RIT, Raytheon to Develop Advanced IR Detectors

ROCHESTER, N.Y., Aug. 1, 2012 — The Rochester Institute of Technology was awarded a $1.2 million National Science Foundation award to develop, fabricate and test a new family of detectors grown on silicon wafer substrates by Raytheon Vision Systems of Waltham, Mass.

Cheaper, larger and better infrared detectors grown on silicon wafers could give more scientists access to infrared astronomy and further spur the hunt for exoplanets and the study of the universe's acceleration. Closer to home, the same technology could advance remote sensing and medical imaging.

"If this is successful, the astronomy community will have a ready supply of affordable detectors that could be deployed on a wider range of facilities," said Don Figer, director of the Center for Detectors at RIT and lead scientist on the project. "Right now infrared detectors are so expensive that there are only a few on the world's biggest telescopes — Keck, Gemini, the Very Large Telescope. Those are the only facilities that can afford them, and then they can only afford a few. They have big telescopes with big focal planes and tiny detectors in the middle."

A strategic goal for the Center for Detectors is building and using advanced astronomical instrumentation, Figer said.

Using silicon wafers to advance infrared detectors will leverage the existing infrastructure built around the semiconductor industry and drive down the cost of building detectors. Silicon wafers are commonly used for semiconductor circuits found at the core of electronic devices. Their wide commercial application makes silicon wafers attractive for a number of reasons — they are produced in high volume, are readily available in large sizes, and are inexpensive.

Cost constraints limit the availability and scale of current detector technology, which uses small, scarcely produced cadmium zinc telluride wafers.

For the past 15 years, researchers have pursued the use of silicon substitutes in the quest for large infrared detectors. Until recently, the crystal lattice mismatch between silicon and infrared materials has hindered advancements, causing defects that generate higher dark current noise, reduced quantum efficiency and increased image persistence.

When infrared light-sensitive materials are grown on silicon, defects are generated because their atoms are not as closely spaced together as atoms in a silicon crystal. Photogenerated charge representing the signal can get stuck and lost, or pop out of the lattice and show up as a phantom signal. The difference in atomic spacing can create the false signal.

Now scientists at Raytheon have developed a prototype detector that uses a method of depositing light-sensitive material onto silicon substrates while maintaining high vacuum throughout the many-step process. The material growth is completed using a molecular beam epitaxy technique.

"Raytheon has come up with an innovation to combine the silicon wafer with the mercury cadmium telluride light-sensitive layer in a way that eliminates all these bad effects," Figer said. "Our proposal is to do a fabrication run of parts based on this new technology and then evaluate the technology in the laboratory and on a telescope."

RIT and Raytheon will design and fabricate arrays of 1024 x 1024 pixels and 2048 x 2048 pixels and test them in the laboratories of the Center for Detectors.

"Not only are silicon wafers much more affordable, but they can be made in much larger sizes because the wafers are now big," Figer said. "Instead of being a four-inch wafer, it can be 12 inches, for instance. We can make a 14,000-by-14,000-pixel detector. That has not been done. It could end up dominating the field in infrared detectors for the next 20 years."

Figer's team will measure the detector's performance using a system based on one he designed for the Space Telescope Science Institute of Baltimore to measure the performance of detectors to be flown on the James Webb Telescope. He will also develop a new lighttight detector housing to keep the detector optically and thermally isolated from its surroundings. The box-within-a-box design is cooled to 60 Kelvin (-350 F) to reduce the blackbody radiation emitted from warmer objects around the detector and to prevent additional noise.

The NSF funding will carry Figer's team into the second phase of the project and the design of a larger, 4000 x 4000 pixel device. An international consortium of organizations is needed to fund the fabrication of these larger detectors.

"I am going around the world talking to directors of observatories currently in existence and future observatories and asking them if they'd like to join a consortium of organizations, each of which contributes to, and benefits from, the development of the first run of 4K parts," he said. "This is the intermediate step before having a final product."

Figer foresees RIT and Raytheon building an instrument for a large telescope during the third and final phase of the program.

"One of the strategic goals for the Center for Detectors is to start a big astronomical instrumentation program at RIT," he said. "There are only a handful of programs like that in the world. It's very competitive, but it's also very fulfilling to both deploy the technology and use it for science in an astronomical instrument."