New Superlattice Structure Enables High Performance Infrared Imaging

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Scientists at the Center for Quantum Devices (CQD) in the McCormick School of Engineering at Northwestern University have demonstrated for the first time a high-performance infrared imager, based on a Type II superlattice, which looks at wavelengths 20 times longer than visible light.

Researchers at center, led by Manijeh Razeghi, Walter P. Murphy Professor of Electrical Engineering and Computer Science, say that such technology has the potential for broad applications in the detection of terrorist activities, such as use in night vision, target identification, and missile tracking.

Any object, including the human body, with a near-room temperature actively emits long wavelength (around 10 micron) infrared radiation (LWIR). Tracking this infrared radiation using high-speed infrared (IR) imagers would help to reveal thermal profiles of hidden targets or objects at night when no visible source is available. Such imagers also have potential use in medical applications where excessive heating or cooling in the body can indicate problems like inflammation, blood flow issues or even cancerous tissue.

In LWIR imaging applications, the dominant technologies are photodetectors based upon the HgCdTe (mercury cadmium telluride or MCT) material platform and the quantum well photoconductors (QWIP). Both of them have shown limitations that stimulated the research for alternative technologies. Type-II InAs/GaSb (indium arsenide/gallium antimonide) superlattices, first proposed by Nobel laureate Leo Esaki in 1973, became a potential for use in infrared detection in 1987. It wasn't until semiconductor epitaxial growth techniques such as molecular beam epitaxy were sufficiently advanced in the 1990s that high-performance infrared photon detection based on these superlattices was fully demonstrated.

"The type-II superlattice will become the next generation infrared material replacing MCT technology," says Razeghi. "MCT has many limitations, especially in the longer wavelength infrared range critical for missile detection."

Razeghi's research group has recently invented a new superlattice structure, called the M-structure, which boosted the performance of the type II superlattice to a new level. This new device structure is capable of detecting very low light intensity with high optical efficiency and exhibits an electrical noise level 10 times smaller than the original design. A LWIR 320x256 pixel focal plane array fabricated from this material has been able to differentiate temperature differences as low as 0.02 degrees Celsius. The camera was able to detect 74 percent of the incident photons, similar to other leading technologies.

Researchers recently presented their findings at the SPIE Photonics West Conference held in San Jose, CA on Jan. 19-24, 2008. This work was also published in the October 18, 2007 issue of the journal *Applied Physics Letters*.

The work performed at CQD has generated much interest in type-II superlattice research and has brought funding from the U.S. Missile Defense Agency, U.S. Air Force Research Laboratory, Office of Naval Research, and the Defense Advanced Research Projects Agency, as well as collaborations with Rockwell Scientific Company, Naval Research Laboratory, Airforce Research Laboratory, Jet Propulsion Laboratory, BAE, Lockheed, and Raytheon Company.