NEWS in Science and Technology
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The following is an Executive Summary of the Academy's quarterly Bulletin (Vol. 24,3) that includes topics and issues in science and technology deemed by the Academy to be both timely and relevant to Connecticut's interests. Each item is briefly summarized from press releases and reports of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Hyperlinks are included to the original online source, where more detailed information is available.

NOTE: Online versions of this newsletter and the Bulletin are available on the Academy website at www.ctcase.org.

FEATURE ARTICLE

➢ Silicon Nanowires Key to Revolutionary New Hand-Held Diagnostic Biosensors

Using silicon nanowires one-millionth the diameter of a human hair, Yale University researchers expect to develop a revolutionary array of novel, hand-held sensors that can diagnose diseases, do blood work, find cancer cells, and identify other proteins in minutes by a patient's bedside.

Background

A nanometer is one billionth of a meter, or 10^{-9} meters. To appreciate the dimensions of a nano-world, the smallest virus is around 17 nanometers across and a glucose molecule is 1 nanometer in diameter. The Yale nanowire device was originally invented and produced for detecting biological and chemical weapons on a battlefield, with a grant from the U.S. Defense Advanced Research Projects Agency (DARPA). "We found we could use these small devices for biosensing," said CASE member Mark A. Reed, Yale's Harold Hodgkinson professor of engineering and applied science.

How it was made

- The nanowire device was developed in Reed's laboratory by former graduate student Eric Stern. Stern designed and fabricated the silicon chip in Yale's clean room, using the conventional method of an electron beam to "sculpt" a perfect silicon crystal. The chip had to be etched in such a way that the sides of the nanowires were "perfectly" smooth.
- The pattern etched into Yale's silicon crystal is deceptively simple —consisting of ten "fingers" 1 to 2 microns long and 20 to 30 nanometers in diameter, lined up in parallel like 10 teeth of a very small comb. Each finger is about 100 times longer than it is wide.

How it works

- The fingers behave like transistors. When the array encounters a charged particle, its voltage increases. Using 10 strips, the circuit is also extremely sensitive to minute changes in the acidity, or pH, of a solution.
- T-Cells are among the first white blood cells that bacteria, viruses and other pathogens encounter. One type of T-cell is studded with CD-4 protein complexes. Antigen-presenting cells grab the pathogen and present it to the CD-4 protein, which signals the T-cell to launch a cascade of additional white cells, enzymes and other proteins to destroy the invaders. The T-cells also begin to emit acid in the form of protons.
    - The purpose of these protons is unknown, but they generate a signal that the ultra-sensitive Yale device can measure, acting as a proton monitor, or pH detector.
    - Between the time the CD-4 protein latches onto an antigen, until the T-cell starts to pump out acid is about 30 seconds. The Yale scientists have tested the circuit in solution. The circuit is able to detect one proton-producing cell out of 1 billion, making it an astonishingly powerful measuring device.
- Tarek M. Fahmy, assistant professor of biomedical engineering at Yale University, compares the proton affinity of the nanowires in Yale's device to hearing a high-pitched voice in the din at a large, loud party. "If your ear is tuned only to sense high-pitched vibrations, then when somebody speaks at the party with a high pitch, you'll detect them," he said. "If cells are around and you add specific stimulus that results in only a few reacting and secreting protons, then the wires will sense them, if the wires are small enough."

Potential Applications

- According to Fahmy, the microscopic pH meter could be used for diagnosing infections, judging the effectiveness of inhibitory drugs, and possibly identifying cancer proteins.
- The device is compatible with circuitry now used in computers and other contemporary electronic devices which means that it can eventually be produced in large numbers and incorporated into equipment by conventional manufacturing methods.
- Fahmy said that the device would be sensitive to cancer cells because these rogue cells tend to carry an overall negative charge.
    - A surgeon removing a cancerous lesion could benefit from such a device, by checking the margins around the tumor for lingering cancerous cells and receiving data without leaving the operating room. These immediate results could spare the patient additional surgery and ensure that virtually all the cancer is removed.
- Reed imagines an instrument the size of a classic iPod. A drop of blood would be placed in a port, and minutes later, the device would diagnose an infection. Since the circuit is so small, many, perhaps hundreds or thousands of the chips could fit into the device. The resulting portable electronics would be able to diagnose dozens of infectious diseases or conditions, or perhaps could be designed to run blood work. Many underdeveloped countries do not have the resources or infrastructure to conduct blood tests or diagnose diseases in rural areas and could benefit from such a device.

"This is just the tip of the iceberg," said Reed. "There's no limit as to what can be sensed—proteins, DNA, antigens—as long as it's charged. Eventually we'll be able to see a single cell emitting protons. There are many modes in which to use these devices. We're opening up a whole new system to look at." — Abram Katz

[Read more at www.ctcase.org/bulletin/24_3/24_3.pdf]

NEWS FROM THE NATIONAL ACADEMIES

➢ America's Energy Future: Technology and Transformation

A new report from the National Academies' Committee on America's Energy Future analyzes the potential of a wide range of technologies for generation, distribution, and conservation of energy. The report —"America's Energy Future: Technology and Transformation"— considers technologies to increase energy efficiency, coal-fired power generation, nuclear power, renewable energy, oil and natural gas, and alternative transportation fuels. It assesses the associated impacts and projected costs of implementation and categorizes them into three time frames. The report's aim is to "inform policymakers about technology options for transforming energy production, distribution, and use to increase sustainability, support long-term economic prosperity, promote energy security, and reduce adverse environmental impacts." Among the variety of technologies under development that might become available in the future, the report focuses on those with the best prospects of fully maturing during the three time periods considered: 2008–2020, 2020–2035, and 2035–2050.

[http://www.nap.edu/catalog/12710.html]

➢ Creative Young Engineers Chosen for NAE Symposium

Sandor Becz, of Connecticut's United Technologies Research Center, was one of 88 of the nation's brightest young engineers selected to partake in the National Academy of Engineering's (NAE) 15th annual US Frontiers of Engineering symposium in September. The participants—engineers from industry, academia, and government ages 30 to 45 who are performing exceptional engineering research and technical work in a variety of disciplines—were nominated by fellow engineers or organizations. The symposium, held at the National Academies' Beckman Center at the University of California, Irvine, Sept. 10-12, examined engineering tools for scientific discovery; engineering the health care delivery system; nano/micro photonics and new applications; and resilient and sustainable infrastructures.

[http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=06252009b]

➢ Report Faults US Plan for Research on Potential Health, Environmental Risks from Nanomaterials

At the request of the US Department of Energy, the National Research Council's Board on Energy and Environmental Systems issued a letter report summarizing its review of the strategy and structure of the FreedomCAR and Fuel Partnership. Although the current focus on nearer-term technologies is on the right track, according to the report, there remains a need for continued investment in longer-term, higher-risk, higher-payoff vehicle technologies that could be highly transformational with regard to reduced use of petroleum and reduced emissions. Such technologies include advanced batteries, technologies for hydrogen storage, and hydrogen/fuel cells. For researchers, contractors, and investors to be willing to make long-term commitments to these and other potentially important developing technologies, a consistent year-to-year level of support must be provided.

[http://www.nap.edu/catalog.php?record_id=12711]

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A CASE FOR CAPTURING CT'S WASTE HEAT

A new study by the Connecticut Academy of Science and Engineering entitled *The Feasibility of Utilizing Waste Heat from Central Electric Power Generating Stations and Potential Applications* underscores the fact that a significant by-product of power generation plants is rejected (or "waste") heat. The CASE report finds that the heat currently being rejected from Connecticut's power plants is an untapped resource that is roughly equal in value to all of the fossil fuels used for the state's residential, commercial, and industrial sectors for process and space heating. The Study Committee concluded that there are several beneficial uses for the heat that is rejected into the environment by power plants in Connecticut and it is recommended that:

- Rejected heat should be used to develop district energy (heating and cooling) systems in high population/employment areas;
- Waste heat enterprise zones should be created to encourage economic development; and
- To complement this effort, Connecticut should also explore the potential of growing algae for generating biofuel from fossil fuel stack gases, or cooling water reject heat

CASE presented its findings at a September 4th meeting of the Connecticut Energy Advisory Board (CEAB), which commissioned the study.

http://www.ctcase.org/reports/waste_heat.pdf

The newly opened KidSpace [Photo courtesy: CT Science Center]

News from the CT Science Center …

The new Connecticut Science Center in Hartford has reached several significant milestones since opening on June 12 of this year. By the end of August, visitors exceeded 100,000. Residents from all 169 Connecticut towns have visited, along with tourists from dozens of other states and countries.

KidSpace, a creative exhibit gallery targeting children ages 2-6 and featuring water play and creative activities, opened in August. The water play area combines five water-based interactive exhibits including a giant water vortex, water fountain designer, and LEGO block, dam building stream table for up-and-coming hydro-engineers. The creative play area includes a build-your-own roller coaster, reading nook, and a 55-foot pneumatic ball transporter.

Two 3D movies —"Dinosaurs Alive!" and "3D Sun"— are currently showing at the 3D digital Hoffman Foundation Theater. "Wild Oceans" will replace the dinosaurs film on December 20. The current traveling exhibit, SPEED, will remain until December 13. In January, a new traveling exhibit, Ends of the Earth, will open. On October 3, the Science Center will host a LEGO Invent: the Future Contest event. This and many other events are listed at http://ctsciencecenter.org/things-to-do/calendar.aspx.