AUTOMATED GLUCOSE MEASUREMENT

Using photonic crystals to automatically test glucose levels will allow tight glucose control to be deployed in settings outside of the Intensive Care Unit, spreading the benefit to more patients.
Welcome to the latest edition of the PITA Newsletter! We hope you enjoy reading about the highlighted projects, which exemplify the kinds of industry-academia collaborative efforts that PITA supports. Outcomes from these projects include creation of a new Pennsylvania company – CarMell – that makes bioplastics for healing of tissue, development of an automated glucose measurement system for bedside monitoring, invention of a new product that makes drinking water safer, seismic testing of piping to keep Victaulic the leading manufacturer of pipe fittings, and formation of a major new government-industry-academia research center at Lehigh on micro-device reliability. The variety of outcomes from these projects underscores the flexibility built into the PITA program to lead to economic impact. These results are a direct result of PITA investment in university research and development that has helped to fill the innovation pipeline for the Commonwealth.

The FY2009 project selection process for the Pennsylvania Infrastructure Technology Alliance (PITA) is underway. The Pennsylvania General Assembly, the Governor and the State Department of Community and Economic Development deserve our collective thanks for their continued support of this important program. In this round, we received 112 technical project proposals. Selection announcements will begin later in the fall, with funding for these projects in place by the first quarter of next year. Even more near term is a series of short presentations on ongoing PITA research that is planned for the morning of November 6 as a lead into the PITA Industrial Advisory Board meeting. We encourage you to visit Carnegie Mellon to attend these morning presentations.

Remember to please consider submitting an article for the next issue in Spring 2009, whether you have news on an ongoing PITA project, new outcomes from a past PITA project, or want to advertise industry research needs to our program participants. And if you are not already involved in PITA, as you read the enclosed articles, please consider how your company or academic program may benefit from similar collaborations.
A consequence that arises from severe illness and major surgery is that blood sugar levels tend to be high due to the “fight or flight” reaction. This occurs even in patients without diabetes. While this is beneficial in the short term, it suppresses germ fighting capacity, makes infections worse and increases damage to multiple organs in the long term. Tight blood glucose control has been shown to mitigate these effects, improving outcomes and survival. This therapy, now routinely performed in many seriously ill patients, requires a continuous infusion of insulin into a vein. It also requires close monitoring via hourly blood sugar measurements around the clock. This is time consuming, labor-intensive and uncomfortable for the patient. In addition, there is considerable risk of producing too low a blood glucose value, which may harm the patient in other ways.

ICES Research Scientist Alan Rosenbloom and University of Pittsburgh Chemistry professor Sanford Asher have been working to create a more efficient system of measuring blood sugar levels that will allow a wider and easier application of tight glucose control, extending its benefits to more patients, reducing staff workload and patient discomfort. This research has been possible due to PITA funding they received at the beginning of this year.

The goal of the research is to develop an automated system for blood glucose measurement at 5-minute intervals by combining microdialysis – a well-established technique for sampling from the body – with a new generation of glucose sensors, which do not rely on electrochemistry. Their research specifically involves using a photonic crystal that changes color based on the glucose concentration in the blood, providing a sensitive and dynamic sensor for glucose. The underlying technology is a fluidic flow cell with an optical interface between the photonic crystal and a fiber-optic spectrophotometer which will interpret the detected color as a specific level of glucose.

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So far, there has been success using an electrochemical glucose sensor produced by the company Medtronic. The goal is to eventually replace the electrochemical sensor with the glucose-sensitive photonic crystal, invented by Dr. Asher, which does not require any calibration and can function with protein-rich solutions. They are partnered with the company Glucose Sensing Technologies, founded by Dr. Asher, to develop and market the photonic crystal for glucose measurements in the blood.

Creating an effective way to automatically and regularly test glucose levels will markedly decrease the expense, discomfort and risk of tight glucose control and allow it to be deployed in settings outside of the Intensive Care Unit, spreading the benefit to more patients.
Micro-electromechanical systems (MEMS) are now widely used in air-bag triggers, electronic-game controllers, cell-phone microphones, digital-camera stabilizers, ink-jet printers, hard-disk readouts, etc. In the future, MEMS devices may be used like transistors as building blocks for very large scale integrated (VLSI) circuits to perform complex functions. However, before MEMS VLSI becomes a reality, multiphysics and multi-scale models and simulation tools must be developed. To this end, Lehigh University, the University of Illinois at Urbana-Champaign, Purdue University, the Georgia Institute of Technology, and their industrial partners have established a new research center – IMPACT Center for Advancement of MEMS/NEMS VLSI. NEMS, the nano version of MEMS, are even more futuristic and challenging.

To date, the Center’s seed funding from PITA and other university and industry sources has been matched by the Defense Advanced Research Projects Agency to pursue an approximately $10 million, six year program. Additional contributions have been obtained from major corporations such as ANSYS and start-ups such as Renaissance Wireless, which are both Pennsylvania companies. Lehigh’s interdisciplinary team under the Center includes Prof. Jim Hwang of Electrical Engineering, Prof. Herm Nied of Mechanical Engineering, Prof. Rick Vinci of Materials Science, and their postdoctoral students and graduate students.

Professor Vinci’s group has developed specialized test techniques for characterizing time-dependent material properties of thin films that show the effects of deposition technique, temperature, and strain rate. Using these test techniques, they have discovered surprising linear viscoelastic behavior in metal membranes and have developed models for the prediction of membrane behavior. Professor Nied’s group has used finite element analysis to predict the mechanical properties of metal membranes in terms of stress distribution, resonance frequency, electrostatic force and displacement. The analysis is applicable to complicated shapes such as the perforated bowtie-shaped membranes shown in the figures. Combining the knowl-
The combination of today’s more active lifestyles and aging population is contributing to the need to develop better methods to repair injured joints and bones. Injuries to joints are now treated arthroscopically using an array of orthobiologics and fixation devices. However, injuries to tendons, ligaments, and cartilage are difficult to heal; at best, they require months of recuperation and physical therapy before a patient can return to full use of the injured joint. While there are numerous products on the market, no product has proven effective in achieving the goal of rapid healing with good clinical outcomes; CarMell is about to change that paradigm.

Originally founded by ICES Research Professor Phil Campbell, Robotics Institute Research Professor Lee Weiss at Carnegie Mellon and James Burgess, a neurosurgeon from Allegheny General Hospital, CarMell has created exciting new bioplastics manufactured from human blood plasma, offering accelerated healing and improved clinical outcomes. CarMell researchers have developed a process for manufacturing plastic materials from plasma such that the materials are sterile, available off-the-shelf, are easy to handle, shape and suture, have controlled degradation, contain known levels of bioactivity, and exhibit mechanical properties that match the repaired tissues.

CarMell’s plasma-based plastics are made by polymerizing the proteins, growth factors and extracellular molecules in the plasma. CarMell’s materials can be molded or extruded to create a range in physical properties from hard and bone-like structures to elastomeric sheets. Most importantly, these plasma-based plastic materials retain the bioactivity of plasma’s growth factors and proteins even after sterilization and months of storage at room temperature. They represent the ideal biomaterial, incorporating naturally occurring growth factors and proteins that have evolved by nature in the ideal proportion to effect wound repair and tissue regeneration following an injury.

Campbell and Weiss’s original tissue engineering that led to the development of CarMell was funded by PITA. To continue their work with bioplastics, CarMell has recently been awarded a grant from the National Institutes of Health, which it will use to help develop some of its first medical products. CarMell has also received grants from Carnegie Mellon, the Allegheny-Singer Research Institute, and Innovation Works, as well as an initial investment from Pittsburgh Life Sciences Greenhouse. Over the next year, CarMell will be seeking additional funding to complete product development and clear the product through the Food and Drug Administration.

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Nearly 50 percent of the United States population currently receives their drinking water from the underground. In general, groundwater is like filtered water and safe to drink. However, for over five thousand small communities in the United States, the groundwater is tainted with trace amounts of naturally occurring dissolved arsenic and is unsafe to drink, according to the United States Environmental Protection Agency (USEPA). Arsenic is by far the most toxic contaminant present in groundwater. The problem is not unique to the United States, however. Halfway around the world, arsenic present in drinking water drawn from underground sources is the cause of widespread arsenic poisoning affecting nearly 100 million people living in Bangladesh and in the eastern part of India, Vietnam and Cambodia are also suffering from the same crisis.

Arup K. SenGupta, P.C. Rossin Professor in the Department of Civil and Environmental Engineering, and his graduate student, Luis Cumbal, have developed a new material that can remove ultra-low concentrations of arsenic very selectively rendering the groundwater fit for drinking. They recently received a United States patent for their invention and the new adsorbent is now commercially manufactured under the trade name ArsenX™ by Purolite Co., in Philadelphia through a license from Solmetex Co. in Massachusetts and Lehigh University. ArsenX™ is essentially a polymer-based hybrid anion exchanger where iron oxide nanoparticles have been dispersed inside an anion exchange resin. What sets ArsenX™ apart from other existing adsorbents is that ArsenX™ is durable, chemically stable and amenable to regeneration and reuse. Compared to other processes, the volume of disposable arsenic-laden solids is reduced two orders of magnitude through the use of regenerable ArsenX™.

More than 300,000 people in the United States now drink arsenic-safe ground water that has been treated by ArsenX™, according to Professor SenGupta. These include municipalities, mobile park homes, schools and single family homes. Professor SenGupta also states that the technology is flexible and has been used in applications ranging from individual houses to municipalities treating more than 3 million gallons of drinking water per day. ArsenX™ is also in use in four other countries including India.

ArsenX™ particles, says SenGupta, are not homogeneous at the microscale, but instead remain heterogeneous down to the level of 10 nanometers. The unique properties of ArsenX™ are attributed to this nano-scale heterogeneity. The development and refinement of this new hybrid material took nearly four years and continued matching funds received from PITA during this period was immensely helpful in bringing the invention to the marketplace.
Victaulic, founded in 1925 and headquartered in Easton, PA, is the world leader in mechanical pipe joining systems. Victaulic introduced the grooved piping method, which dramatically reduces the amount of installation time as compared to welding, threading or flanging and is used extensively in HVAC, plumbing, fire protection, mining, industrial utilities plus water and wastewater systems throughout the world, including areas of high seismicity.

During earthquakes, there have been cases of successful performance of piping joined with Victaulic couplings. However, only limited full-scale testing had been performed in the past to demonstrate the seismic performance of this structure. As a result, Victaulic initiated a full-scale seismic testing program with Lehigh University’s Advanced Technology for Large Structural Systems (ATLSS) Engineering Research Center. The impetus of this testing is also the emergence of new and updated seismic design and testing codes that apply to piping in seismic zones and the need to demonstrate the performance of piping joined with Victaulic grooved couplings under state-of-the-art real-time seismic loading. A number of real-time shake tests on representative large-diameter full-scale piping systems joined with Victaulic couplings have been performed.

The testing has served two purposes, namely (1) to demonstrate the ability of piping joined with Victaulic grooved couplings to maintain operational integrity during a major seismic event; and (2) to demonstrate that specialized isolation assemblies possess sufficient freedom-of-motion to accommodate the differential displacements at seismic separation joints.

During all tests, the piping was found to have performed very well. In all cases, pressure in the pipeline was maintained and no leaks were observed. The results of this testing program will aid Victaulic and its customers to confidently design safe and reliable piping systems using Victaulic couplings in areas of high seismicity worldwide.

Test setup in the ATLSS laboratory.

The ATLSS Center houses Lehigh University’s Real-Time Multi-Directional (RTMD) Equipment Site, which is part of the Network for Earthquake Engineering Simulation (NEES). NEES was established by the United States National Science Foundation as a national networked collaboration of geographically-distributed, shared-use experimental research equipment sites. The real-time testing capabilities of the Lehigh’s RTMD Site have been used successfully to apply large simulated earthquake motions to a full-scale piping system.

This project was primarily funded by Victaulic Company with additional funding provided by PITA.
On Thursday, November 6, 2008, ICES will host the fall PITA advisory board meeting at Carnegie Mellon in the Singleton Room, Roberts Hall. The morning will begin with a series of speakers discussing ongoing PITA-funded projects. The morning event is open to Carnegie Mellon Faculty and local industry leaders.

Representatives from ICES’s academic PITA partner, the Center for Advanced Technology for Large Structural Systems (ATLSS) at Lehigh University, will also attend the morning program and afternoon advisory board meeting. For more information about attending the morning program, please contact Christina Cowan at ccowan@andrew.cmu.edu.

For more information, please visit the PITA website at www.pitapa.org or call 412-268-3372

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PITA is a Pennsylvania Department of Community and Economic Development (DCED) program designed to provide economic benefit to Pennsylvania through knowledge transfer, the discovery of new technologies, and the retention of highly educated students.

It is a collaboration between the Commonwealth of Pennsylvania, the Center for Advanced Technology for Large Structural Systems (ATLSS) at Lehigh University, and the Institute for Complex Engineered Systems (ICES) at Carnegie Mellon University.

PITA’s research and education projects involve Pennsylvania companies, faculty, and students. PITA’s programs have led to the creation and implementation of numerous cutting-edge technologies in Pennsylvania companies and have also enabled several start-up companies to form within the Commonwealth.