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Versatile VCSELs shine at longer wavelengths

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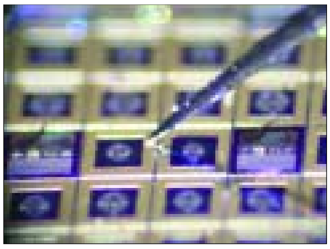
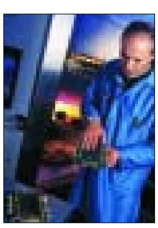
IOPPW BPA

Show report: the low-down on KMI's optical networking conference. p11.



Square deal: tunable vertical-cavity SOAs can construct 2D arrays. p7.

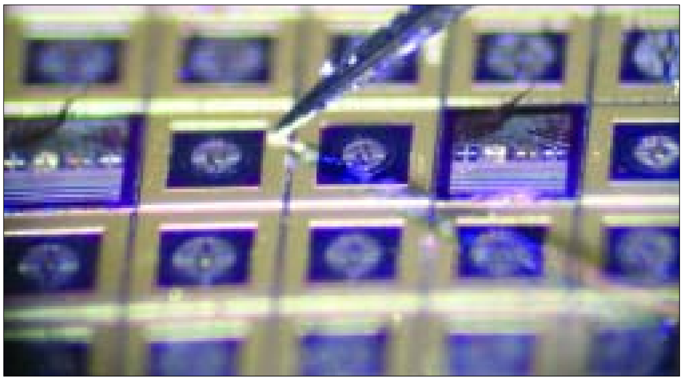
Big benefit: optical control planes promise new service prospects. p16.



On the cover: Long-wavelength VCSELs begin to exploit commercial opportunities. p13. Photo: OCP.

R&D News

MEMS make SOAs tune farther and faster



Stacked up: VCSOAs can be fabricated as two-dimensional arrays. As each device has its own tuning element, the centre wavelengths can be controlled individually.

Pioneers of vertical-cavity semiconductor optical amplifiers (VCSOAs) tout these next-generation devices as a low-cost alternative to erbium-doped fibre amplifiers and in-plane SOAs for metro and access networks. They cite benefits such as low power consumption, high fibre-coupling efficiency, polarization-insensitive gain and compatibility with on-wafer testing.

What's more, the device's narrow amplification bandwidth means it can operate as an amplifying filter, in which a single channel is amplified while out-of-band noise is removed. And now, researchers at the University of California, Santa Barbara, US, have taken things further by incorporating a microelectromechanical systems (MEMS) element to create a VCSOA with an 11 nm tuning range.

The research team formed the tunable VCSOA using an indium phosphide-based active region sandwiched between two aluminium-gallium-arsenide distributed Bragg reflectors. Applying a voltage to an overlying MEMS membrane tunes the amplification wavelength. The device exhibits more than 10 dB gain between 1580 and 1569 nm and has a peak gain of 17 dB at 1570 nm. The gain level is wavelength-dependent, but may be held constant across the tuning range by adjusting the optical pump power.

"Adding wavelength tunability allows the VCSOA's peak gain to be precisely adjusted to match the signal wavelength," said researcher Garrett Cole. "This is particularly useful in low-cost optical networks where the lack of temperature control may cause signals to drift over a fairly wide wavelength range. Also, by developing widely tunable VCSOAs it may be possible to selectively isolate and amplify individual channels in a multiwavelength system."

Previous attempts at tuning VCSOAs via temperature control were hampered by a slow response (of the order of milliseconds) and a tuning range of just a few nanometres. MEMS-based electrostatic tuning, on the other hand, enables tuning speeds of a few microseconds, as well as a wavelength range of tens of nanometres. In addition, electrostatic tuning consumes little power due to low current requirements (in the nanoamp range) and does not need external components.

The team is now revising the mechanical design to cut the tuning voltages and extend the wavelength range. "We would also like to look into updating the optical cavity design to develop devices with a more constant gain profile over the achievable wavelength span. And we will be developing electrically pumped devices," said Cole.

Dual-core photonic-crystal fibre tackles chromatic dispersion

Top notch: dual-core PCF is predicted to demonstrate a negative dispersion value of up to –18 000 ps/nm.km, said to be the largest for any pure air and silica fibre.

Today's state-of-the-art dispersion-compensating fibre offers a dispersion value, *D*, of between –100 and –300 ps/nm.km. Innovation being what it is, researchers are continually striving to boost this value, to overcome the chromatic-dispersion limits of standard singlemode fibre.

Dual-core fibre with asymmetric concentric cores and a high refractive-index contrast can deliver *D* of –1800 ps/nm.km at 1550 nm – though a high index contrast generally means high dopant levels, which in turn increases fibre loss. Photonic-crystal fibre (PCF), meanwhile, offers large *D* (more than –2000 ps/nm.km) but tends to have a small effective area, which can lead to undesirable nonlinear effects during transmission.

Now, however, a research group at Tsinghua University in Beijing, China, has combined the two different approaches and come up with a design for a dual-core PCF. The proposed fibre comprises a silica centre that is surrounded by six small air holes (diameter of 0.86 µm, pitch of 2 µm), which in turn is surrounded by an outer array of holes (diameter of 5.9 µm, pitch of 7.8 µm). The solid inner core has a diameter of 4 µm and the ring of small holes is 2 µm in width.

Simulations predict that this fibre will exhibit *D* as large as –18 000 ps/nm.km and an effective area of 12 μm^2 at 1551 nm – both figures of merit roughly an order of magnitude higher than that exhibited by existing dispersion-compensating PCF designs.

"PCF consists of pure silica and air, so no doping is required," said researcher Ni Yi. "As a result, it's possible to reduce the intrinsic loss and simplify the fabrication. If the fabrication process is mature, I think it may be easier to manufacture dual-core PCF than other dispersion-compensating fibre."

Ni now plans to put this theory to the test by fabricating the fibre, and he is also investigating alternative PCF designs.

Modulation schemes can ramp 40G reach

Return-to-zero (RZ) modulation has proved itself ideal for 40 Gbit/s transmission over standard singlemode fibre, though the dispersive nature of RZ pulses can lead to intrachannel nonlinear effects such as four-wave mixing and cross-phase modulation.

To suppress such intrachannel distortions, scientists at University College London in the UK have used a combination of two modulation schemes – alternating the polarization between adjacent bits, and then using an alternate-phase modulation of π rad between the 20 Gbit/s-spaced tributary channels.

The team launched a multiplexed 40 Gbit/s RZ signal into a recirculating loop comprising 60 km of standard singlemode fibre and 12 km of dispersion-compensating fibre. For a standard RZ signal with parallel polarization between adjacent bits, the maximum transmission distance was 240 km (at a launch power of 4.9 dBm).

Using alternate polarization increased the transmission distance to 360 km, while employing the alternate-phase RZ modulation scheme doubled the reach to 480 km.