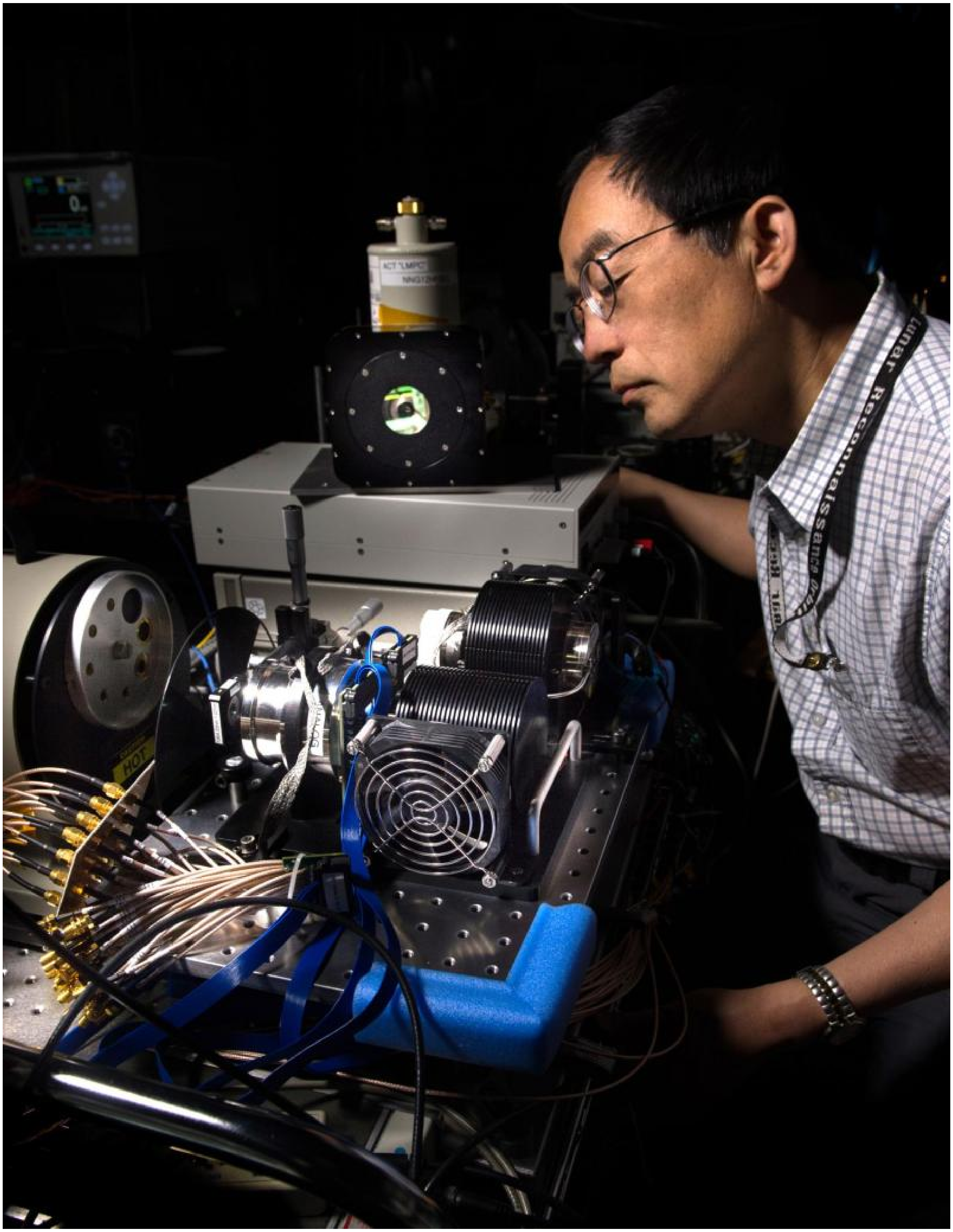
NASA collaborates with DRS Technologies to create mid-infrared detector

June 30 2015, by Lori Keesey



Xiaoli Sun, a scientist at NASA's Goddard Space Flight Center in Greenbelt, Md., worked with his contractor partner to create the world's first photon-counting mid-infrared detector. Credit: NASA Goddard/Bill Hrybyk

NASA scientist Xiaoli Sun and his industry partner have created the world's first photon-counting detector sensitive to the mid-infrared wavelength bands—a spectral sweet spot for a number of remote-sensing applications, including the detection of greenhouse gases on Earth, Mars and other planetary bodies, as well as ice and frost on comets, asteroids and the moon.

"We have developed a new type of mid-infrared detector," said Sun, a scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, who worked with the Dallas-based DRS Technologies to advance the detector, which has since garnered additional funding support from the U.S. Department of Defense. "This is a true success story," Sun said, adding that NASA had been looking for this type of detector for years. "It's a happy story because new detector development is difficult, requiring years of hard work, continued funding and some luck."

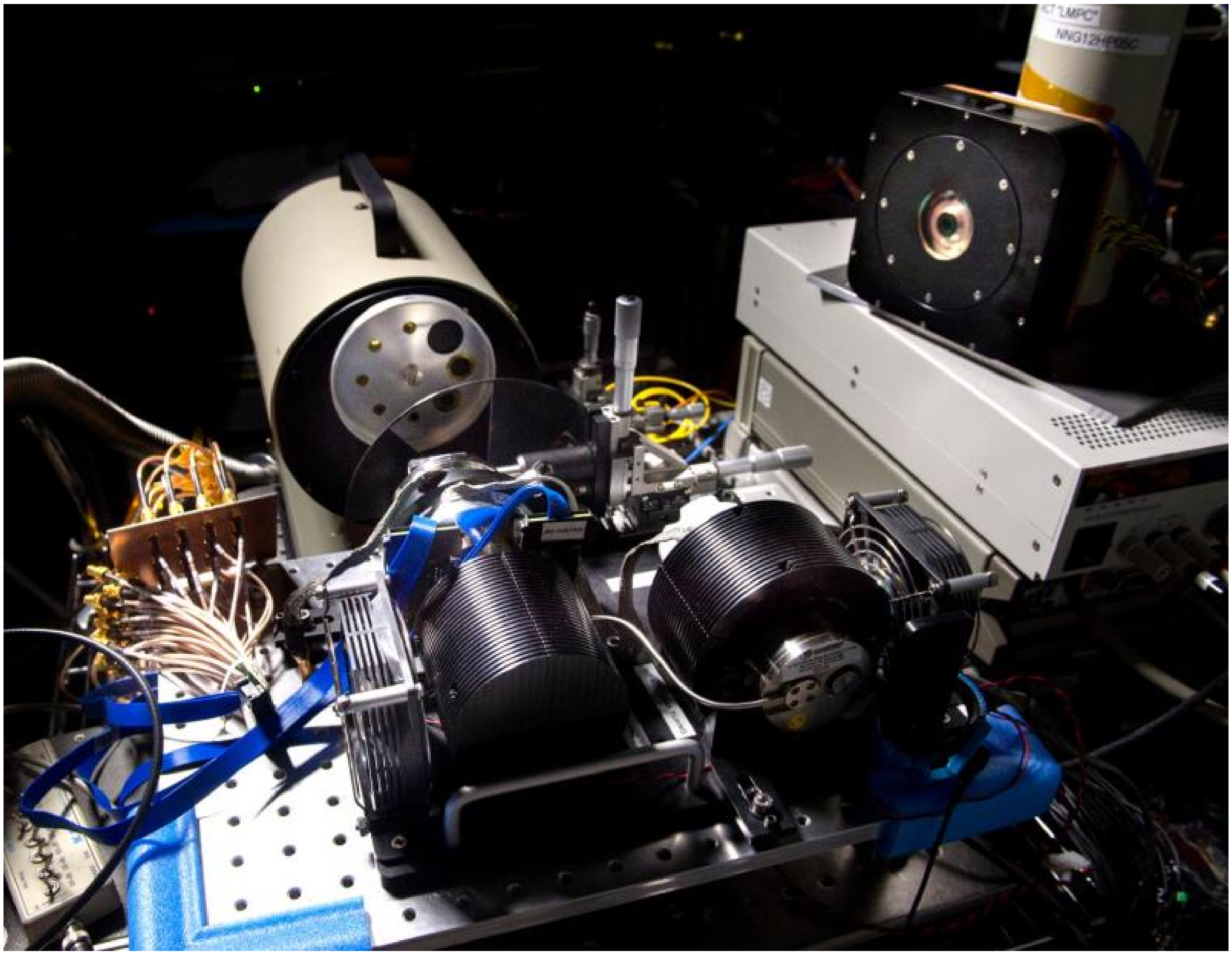
The new detector, made of a special alloy called Mercury-Cadmium-Telluride (HgCdTe) used principally in infrared detectors, is well suited for lidar. Lidar stands for "light detection and ranging" and is a remote-sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances).

This remote-sensing technique involves shining a laser light on a target and then analyzing the reflected light or signal to learn more about the physical properties of the illuminated object and everything along the path.

What's unique about this detector, which is about the size of a sesame seed, is its ability to process the returning infrared signal at a single-photon level. Photons are particles of light. "People have tried to produce single photon detectors in this wavelength band for a long time," Sun said. "Existing detectors can only detect signals containing hundreds of photons per pulse. It is the combination of the HgCdTe material and a near-noiseless avalanche photo-electron multiplication process that made this possible." As a result of this advance, the new detectors enjoy unparalleled sensitivity.

Achieving this level of sensitivity wasn't an easy feat. Detecting photons one-by-one with near-perfect reliability is dauntingly difficult, especially at mid-infrared wavelengths, Sun added. In fact, it took DRS Technologies nearly eight years to manufacture a 16-pixel photon-counting detector array. "It's difficult manufacturing these things," Sun said. "DRS is the only company in the world that can routinely make them."

First Out of the Gate



The new detector applies to a range of spaceflight uses. Credit: NASA Goddard/Bill Hrybyk

The detectors already have customers. Two new aircraft instruments—both strong candidates for NASA's proposed Active Sensing of CO2 Emissions over Nights, Days and Seasons mission, are using the technology.

Goddard scientist Jim Abshire has installed the detector into his CO2 Sounder Lidar. This instrument carries a pair of tunable laser transmitters and a two-wavelength laser-absorption spectrometer that measures both carbon dioxide and oxygen. His colleague, Harris Riris, is now developing a similar instrument to measure methane using the same technique.

Both instruments operate by bouncing a laser light, which is tuned to a narrow band in the infrared, off Earth's surface. Like all atmospheric gases, carbon dioxide, oxygen and methane will absorb the infrared light as it travels to the illuminated surface and back to the instrument. The more gas along the light's path, the deeper the absorption lines as measured by the detectors.

"We always wanted to have more sensitive detectors because we can then use lower-power lasers, which, in turn, reduce the size power, and cost of the instrument," Sun explained, adding that a researcher at NASA's Langley Research Center in Hampton, Virginia, also has acquired the detector for a lidar instrument he's developing for carbon-dioxide measurements. In addition, Abshire is now investigating the detectors' use for measuring the global climate on Mars.

Laser-Altimeter CubeSat Demonstration

The detector also holds great promise for laser altimetry, and more particularly, NASA's proposed Lidar Surface Topography (LIST) mission, which would measure land surface topography for hazards and water runoff, also by bouncing laser light off Earth's surface and analyzing the time of flight, amplitude and polarization of the returned signal.

Next year, Sun and his team are expected to find out just how well the detector array performs a LIST-type measurement when it flies as the principal payload on NASA's CubeSat Demonstration of a Photon-Counting Infrared Detector, a three-unit CubeSat now being built by the California-based Aerospace Corporation.

Funded by NASA's In-Space Validation of Earth Science Technologies program, Aerospace Corp. is adapting a small cryogenic cooler previously used on a Black Brandt rocket to hold the 16-element detector. As part of this year-long technology demonstration, the team will fire laser light from a ground station to the low-Earth orbiting CubeSat to determine the detectors' performance and ability to withstand the harsh radiation found in space.

Infusion Success: Other Beneficiaries

In addition to benefiting Earth and planetary remote sensing, for which Sun and DRS Technologies originally began the development effort, the new detector could be used in fiber-based telecommunications, information science and data-encryption, medical imaging, DNA sequencing, astrophysics and materials science, just to name a few applications.

Working with DRS Techonlogies, the Defense Advanced Research Projects Agency is now investing in a larger array for a flash lidar—a research effort that Sun hopes to leverage as he further advances the technology for civilian-space use.

"The future of these detectors is big," said Irene Bibyk, an associate with NASA's Earth Science Technology Office, one of several technology-development programs that helped advance the HgCdTe detectors. "They're evolutionary. They're disruptive. They have so many applications. Everything about this technology development was exemplary. That's why I call Xiaoli Goddard's 'rising sun.'"

Provided by NASA's Goddard Space Flight Center