world news

Plasmon imaging
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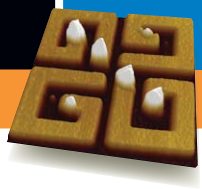

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TUNABLE LASERS

760 kHz OCT scanning possible with MEMS-tunable VCSEL

Microelectromechanical systems (MEMS)-tunable vertical-cavity surface-emitting lasers (VCSELs) would be ideal for swept-source optical-coherence tomography (OCT) applications due to their micron-scale cavity length and low mirror mass for high sweep speeds, singlemode operation without mode hops, and long dynamic coherence length for long imaging range. But while MEMS-tunable VCSELs also offer wafer-scale fabrication and testing and correspondingly low-cost operation, their output power and tunability have been limited, with a 65 nm tuning range at 1550 nm the best previous performance.

Fortunately, scientists at Praevium Research (Santa Barbara, CA), Thorlabs (Newton, NJ), Advanced Optical Microsystems (AOMicro; Mountain View, CA), and the Massachusetts Institute of Technology (MIT; Cambridge, MA) have improved this scenario by developing a 1310 nm singlemode MEMS-tunable VCSEL with a 110 nm tuning range, an approximate factor-of-two improvement in fractional tuning range (Δλ/λ). The new, broadly tunable source achieved a record 760 kHz axial scan rate and uses optical amplification to achieve 40 mW average power output, opening new applications for swept-source OCT.

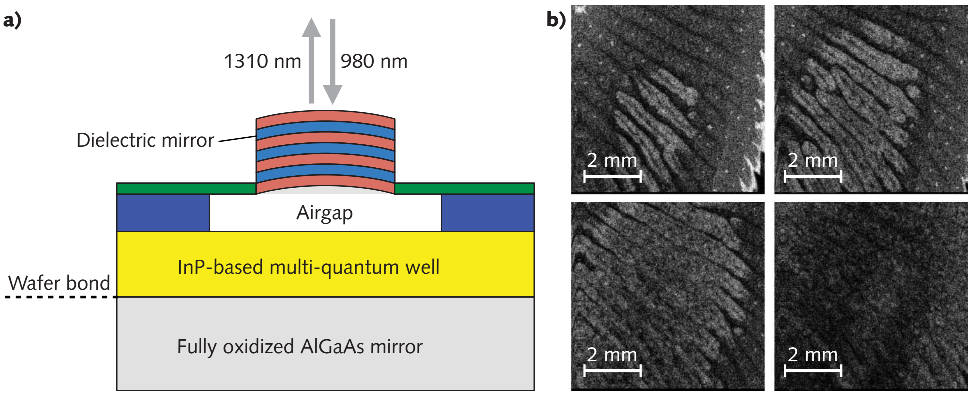
Singlemode operation and MEMS tuning

The tunable VCSEL is constructed by bonding a wide-gain, indium phosphide (InP)-based quantum-well active region to a gallium arsenide (GaAs)-based oxidized mirror. An electrostatically actuated dielectric mirror suspended over the top of this structure and separated by an air gap moves to generate 1310 nm tunable emission as the device is pumped by a 980 nm laser source (see figure). The emission is then coupled to a broadband semiconductor optical amplifier, which not only increases output power but also shapes the spectral output of the tunable VCSEL before it is input to an OCT system.

For ultrahigh-speed imaging at 760 kHz with axial scanning, a 6 dB rolloff is observed at a 4.5 mm imaging depth, corresponding to a minimum 9 mm coherence length for the tunable VCSEL, limited by measurement bandwidth. At slower imaging rates of 150 kHz with axial scanning, a coherence length of more than 25 mm has been experimentally measured. Imaging speed and range are significantly better than other swept laser sources. Because VCSELs operate in true single longitudinal mode rather than a set of modes, they can sweep at adjustable repetition rates while maintaining superior coherence length.

"Singlemode, high-speed swept sources are very promising for the next generation of OCT," says James Fujimoto, professor of electrical engineering at MIT. "These light sources offer record imaging performance and can enable a range of new applications and markets."

—*Gail Overton*



A mirror bonded to a quantum-well structure comprises the heart of a tunable vertical-cavity surface-emitting laser (VCSEL), with tunable 1310 nm emission aided by an electrostatically actuated dielectric mirror placed over the structure (a). As the tunable source for an optical-coherence tomography (OCT) system, the tunable VCSEL enables a 760 kHz axial scan rate for finger-pad imaging (b). Here, a series of four 512 × 512 *en-face* finger-pad images separated by 125 μm in depth show the scanning-OCT capabilities enabled by the tunable VCSEL. (*Courtesy of Praevium Research [a] and Thorlabs [b]*)

REFERENCE

1. V. Jayaraman et al., 2011 Conf. on Lasers and Electro Optics (CLEO), postdeadline paper PDPB2, Baltimore, MD (May 2011).