Quantum Dots See In The Dark

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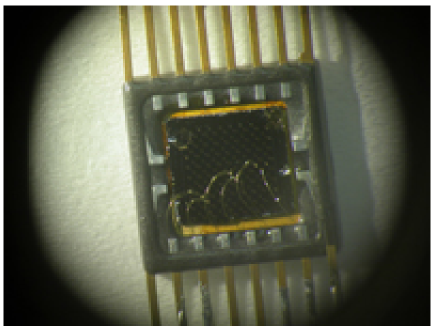

Researchers at the University of Southern California and the University of Texas at Austin have built and tested a device based on nanostructures called quantum dots that can sensitively detect infrared radiation in a crucial wavelength range. Quantum dot IR receptor unit.

The atmosphere is opaque to most infrared, but it is transparent for a narrow "window" between 8 and 12 microns. Night vision goggles, military target tracking devices and environmental monitors utilize this range of wavelengths.

Anupam Madhukar, holder of the Kenneth T. Norris Chair in the USC Viterbi School of Engineering with appointments in the departments of materials science, biomedical engineering and physics, says "a class of existing infrared detectors are based on what is called 'quantum well' technology. But we have created a detector based on different physics--quantum dot physics--that works at least as well and has the potential to perform better."

Madhukar worked with Joe C. Campbell, who holds the Cockrell Family Regents Chair in the UT Austin College of Engineering's department of electrical and computer engineering. The two engineers described the device in the April 24 issue of Applied Physics Letters.

The device uses self-assembled "quantum dots," island-like pyramidal structures made of semiconductors. Each dot has a core of indium arsenide surrounded by gallium arsenide and an indium-gallium arsenide alloy. A single dot is approximately 20 nanometers (2 millionths of a centimeter) in base size and about 4 nanometers in height.

The three-dimensional confinement of electrons within these structures creates unique, characteristic behavior. By using varying proportions of the materials and changing synthesis procedures, engineers can tailor quantum dots for use in lasers, detectors, optical amplifiers, transistors, tunneling diodes, and other devices.

"Quantum dots are emerging as the most viable semiconductor nanotechnology for future higher performance communication systems, biomedical imaging, environmental sensors, and infrared detection," said Madhukar.

Unlike their alternatives, quantum dot infrared detectors strongly absorb radiation shining perpendicular to the plane of an array of quantum dots.

By contrast, the alternate quantum well detectors don't pick up radiation that shines straight down on them. To achieve this "necessitates additional processing steps," Madhukar said. This increases the cost of the well detectors.

When the engineers benchmarked the new device using standard tests, its detectivity was nearly 100 times higher than the previously reported peak for quantum dot systems. The new range is competitive with the corresponding values for the well-established quantum well infrared photo detectors.

"It is about an order of magnitude lower than a third technology, mercury-cadmium-telluride material based infrared detectors. These now provide the best available performance, but suffer from materials uniformity and long-term stability issues," said Campbell.

The researchers expect that placing the dot arrays in a configuration called a "resonant cavity," which traps the radiation and bounces it back and forth between mirroring walls, will make them more sensitive.

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