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January/February 2006 fibers.org

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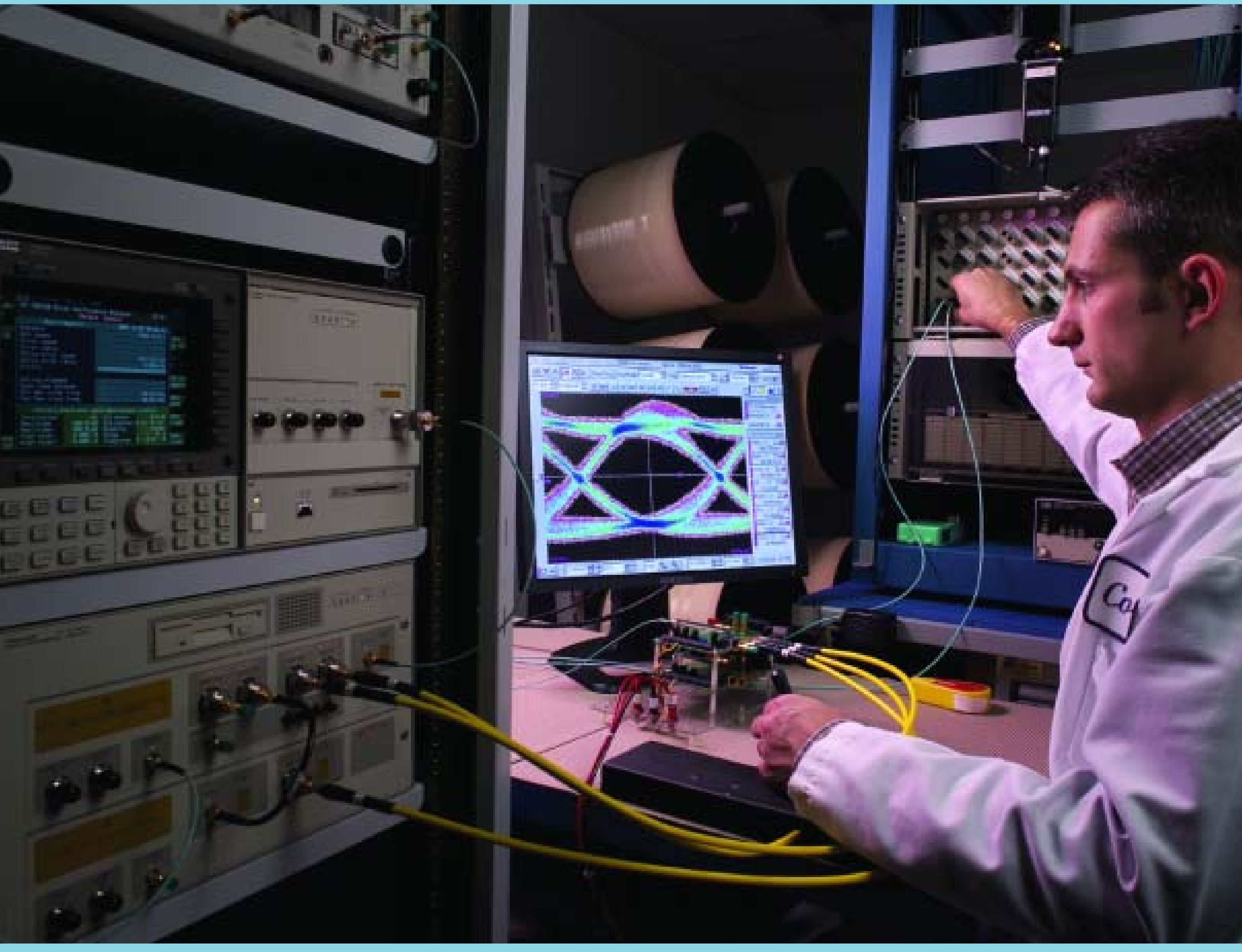


Next-generation fibre: assessing the options

EAM-based converter operates at 40 Gbit/s

All-optical wavelength conversion – the transfer of data streams from one wavelength carrier to another – could play a central role in the management and routing of signals in next-generation optical networks. Importantly, say its advocates, it can help to decrease the number of optical–electrical–optical conversions.

Electroabsorption modulators (EAMs) operating in cross-absorption-modulation configuration perform wavelength conversion across a wide spectral range. Previously, however, they only worked efficiently at lower bit rates as their slow absorption recovery time led to intersymbol interference (ISI). Now, researchers in France have developed an EAM-based converter that operates at 40 Gbit/s with low power penalty.

The key development is redshifting the filter that's applied to the converted signal, which reduces the impact of the limited EAM response time and improves conversion quality. The scientists, from Alcatel Thalès III-V Laboratory, France Telecom R&D and Centre National de la Recherche Scientifique, say that the red-shifted bandpass filter reduces the bit-error rate (BER) penalty at 40 Gbit/s by 4.7 dB compared with a centred filter.

"It is possible to remove the ISI by using a red-shifted filter," said France Telecom's Benoît Charbonnier. "After travelling through the modulator, the converted signal bits overlap with their nearest neighbours, leading to ISI. Light in the regions where this overlap occurs is blue-shifted by nonlinear effects occurring in the modulator. Shifting the filter towards lower frequencies attenuates the regions where the light has been blue-shifted, hence reducing the ISI."

He claims that the maximum bit rate that can be converted this way has been "pushed further towards 160 Gbit/s". The researchers demonstrated conversion of a 40 Gbit/s data channel with a 1.8 dB power penalty at a BER of 10^{-9} and low switching energy.

"France Telecom's goal is to understand the implications at the network level of using wavelength converters, which have the capacity to regenerate the signals as well." said Charbonnier "This has direct impact on the architecture and design of future networks."

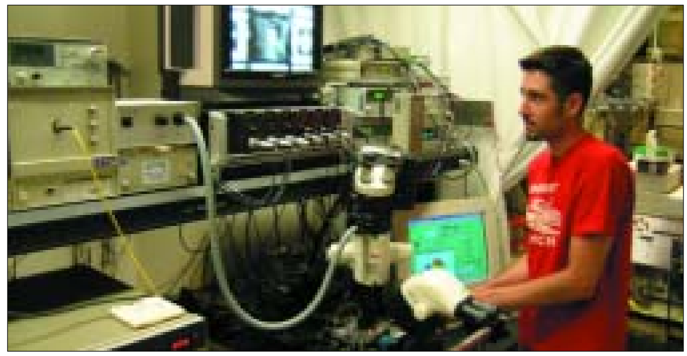
Inverted VCSOA ramps tunability

Researchers at the University of California, Santa Barbara, have ramped the specifications of their tunable vertical-cavity semiconductor optical amplifier (VCSOA). The device now delivers at least 5 dB fibre-to-fibre gain across a 21 nm tuning range.

The VCSOA comprises a layer of multiquantum wells sandwiched by two distributed Bragg reflectors (DBRs). A MEMS-based electrostatic actuator controls the thickness of an air gap between the active region and the top DBR, which tunes the operating wavelength and enables channel-selective amplification.

In the original tunable VCSOA design (*FibreSystems*, August 2004 p7), changing the air-gap thickness significantly altered the reflectance of the tunable mirror, limiting the amplifier gain and reducing its tuning range. Now, by inverting the optical cavity and using the MEMS-tuning structure as the high-reflectivity mirror, the researchers have cut the reflectance variance to 0.7%.

"Increasing the reflectance of the suspended MEMS structure means that the stronger membrane reflectance dominates over reflection from the active-region–air interface," said researcher Garrett Cole. "With a more constant reflectance, the amplifier now exhibits a wider effective tuning range."



Power cut: the bottom-emitting amplifier requires a maximum tuning voltage of 10.5 V – a five-fold reduction on the voltage needed for the previous devices.

As the MEMS mirror in the updated design has a reflectance of near unity (varying between 0.993 and 0.986), it can't be used for signal input/output. So the researchers incorporated a transmissive bottom mirror instead. The bottom-emitting VCSOAs exhibit double the tuning range of their top-emitting counterparts and, importantly, operate within the 1550 nm window (1536.4–1557.4 nm).

"We were able to grow DBRs with thicknesses almost identical to the nominal values," commented Cole. "This allowed the tuning range of the device to be centred on the gain peak of the quantum wells, near 1550 nm."

Other figures of merit include a maximum fibre-to-fibre gain of 11.2 dB at 1548 nm, a maximum saturation output power of –1.4 dBm, and an average gain bandwidth and noise figure of 65.2 GHz and 7.5 dB – values that are comparable to state-of-the-art fixed-wavelength VCSOAs.

The next goal is to develop efficient electrically injected VCSOAs. Such devices are powered by directly injecting the charge carriers into the gain medium, removing the need for an external pump laser . "I believe that people will only seriously contemplate the commercial development of VCSOAs when electrically injected devices are demonstrated in the 1300–1500 nm transmission window," explained Cole, who is continuing to develop the VCSOAs at Aerius Photonics.

Polymer switches slash the crosstalk

Optical waveguide switches based on total internal reflection (TIR) benefit from a compact size and wavelength insensitivity. When such switches are fabricated from polymers, they also boast a large polarization-independent thermo-optic effect, which results in a lower power consumption.

Polymers, however, can suffer from instability, where changes in the material's bulk volume gradually alter its refractive index. Now, the University of Texas at Austin and Omega Optics in the US have developed a polymer TIR switch that overcomes this volume relaxation phenomenon. The secret, say the researchers, lies in the use of a large half-branch angle.

In simple terms, a TIR switch comprises crossed waveguides with two inputs and two outputs. The waveguides widen at the crossing point, above which is placed an electrode heater. With no power to the heater, light from input 1 is routed to output 2 (cross state). Conversely, when the heater is powered, light is reflected at the crossing point and propagates to output 1 (bar state). The angle between the outputs determines the device performance, with larger half-branch angles decreasing the crosstalk but raising the power consumption.

Smooth sides: the SEM image shows a junction between two tapered-width polymer waveguides within the switch.

"Increasing the half-branch angle will not overcome the volume relaxation of the polymer, which is an intrinsic property," said researcher Xiaolong Wang. "However, it will optimize the optical characteristics, making the crosstalk insensitive to the index modulation."

The researchers showed that a thermo-optic 2 × 2 switch with a half-branch angle of 5° exhibits crosstalk of less than –40 dB in both its cross and bar states, as well as a power consumption of 66 mW in the bar state. The device also achieved 2.8 dB insertion loss and 0.1 dB polarization-dependent loss.

"We are working to integrate the TIR switches together with waveguide delay lines to provide true time delay for phased-array antenna systems," said Wang. "Such systems require optical switches with low crosstalk (less than –30 dB) to suppress phase errors."