Research / Discovery

Engineering professors use optics to advance lab-on-a-chip technology

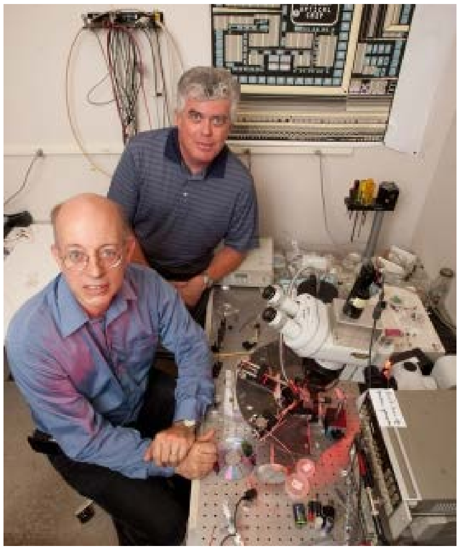
August 26, 2009

Someday soon, early detection of heart disease or cancer may be as simple as putting a drop of your blood on a semiconductor chip smaller than a fingernail, according to a new paper in a scientific journal published by two Colorado State University engineering professors.

Detect proteins with laser beam

In an article featured on the cover of an August issue of the journal, *Lab on a Chip*, the professors reported they can detect proteins landing on a silicon chip by directing a laser or LED beam along the surface of the chip and watching where the light is deflected very slightly toward the proteins.

Surface treatments that allow only specific types of proteins or other biomolecules to stick to particular areas on the chip let the researchers test what proteins are present in a fluid such as blood, urine or saliva.



Speed up medical diagnostics

The new chip is intended to simplify and speed up medical diagnostics and other biosensor applications by eliminating extra chemicals, special equipment and complex steps often required for current laboratory tests. The ability to sense the type of biomolecules reaching the chip qualifies it as a biosensor - a class of devices used in medical, environmental and food safety applications.

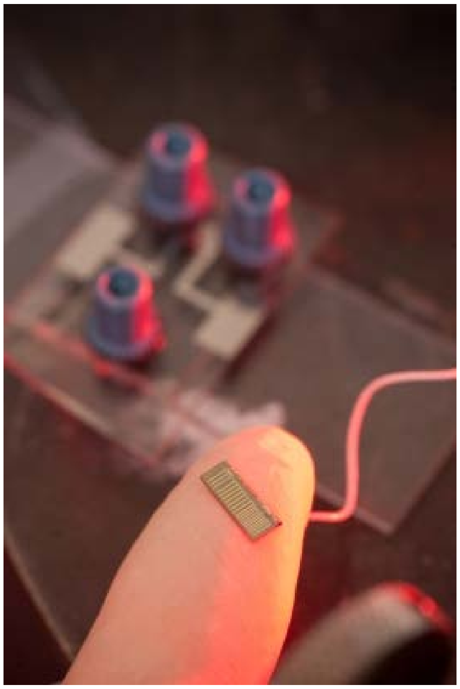
Lower costs for escalating price of medical tests

“Our team is working to reverse the current trends of escalating prices for medical tests by applying chips that are made the same way as integrated circuits, which allow greater performance in computers at lower costs,” said Kevin Lear, a Colorado State electrical and computer engineering professor who is leading the research. He noted that using silicon microelectronics technology makes it easy to include “smarts” on the chip to interpret the sensor signals and send them to a laptop or cell phone.

Lear’s co-principal investigator on the project is David Dandy, head of the Chemical and Biological Engineering department. Lear and Dandy are also faculty members in CSU’s School of Biomedical Engineering.

How the technology works

How the CSU technology works: An optical waveguide – similar to a fiber optic – is molded on the top surface of a microchip. Light flowing along the waveguide is deflected toward



molecules captured on the surface of the chip. Using small patterned patches of special molecules such as antibodies or DNA that only latch onto matching molecules on the chip allows scientists to simultaneously detect the presence of many types of tiny molecules. The chip can distinguish different proteins by using optical detectors, equivalent to microscopic solar cells, to determine where the light is pulled toward the surface.

Compact, self-contained

Their research may speed the detection of biological substances in body fluids such as blood that can more quickly provide information about the state of a patient's health. The scientists say the technology will be more compact, self-contained and self-interpreting than conventional diagnostics – important traits particularly in the developing world where basic medical care resources are scarce. They added the method could be commercialized cheaply because the chips can be manufactured with older, less expensive semiconductor technology.

The approach can measure a wide range of protein molecule sizes, which are much too small to be seen even with a microscope, from 100-nanometer viruses – a relative giant in the biomolecular world at a 1,000 times smaller than the diameter of a hair – down to one nanometer, which is the distance spanned by a chain of about six carbon atoms. The professors believe the technique will ultimately sense a layer the thickness of a single atom covering only a tiny surface area.

Currently focused on diagnosing tuberculosis

For now, the scientists have focused their research on diagnosing tuberculosis. Colorado State has world-renowned tuberculosis researchers such as Richard Slayden, associate professor of Microbiology, Immunology and Pathology at CSU, who is working on novel treatments, vaccines and diagnostics, particularly for extreme drug-resistant strains.

"This is part of the new wave of personalized medicine and point-of-care diagnostics, which can help with testing conditions in sub-Saharan Africa where 5,000 people a day die from tuberculosis," Dandy said. "With this proposed lab-on-a-chip technology, a nurse or doctor in Africa could put a drop of blood on a device the size of a USB flash drive and almost instantly make a diagnosis."

Biosensor chip concept launched in 2003

The biosensor chip concept was launched in 2003 with a $2.5 million grant from the National Institutes of Health. The researchers recently obtained $50,000 in seed money from Colorado State's Infectious Disease Supercluster – a unique model designed to speed university innovation in infectious disease to the marketplace - to improve the platform for tuberculosis detection. But the group intends to expand that research so the technology could fit a wide variety of uses, which may lead to commercialization, Lear said.

A patent is pending on the underlying technologies through the Colorado State University Research Foundation.

Avago Technologies has donated processing time to create hundreds of semiconductor microprocessing chips for the research.

Contact: Emily Wilmsen
E-mail: Emily.Wilmsen@colostate.edu
Phone: (970) 491-2336

Print this Story | Posted in Research / Discovery | Share |