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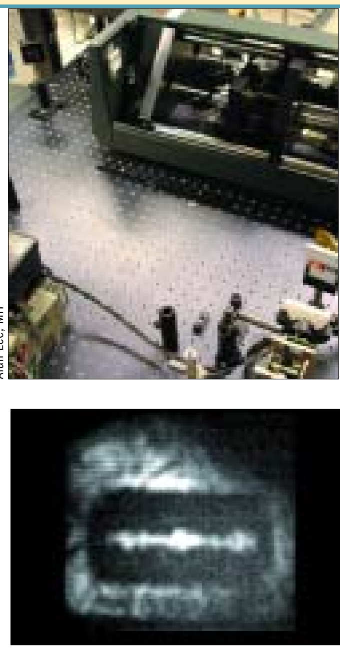
Two scientists from MIT, US, have demonstrated the potential of a real-time terahertz imaging system to screen mail for suspicious objects. Combining a commercially available microbolometer camera and a continuous-wave source at 118 µm, the system acquires images at 60 frames per second and has already spotted metallic objects in a FedEx envelope (*Optics Letters* **30** 2563).

Alan Lee and Qing Hu believe their approach offers several advantages over mechanically scanned terahertz systems that have been reported in the past.

"Mechanically scanned systems acquire an image one pixel at a time by scanning the object through the path of the terahertz source," Lee told *OLE*. "We use a focal plane array of microbolometers so there is no need to scan the object. We also use a single frequency source which provides a large-power spectral density."

To create a source of terahertz waves, the researchers pump methanol vapour with a carbon dioxide laser and generate approximately 10 mW at 118 µm (2.52 THz).

The other key aspect is the camera which uses a 160 × 120 element array of microbolometers spaced at a pitch of 46.25 µm and is sensitive in the 7.5–14 µm range. Despite this, Lee says the camera can still pick up the 118 µm emission thanks to the use of broadband absorbing materials in the resonant cavity.



Alan Lee, MIT

The setup used a compact 5 × 5 × 5 cm microbolometer camera weighing just 250 g (top). The terahertz picture (bottom) shows the 2.9 cm-long razor blade cut-out imaged through the FedEx envelope.

"The cavity consists of an absorptive element composed of thin films of silicon nitride and vanadium oxide forming an air-bridge suspended over a reflecting metal layer. These thin films are absorptive at 118 µm," said Lee.

Radiation from the source is directed on to an off-axis paraboloid and backlights the object over an area of roughly 4 × 4 cm. The transmitted light is collected by a germanium lens and passed to the microbolometer array.

To test their system, Lee and Hu placed an aluminum cut-out of a razor into a standard FedEx envelope. "The signal-to-noise is estimated to be 13 dB for a single frame decreasing toward the edges where the signal diminishes," explained Lee. "The resolution is limited by the size of the lens. Our 10 mm lens limits us to features of about 1.5 mm. A larger lens would give a slightly better resolution."

Lee and Hu now intend to use an array of quantum cascade lasers, each at different frequencies, to illuminate an object.

University, US. Led by Yong-Hang Zhang, the team says it has fabricated a VCSEL that operates at room temperature, emits 7.5 mW continuous-wave and has a side-mode suppression ratio of 20 dB (*Applied Physics Letters* **87** 161108).

SOURCES

Charles Lieber's group at Harvard University, US, has grown gallium nitride (GaN) nanowires that have a lasing threshold power density of 22 kW/cm^2. "To our knowledge, this is the lowest lasing threshold at room temperature reported for GaN materials," say Lieber and his colleagues. "It is also comparable to that of the CdS nanowires used to realize the first single-nanowire electrically driven laser" (*Applied Physics Letters* **87** 173111).

The group grows its nanowires by MOCVD, which results in natural free-standing Fabry–Perot cavities with triangular cross-sections and uniform diameters. Along with the structural properties, the team lists a non-polar growth direction and silicon doping as essential to lowering the threshold power density.

SILICON PHOTONICS

Visible silicon laser makes its debut

The first silicon laser to emit visible light has been reported by a research team at the University of Cincinnati, US (*Journal of Applied Physics* **98** 056108). Unlike the infrared Si lasers demonstrated previously by the University of California and Intel, which both relied on the Raman effect to achieve optical gain (see *OLE* December 2004 p5 and February 2005 p14), the Cincinnati device uses rare-earth doping instead.

Andrew Steckl and his co-workers observed room temperature red (620 nm) emission when they optically pumped their hybrid material laser. The structure consisted of thin layers of AlGaN and Eu-doped GaN deposited by molecular beam epitaxy on a Si substrate. It was pumped with 600 ps duration ultraviolet (337.1 nm) pulses from a nitrogen laser and started to lase at a threshold of 117 kW/cm^2.

"The combination of GaN and rare earth ions makes for a very versatile optical material system, enabling emission over the entire visible range as well as quite deep into the infrared," said Steckl.

"We can replace Europium with Erbium to achieve green and IR emission, or Thulium for blue emission," he told *OLE*.

One of the big challenges to overcome in making the laser was combating stress due to mismatch in the lattice and the thermal expansion properties of the Si and GaN. The use of a special intermediate AlGaN buffer layer between the two helped to solve the problem.

The Cincinnati team is now looking to develop an electrically pumped version of the laser. "While our results, like the ones from Intel and UCLA, were obtained with use of another laser for pumping, I believe that our approach has a better chance to ultimately result in an electricall y pumped 'injection' laser on silicon," said Steckl. "This is of course a very challenging goal, but the payoff could be enormous."