



NEWS

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New engineering center to transform sensor technology

Use of mid-infrared light opens way for breakthroughs in medicine and environment

PRINCETON, N.J. — The National Science Foundation has funded a multimillion-dollar Engineering Research Center based at Princeton University that is expected to revolutionize sensor technology, yielding devices that have a unique ability to detect minute amounts of chemicals found in the atmosphere, emitted from factories or exhaled in human breath.

The goal of the research is to produce devices that are so low in cost and easy to use that they transform aspects of the way doctors care for patients, local agencies monitor air quality, governments guard against attack and scientists understand the evolution of greenhouse gases in the atmosphere.

Core partner institutions with Princeton are the University of Maryland, Baltimore County, Rice University, Johns Hopkins University, Texas A&M University and the City College of New York. Funding for the center, which is expected to include industrial support in addition to the NSF funding, could exceed \$40 million over 10 years. NSF funding started May 1 with \$2.97 million for the first year.

The center – dubbed MIRTHE, for Mid-Infrared Technologies for Health and the Environment – will combine the work of about 40 faculty members, 30 graduate students and 30 undergraduates from the six universities. The center also is collaborating with dozens of industrial partners to turn the technology into commercial products, and is working with several educational outreach partners, which will use MIRTHE’s research as a vehicle for improving science and engineering education.

The work of the center will span from fundamental science to applied technology. At the Johns Hopkins Bloomberg School of Public Health, for example, Professor Terence Risby and colleagues are developing devices that allow doctors to diagnose and monitor kidney and liver disorders by measuring chemicals in a patient’s breath. Other MIRTHE participants will explore sensors that monitor air quality or detect chemical weapons.

“The sensors we are creating will be portable and easy to use,” said Claire Gmachl, associate professor of electrical engineering at Princeton and the center’s director.

“Today’s state-of-the-art sensors are very sensitive, but require an expert to operate and are bulky and expensive. MIRTHE’s vision is to make sensors with the same or better level of sensitivity at a fraction of the size and cost.”

The center’s deputy directors are Anthony Johnson, professor of physics and professor of computer science and electrical engineering and director of the Center for Advanced Studies in Photonics Research at University of Maryland, Baltimore County, and Matthew Fraser, associate professor of civil and environmental engineering at Rice University.

A key technology enabling the center’s work is the quantum cascade laser, which is named for the way the electrons “cascade” through thin layers of material stacked within the device. Gmachl, a member of the Princeton Institute for the Science and Technology of Materials (PRISM), is a pioneer in creating quantum cascade lasers and is a recipient of a 2005 MacArthur “genius grant” in recognition of that work.

The major advantage of quantum cascade lasers is that they emit light in regions of the spectrum known as the mid-infrared. The ability to produce and detect these wavelengths allows scientists to “see” certain chemicals in the same way that sunlight and the human eye reveal everyday objects. “When viewed in the mid-infrared, the world is alive with chemicals like ammonia, carbon, methane, carbon dioxide, carbon monoxide and benzene,” said Fraser. “The ability to detect or monitor these gases with a high degree of sensitivity provides important information about the processes that produced them.”

“If you look in your house, probably the only laser you’ll find is in your CD player, just as 30 years ago you would have found very few transistors in the average home,” said Tim Day, chief executive officer of Daylight Solutions, a manufacturer of advanced detection and imaging instruments and one of MIRTHE’s industrial partners. “But now transistors are everywhere – wristwatches, microwaves, TVs. Sensors based on quantum cascade lasers are poised to become just as ubiquitous. MIRTHE is on the front end of making that happen.”

An important aspect of MIRTHE is that it stresses both fundamental science and practical applications, said Alexey Belyanin, assistant professor of physics at Texas A&M University. “This center adopts a comprehensive, unifying approach that pushes forward each of the necessary ingredients for a sensor: infrared sources, detectors, circuits, interconnects – all while working in close collaboration with end users,” he said.

This approach will allow each of MIRTHE’s research teams to capitalize quickly on each other’s advances, said Johnson. “We make use of established technologies while also pursuing novel high-risk approaches,” he said. “The potential payoff is enormous.”

A key mission of MIRTHE is to help ensure a competitive U.S. workforce by educating students who carry forward the center’s knowledge to industry, government and academia. The center seeks to make science attractive to a diverse population of students by demonstrating the direct relevance of technology in solving societal problems. MIRTHE will incorporate extensive efforts to engage college and K-12 students in

hands-on science and engineering projects, with major outreach programs taking place at the City College of New York, the University of Maryland, Baltimore County and Princeton.

Fred Moshary, professor of electrical engineering at City College New York said MIRTHE's goals are an excellent match for current activities at CCNY. "Our programs have a strong focus on recruitment and training of traditionally underrepresented minorities in science and engineering," Moshary said.

At the University of Maryland, Baltimore County, MIRTHE will partner with the Meyerhoff Scholars Program, which is recognized nationally as a model for preparing high-achieving undergraduate students, particularly African-Americans, for research careers in science and engineering.

MIRTHE's Student Leadership Council, headed by Princeton graduate student Afusat Dirisu, will organize student involvement in the center by planning talks and student exchanges between groups. "The many universities and industry partners behind MIRTHE are definitely a big plus for students because they will give us many opportunities to explore," said Dirisu.

H. Vincent Poor, the incoming dean of engineering at Princeton, echoed this theme. "Collaborations that transcend individual departments and institutions are the wave of the future," Poor said. "Bringing together people of diverse expertise to work on important and very complex problems creates a highly effective environment for research. It's also the best way to educate students for leadership in an increasingly technological world."

The center builds on research connections that have existed for many years between the partner universities, each a recognized center of excellence in sensing and associated fields. "We are delighted to be partnering with Princeton and the other fine institutions in the Engineering Research Center's critical work," said Freeman Hrabowski, president of the University of Maryland, Baltimore County, which is contributing expertise in optical materials, mid-infrared sources and environmental science.

MIRTHE is a National Science Foundation Engineering Research Center, one of several interdisciplinary centers located at universities across the United States. The centers are among the foundation's largest and most prestigious grants. The NSF has agreed to provide \$15 million in funding over five years, with the possibility of renewal for another five years. Through additional funding from corporate partners and other sources, the center is expected to conduct more than \$40 million in research and educational activities over 10 years.

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