical problems and those with potential solutions find each other.

To be sure, many helpful structures are already in place; others are forming all the time. In fact, I've joined a new regenerative medicine working group eager to harness the deep but distributed expertise in this field at U-M. Among the strategies discussed is an advisory panel tasked with identifying clinicians' unmet needs and linking them with researchers working on applicable technologies. The hope is to form problem-based teams, with members providing multiple, ideally synergistic, approaches to the most challenging clinical problems.

I am eager to work with colleagues across engineering and medicine to develop additional strategies to foster such connections. We will also be using the tremendous opportunity we have to grow our faculty to further integrate with the medical school. For example, new hire ***Alberto Figueroa*** *(see page 4), whose expertise is blood-flow modeling, shares an appointment in BME and surgery, and we are poised to bring photoacoustic imaging expert* ***Xueding Wang*** *from radiology to BME early next year. We will work to continue this integration as we make upcoming hires in areas such as immunobioengineering, mechanobiology, and synthetic and systems biology.*

CONNECTIONS TO INDUSTRY

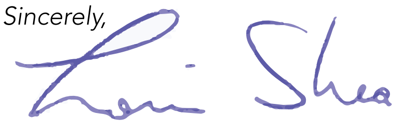
Of course, this same "connections" theme applies to the department's educational mission. Along with our ties to the clinic, I'm eager to strengthen our relationships with industry. Certainly, the department has a rich history in this area, through mechanisms like the Coulter Translational Research Partnership, NIH training grants like the Microfluidics in Biomedical Sciences Training Program and the Cellular Biotechnology Training Program, the student design program, the new master's degree in product development, and individual internship and co-op experiences. My hope is that we will continue this trajectory. Exposure to industry is a critical way for students to learn how they can exploit the many possibilities open to them with a BME degree.

In particular, I encourage my fellow alumni at various stages of an industry career to come back to campus and talk with our students, both undergraduate and graduate, about your experiences. What should students be thinking about as they consider a career in industry? How should they be preparing? What does such a career look like in terms of focus, constraints, and resources?

Others may find you'd be interested in hosting students as interns or working with them through our design program, like 2014 Alumni Merit Award winner Scott Merz (see page 7). There are few better ways for students to learn what it takes for a technology to make it to market. In my experience running Northwestern's Biotechnology Training Program, internship requirements never extended the time it took students to graduate, and they came back motivated and focused, with a new set of skills to apply to the lab.

I am delighted to be here and look forward to building on the tremendous strengths of U-M BME!

Sincerely,



Lonnie D. Shea, PhD
William and Valerie Hall Chair of Biomedical Engineering
Professor, Biomedical Engineering

New BME Core Faculty

ALBERTO FIGUEROA

Computational Hemodynamics

C. Alberto Figueroa joins BME as the Edward B. Diethrich MD Associate Professor of Surgery & Biomedical Engineering, bringing expertise in the computer modeling of blood flow. His mission is to develop tools that faithfully represent blood flow under a variety of physiologic conditions and can be used to study disease, guide treatment planning, and evaluate medical devices.

He's served previously as a research engineer at Stanford University, where he completed his PhD in mechanical engineering, and an associate professor at King's College London. His work has shed light on how artery walls respond to changes in the biomechanical environment through growth and remodeling, and he's modeled issues such as blood flow in abdominal aortic aneurysms and endograft migration following aneurysm repair.

In coming to U-M, Figueroa plans to continue exploring what he calls "transitional physiology" – how the circulatory system interacts with the central nervous system to adapt blood flow to various conditions, such as exercise, severe bleeding, and hypertension. He's also interested in modeling venous circulation, an area largely ignored in simulations to date. "Arteries carry blood at high pressure so they're very circular," says Figueroa, "but veins are collapsible, making their physics more challenging to simulate." He is eager to collaborate with U-M's strong research groups in venous disease and physiology, as well as in pediatrics, vascular surgery, and cardiothoracic surgery, where his techniques can help clarify the physics underlying various cardiovascular conditions. In addition, because his methods are image-based, he's interested in tapping into BME's imaging expertise.

Figueroa has been heavily involved in developing state-of-the-art blood-flow modeling software, which he plans to introduce to interested researchers and students in a two-day conference, December 4 and 5, at the North Campus Research Complex. For more information, contact figueroc@umich.edu.

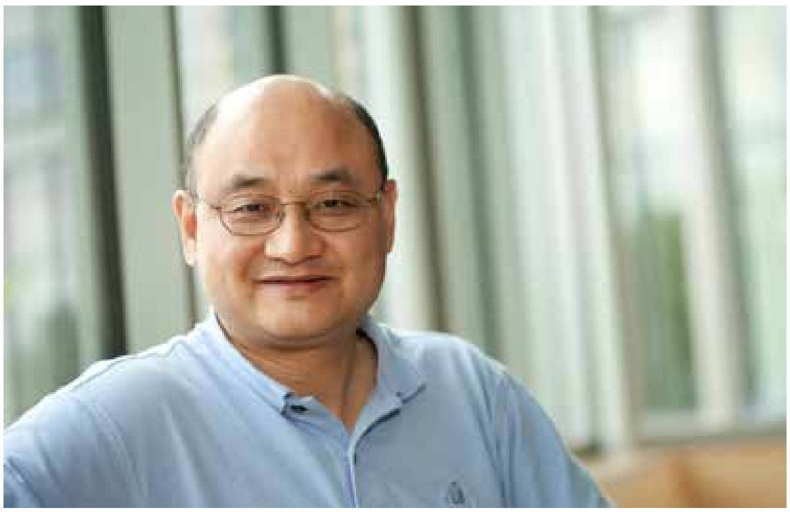
Shrinking Size, Increasing Performance

HOW THE FAN LAB'S SMALL BUT POWERFUL SENSORS AIM TO IMPROVE TESTING IN REALMS FROM HEALTH CARE TO HOMELAND SECURITY

by Aimee Balfe

BME Professor **Xudong (Sherman) Fan***, PhD, is working to revolutionize biological and chemical sensors, making them smaller, cheaper, more portable, and ultimately more useful for in-office and on-site detection. He envisions a world where doctors can diagnose cancer in minutes from a finger-stick of blood, peacekeepers can detect chemical weapon precursors with an instrument as discreet as a watch, and paramedics can identify life-threatening sepsis through a puff of a patient's breath.*

And he's working hard to make this a reality. Over the years, his lab has combined its expertise in optics with microfluidics (together termed "optofluidics") and nanotechnologies to develop multiple platforms that aim to improve sensors' performance while shrinking their size.



Sherman Fan. Photo: Joseph Xu.

VAPOR SENSING

One of the areas in which his lab and collaborators are leading the way is the development of smart, portable, power-efficient vapor sensors. Gas chromatography (GC), which employs long columns to separate gases before analyzing them, is the gold-standard instrument in analytical chemistry. "However, traditional GC is very large – probably 100 pounds – and the column can be as long as 30 meters," says Fan. "It's also very power-intensive and requires dedicated personnel. So it's not portable. Our goal is to shrink everything to the size of a shoebox or even a watch."

Traditional GC systems feature two long columns in tandem: one that separates a vapor mixture into subgroups by volatility, and a second that subdivides these partially separated clouds into individual gases based on the molecules' polarity. The longstanding problem with shrinking these systems is a loss of resolution; there isn't enough column length to fully separate individual gases. To solve this, Fan and colleagues at U-M and the University of Missouri have been developing a new technique called "multi-dimensional micro-gas chromatography."

In this setup, a small first column begins as usual, separating the mixture by volatility. But instead of proceeding directly to a second column, each partially separated gas cloud is first fed into a "detector" – for example, a capillary lined with a polymer that shrinks or expands as it absorbs the gases. This absorption is measured optically and provides information about the gases' identity based on how long they remain in the column. Once the detector determines that it has a complete subgroup from the first separation phase, it routes that cloud to one of several

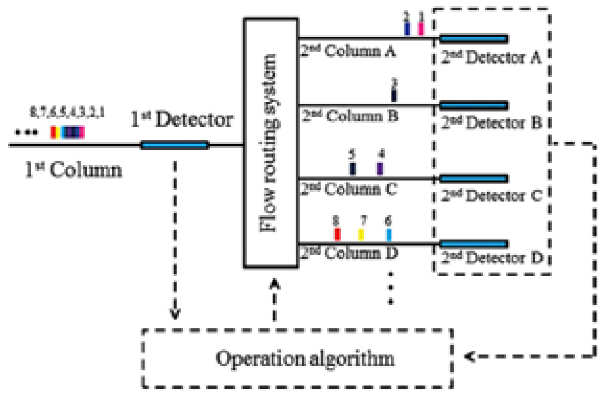


Diagram of the Fan group's smart 2-D micro-gas chromatography system. 2-D signifies two levels of separation and detection, and "smart" references an automation algorithm that can route partially separated gas clouds to the appropriate (vacant or specialized) second-level column. Dashed lines represent signal pathways. Source: Lab Chip, 2013, 13, 818 <tinyurl.com/2DmicroGC>. Reproduced by permission of The Royal Society of Chemistry.

small second columns that can further separate it by polarity before sending the gases to another in-line detector.

Having a cascade of multiple secondary columns allows samples emitted from the first phase to be processed concurrently, rather than serially, for faster analysis. In addition, the use of detectors allows the system to be programmed to send clouds with certain characteristics to customized secondary columns for specialized analysis, if needed.

The system can be used to analyze a complete sample or can be set to analyze only gases with certain readings from detector 1. This way, it can rapidly identify particular gases of concern while ignoring common atmospheric components. The team has shown that their first-generation, 2-D system could accurately identify more than 30 common workplace hazardous volatile organic compounds and could rapidly detect particular compounds of concern from a complex mixture.

Fan is now working to further improve the sensor by adding additional sets of columns – creating 3-D and even 4-D systems, capable of quickly separating hundreds of molecules with a tiny device. He's also experimenting with different types of detectors, from optical to nanoelectronic, and has begun collaborating with U-M physicians to apply the system to breath analysis for disease diagnosis and monitoring.

ON THE PATH TO COMMERCIALIZATION: OPTOFLUIDIC ELISA

Fan and his team are now working to commercialize their optofluidic ELISA (enzyme-linked immunosorbent assay), a traditional wet-lab test in which an enzyme fluoresces whenever antibodies detect their target molecule, such as a disease biomarker.

Their device replaces the traditional 96 well plates with 96 flow-through multi-hole capillaries, a design which improves both analyte capture and signal-to-noise ratio. Not only does this make it more sensitive, but the test can be completed in a half-hour, compared to the standard four hours, with a sample volume that is 10 times lower. It's also fully compatible with existing ELISA readers.

Because of its advantages, Fan's optofluidic ELISA has the potential to yield dramatic cost savings and to be especially useful in outbreaks, where its speed could facilitate triage and its sensitivity improve early diagnosis when analyte concentration is still low.

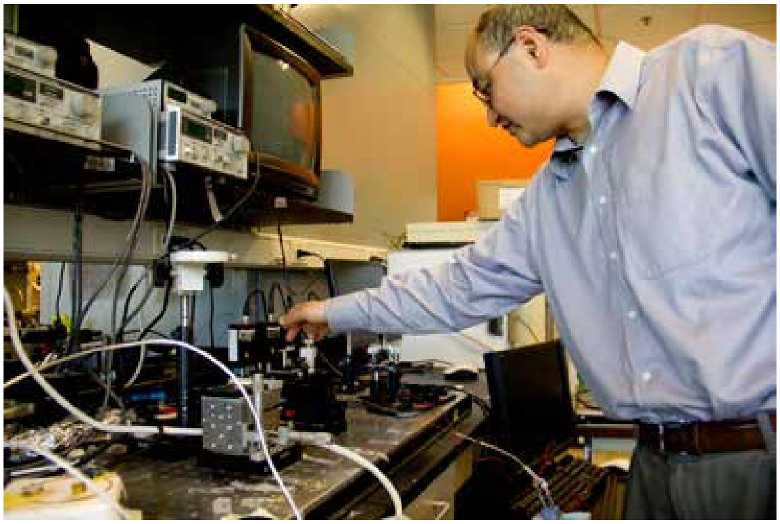
BIOSENSORS

Another area for which Fan's lab is particularly well-known is the development of biosensors, instruments that detect specific biomolecules in liquids like blood, saliva, drinking water and urine.

His lab has long been using optical ring resonators for label-free sensing. These sensors measure changes in the refractive index of a solution caused by an analyte's presence. But in order to make these sensors effective with complex mixtures like blood, his team has incorporated nanofluidics to both separate out unwanted molecules and to concentrate the analytes. He's also developed some "tricks" to deliver these analytes to areas on the sensor that are optimal for detection.

"This is important," says Fan, "because cancer biomarkers, for example, are at extremely low levels in the blood – as little as one billionth of the total protein." Using their unique set-up, his lab has shown that they can find a single target molecule in an extremely small sample of fluid.

His group has also been working on nanophotonic sensors for even greater sensitivity and portability with smaller sample volumes.



Sherman Fan looks over equipment in his sensor lab in LBME. Photo: Joseph Xu.

OPTOFLUIDIC LASERS

Another biosensing platform in which Fan's lab is a front-runner is the optofluidic laser. Lasers work when an external energy source excites molecules in a gain medium. These excited molecules then emit energy at a certain wavelength of light, which is amplified within a reflective optical cavity and emitted as a collimated beam.

Fan's optofluidic laser uses a specially designed microfluidic chamber as the optical cavity and a fluorescent solution as the gain medium. This way any changes in fluorescence – from, say, fluorescent-labelled strands of DNA binding with each other or a tagged protein folding a certain way – are amplified in the laser cavity to create a strong, clear signal.

Fan's group has recently demonstrated the power of this "intracavity sensing." They were able to use fluorescence inside the laser cavity to see a single base mismatch in the breast

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2014 Alumni Merit Award Winner Scott Merz

CELEBRATING A CAREER IN TRANSLATION

by Aimee Balfe

The 2014 BME Alumni Merit Award was presented to Scott Merz (PhD '93), president, CEO and co-founder of MC3, Inc., during an awards ceremony hosted by the CoE on October 31.

Merz came to Ann Arbor in the late '80s, planning to spend a year on a master's degree before heading home to Pennsylvania. But instead he found himself working at the cutting edge of artificial organ development and launching a company that would become a leader in the local translational research movement.

MC3 CEO Scott Merz (center right) spoke at the 2014 Alumni Merit Awards ceremony about the importance of building bridges between scientists and businesspeople to help biomedical innovations reach the marketplace. Photo: Holly Taylor.

It all started when Merz joined the lab of Robert Bartlett, a surgeon with an appointment in BME and a pioneer in heart-lung machines. Intrigued by the work, Merz stayed on for his PhD. During this time he joined Bartlett and fellow engineer Patrick Montoya in tinkering with the blood pumps lying around Bartlett's lab. The team soon had the makings of an improved design and applied for an NIH Small Business Innovation Research (SBIR) grant to develop it. But to do this, they needed to form a company. So they launched Michigan Critical Care Consultants, Inc., or MC3, the company Merz still runs today.

The group secured funding, built their pump, and licensed it to a series of large medical device manufacturers. It was used in heart-lung surgery for the next six years.

The bigger story is what happened afterward. The company Merz launched as a student would continue to develop cardiopulmonary technologies for the next 25 years. But more than that, it would help guide other scientists' biomedical innovations along the path to commercialization. And by adding manufacturing capacity just this year, MC3 is now poised to become an even bigger player in the cardiopulmonary device industry.

This has been possible, says Merz, because of a flexible business model and a willingness to apply the lessons from MC3's initial commercialization success to both its subsequent work and that of other scientists working to traverse the path from concept to prototype to market-ready product.

A CARDIOPULMONARY CORE

Since its beginnings, MC3 has put significant R&D into early-stage cardiopulmonary devices. Among these is an artificial lung for the long-term support of patients awaiting transplant. Though seeded in Bartlett's lab, this work has evolved substantially through the years and has been picked up in a number of commercial efforts that are now under development.

Other efforts have taken Merz in unexpected directions. He has spun off a biocompatible coatings company and a German joint venture, which allowed him to pursue treatments for lung failure considered "ahead of their time" in the U.S. Called Novalung, this company made headlines over the last decade in the military newspaper Stars and Stripes for using its interventional lung assist device to save dying soldiers in Iraq. The device provides partial respiratory support to bedridden patients by using their own heartbeat to pump blood through a gas-exchange membrane.

LEVERAGING LESSONS

Despite its own R&D progress, a large measure of MC3's success has come from helping other researchers, many at U-M, along the translational path. Sometimes this support has focused on the early steps, such as when MC3 helped U-M heart surgeon Steven Bolling turn his idea for percutaneous heart valve reconstruction into an investment-ready prototype. Merz and his colleagues helped Bolling incubate a company and apply for an SBIR grant. They then used their technical capacity to design a working prototype for his concept, which involves using a catheter to place a stabilizing device around the natural heart valve. Bolling's group was then able to conduct experiments with the device

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BME News

Lonnie Shea with Bill and Valerie Hall. Photo: Michigan Photography.

SHEA NAMED ENDOWED CHAIR

On November 4, **Lonnie Shea** was installed as the William and Valerie Hall Chair of the Department of Biomedical Engineering. The endowed chair's position was made possible by a generous $2 million gift from William and Valerie Hall, who together hold six degrees from U-M. Bill has had an extensive career in industry and is now the General Partner of Procyon Advisors LLP, a Chicago-based firm that provides consulting and growth capital for healthcare services companies. He also volunteers as an adjunct professor at U-M. Val is an active community volunteer, gardener and former teacher.

Family & Friends of Alan J. Hunt. Photo: Brandon Baier.

HUNT MEMORIAL LECTURE

On November 7, the department hosted its second **Alan J. Hunt** Memorial Lecture. Speaking was Hunt's former postdoctoral advisor, J. Richard "Dick" McIntosh, PhD, from the University of Colorado Boulder, who discussed microtubule dynamics as an engine for mitotic chromosome motion. The Hunt Memorial Lecture was endowed in 2013 in loving memory of Alan by his family, friends and numerous colleagues in the BME Department.

More at: giving.umich.edu/AlanHunt

Ariella Shikanov. Photo: Joseph Xu.

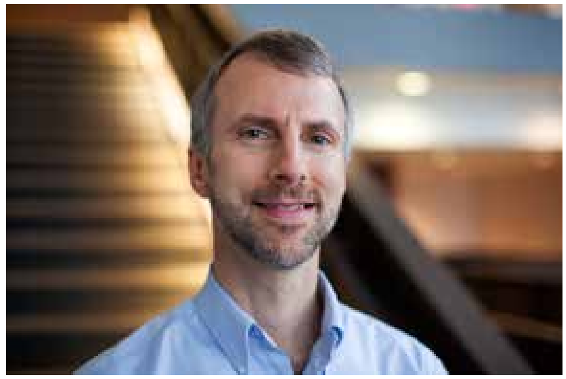
SHIKANOV WINS HARTWELL AWARD

BME Assistant Professor **Ariella Shikanov** received a Hartwell Individual Biomedical Research Award. The award provides three years' support for her work developing a bioengineered matrix to support ovarian follicle survival. Her goal is to develop a follicle transplant strategy for female survivors of childhood cancer that will allow them to recover lost ovarian function and experience normal puberty and development.

NEW GRANTS

FESSLER: LOW-DOSE CT

Jeffrey Fessler and his collaborators recently received a $1.95 million NIH grant to develop model-based image reconstruction methods to improve low-dose CT imaging. Their software aims to create images on par with traditional CT scans at significantly



Jeffrey Fessler. Photo: Joseph Xu.

lower doses of radiation in just five minutes by taking advantage of the multiple processors available on modern computers. Such scans would be useful for rapid diagnostics as well as conditions requiring repeat monitoring scans, such as cancer. Fessler is a professor of electrical engineering & computer science, BME, and radiology.

More at: **tinyurl.com/fessler14lowdosect**

PUTNAM: CAPILLARY GROWTH

BME Associate Professor **Andrew Putnam** received a new NIH R01 grant entitled, Microenvironmental Control of Capillary Morphogenesis. This grant builds on his lab's work

Andrew Putnam. Photo: Joseph Xu.

to create vascularized tissues using endothelial and stromal cells delivered in a hydrogel extracellular matrix (ECM). This project aims to identify how both the type of stromal cell and the degradable properties of the ECM affect the quantity, quality, and stability of the capillaries produced.

STEGEMANN: REBUILDING BONE

BME Professor **Jan Stegemann** received a new NIH R01 grant entitled, Bone Regeneration

Jan Stegemann. Photo: Joseph Xu.

using Osteogenic and Vasculogenic Tissue Modules, with BME faculty **Andrew Putnam** and **Steven Goldstein** as co-investigators. The grant aims to test an injectable paste of small, modular tissue units that can grow into vascularized bone capable of bridging large defects. The team will test various formulations of microbeads, containing either bone- or vessel-forming cells in a tailored ECM, to see which yield the most biomechanically competent and metabolically active bone. The project will lead to a better understanding of the complex interplay between blood vessel and bone regeneration during large defect healing.

YOON: LASER BRAIN MAPPING

Jointly appointed BME professors **Euisik Yoon** and **Kensall Wise** are part of a team that received a $2 million grant from the NIH's BRAIN Initiative aimed at developing lasers and LEDs that can be used to activate individual neuron circuits for highly targeted studies of brain function.

STUDENT NEWS

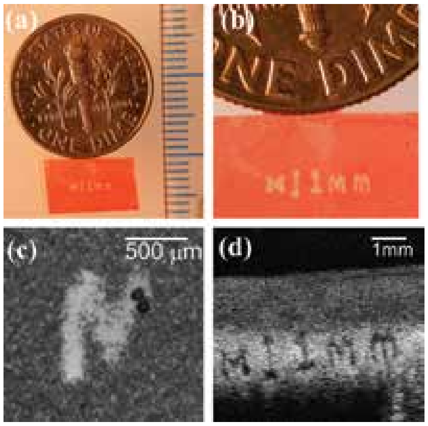
Derek Tat, a PhD student in Cindy Chestek's Cortical Neural Prosthetics Lab and a newly named NSF Fellow, passed away Friday, October 17, 2014, in a vehicle accident. Derek was a brilliant student and close friend to the Chestek Lab as well as the greater Michigan community. The entire U-M BME family is deeply saddened by the news of his tragic death. Our thoughts and prayers go out his family, lab and everyone his life touched.

Derek Tat

Six BME doctoral students were awarded National Science Foundation (NSF) Graduate Research Fellowships. These fellowships provide three years of support to graduate students who show potential for significant achievement in science and engineering. They include:

- **Autumn Bullard**, **Derek Tat**, and **Philip Vu** (Advisor: **Cindy Chestek**)
- **Susannah Engdahl** (Advisor: **Deanna Gates**)
- **Jared Houghtaling** (Advisor: **Michael Mayer**)
- **Steven Peterson** (Advisor: **Dan Ferris**)
- **Uziel Mendez** (Advisor: **Ariella Shikanov**)

Recent BME PhD graduate **Kuang-Wei Lin** won the outstanding oral presentation award at the 2014 Annual Meeting of the International Society for Therapeutic Ultrasound, based on a paper he authored with members of BME's histotripsy group. Two other papers from this group on which Lin was the lead author were highlighted on the cover of *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*. The first is entitled, Histotripsy Beyond



IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control February 2014 Cover.

the Intrinsic Cavitation Threshold Using Very Short Ultrasound Pulses: Microtripsy. The cover image is a submillimeter-sized block "M" lesion in a red blood cell tissue phantom, demonstrating the precise sculpting of soft tissue possible with this technique. The cover of the July 2014 issue illustrates the group's novel approach for generating near-monopolar ultrasound pulses.

PhD students **Joseph Labuz** and **Kunal Rambhia** were accepted to the health team of the Zell Lurie Commercialization Fund, a pre-seed investment fund at the Ross School of Business.

More info: www.zlcfund.com

CONTINUED FROM FAN LAB PAGE 6

cancer gene BRCA1. Fan is encouraged by these results and sees great potential for optofluidic lasers in drug development, where tiny but important changes in a drug's effect could be readily perceived.

MICROFLUIDIC OPTOMECHANICS

Fan is also breaking new ground by combining optics, fluidics and mechanics to create mechanical sensors for biodetection. Called "microfluidic optomechanic sensors," they measure mechanical properties of molecules being flowed through them or attached to the sensor surface, like viscosity, stiffness, and acoustic frequency.

"The technology is based on our optofluidic ring resonators," says Fan, "but when we couple light into the resonator, the light exerts a force on the wall, which vibrates at a high frequency – as high as a gigahertz – and we can maintain this even in the presence of liquid. So we're able to flow different molecules through the sensor and analyze them both optically and mechanically. This has allowed us to analyze some biomolecules and polymers down to very fine details." The lab's new paper on this topic is featured as a cover article in the November issue of *Applied Physics Letters*.

For more information on the Fan Lab's latest research, see bme.umich.edu/labs/fanlab.

CONTINUED FROM SCOTT MERZ PAGE 7

and generate the data needed to secure venture capital. With MC3's early-stage support, Bolling's company is now off and running, working on their next-generation design.

At other times, MC3 has focused on the latter part of the commercialization process, like when it helped U-M restorative dentistry expert Brian Clarkson handle the business aspects of commercializing an innovative dental material from his lab. "They'd developed a way of growing crystals that are similar to natural enamel," says Merz. "In this case, they didn't need help with technical design; they needed help interacting with the major dental health companies." MC3 helped Clarkson's group start a company, obtain rights to their materials through the university's Office of Technology Transfer, then negotiate contracts and manage the technology rights. "This support is invaluable," says Merz. "It means these scientists can keep working on dental materials; they don't have to quit their day jobs."

While dental materials may seem outside MC3's core, Merz says his own experience spinning off a materials company made him a good guide. "Materials are materials," says Merz, "and the contractual terms of dealing with a company like that are the same."

At other times, MC3 has helped technologies traverse the entire path from concept to saleable medical device. The company recently teamed up with students in the ME design program to help U-M pediatric surgeon Daniel Teitelbaum develop a solution to short bowel syndrome, a condition in which children are born without enough intestine to sustain life. Teitelbaum was looking for a way to apply traction from within the small intestine to lengthen it over a period of days to weeks.

"The students' research led to a good understanding of the problem, and they came up with some great designs that uncovered the technical requirements for a device of this nature," says Merz. "We used these as the basis for a design that could be manufactured at a reasonable cost, and we helped develop it so that Dr. Teitelbaum could test it in his lab." MC3 has helped bring the device to a stage where it is being considered by a large medical device company for production as a low-volume or "orphan" product to treat this rare but devastating condition.

MC3 now aims to replicate this success with a BME student design group that is working with a local inventor on a device for patients with nerve damage that impedes their ability to walk. While **Rachael Schmedlen**'s BME 451/452 capstone design team generates its first set of concepts, MC3 is providing support in areas like business formation and intellectual property management.

NEXT STEPS

Though MC3 has supported biomedical innovations of various types, in 2014 it made a decision to return to its cardiopulmonary roots. It has taken on a partner/investor that is allowing the company to establish a state-of-the-art medical device manufacturing operation in Dexter, Michigan. MC3 will continue to pursue cutting-edge technologies but will now have the capacity to manufacture and market these devices directly.

"We've been very successful in finding ways to get technologies to the marketplace," says Merz. "But these can be long hauls. We've come to realize that the best path into the market may sometimes be to blaze it ourselves."

They plan to begin producing a line of sterile disposable medical devices by the middle of next year and to add other elements to the pipeline going forward.

Merz says there are few areas that could rival Ann Arbor as a place to build his career in BME. "There's a long history of cardiopulmonary advances here, and U-M remains one of the top places in the country for medical research," he says. "MC3 has been an integral part of the growth of translational research here, and that's been both an opportunity and an accomplishment."

What did you do last summer?

BME STUDENTS SHARE THEIR SUMMER ADVENTURES & EXPERIENCES

Nick Landgraf (senior) studied abroad from February to August at the Swiss Federal Institute of Technology. Notable alumni of this prestigious institute include Albert Einstein and many Nobel Laureates. Nick studied biosystems science and engineering, and researched microfluidics and mammalian cell biotechnology. He also travled throughout Switzerland and Europe.

Nick Landgraf (front row 2nd from left) on a department retreat at Lake Gruyère in Switzerland.

Erik Thomas poses with some of his newly hatched turtle friends on a beach in Costa Rica.

Erik Thomas (sophomore) participated in a sea turtle conservation project in Costa Rica. He conducted beach patrols, collected and counted eggs, and supervised a hatchery to protect four endangered turtle species.

Ryan Thomas (sophomore), along with two members of M-HEAL's medical device repair collaborative team, worked in mobile clinics near Mao, Dominican Republic, for a week in August. Their medical service brigade served nearly 350 patients through Timmy Global Health, an Indianapolis-based nonprofit that helps student volunteers expand global access to health care. Ryan also collected needs assessments for his honors capstone project, which he hopes to implement in a community there.

Ryan Thomas (middle row left) and members of M-HEAL show some "Maize & Blue" pride outside of Banelino Clinic in the Dominican Republic.

Natalie Setterberg (junior) traveled with the Society of Women Engineers (SWE) to Walchandnagar, India, where she and 12 other SWE members spent a week running an engineering outreach summer camp for 100 sixth to twelfth graders. They introduced concepts such as force analysis, renewable energy and buoyancy to the students. They also held sessions with teachers to compare the education systems of India to those in the United States. The team also went sightseeing in Japiur, Agra, and Delhi with highlights including tours of the Taj Mahal and elephants rides.

Natalie Setterberg (left) and other members from SWE pose for a photo in front of the Taj Mahal.

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