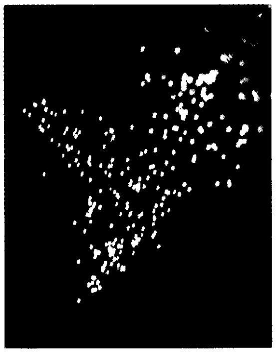

Recent Research

Summarized by George Leopold

These post-deadline papers were prepared for the Optical Fiber Communication Conference (OFC), March 17-22, 2002, Anaheim, California.

High nonlinearity extruded single-mode holey optical fibers

The development of high effective nonlinearity fibers represents a promising new application for holey fibers, which offer a combination of wavelength-scale features and design flexibility. Holey fibers have typically been made by stacking capillaries to form a microstructured cladding region. The Southampton team reported for the first time that extrusion can be used to produce the microstructured fiber preform. They also demonstrated single-mode guidance and nonlinearity enhancement in a non-silica holey fiber. Measured effective nonlinearity was 550 W^{-1} km^{-1}, which they said was more than 500 times larger than that of standard silica fiber. The researchers found that extrusion offered a controlled and reproducible method for fabricating complex, structured preforms with good surface quality. Since fewer interfaces are used than in the stacking approach, extrusion could ultimately offer lower losses than existing techniques. They reported that by combining the tight mode confinement of an effectively air-suspended core with the high intrinsic nonlinearity of glass material, a practical, compound glass optical fiber—with an extremely large nonlinearity per unit length of 550 W^{-1} km^{-1} at 1550 nm—was produced.

T.M. Monro, K.M. Kiang, J.H. Lee, K. Frampton, Z. Yusoff, R. Moore, J. Tucknott, D.W. Hewak, H.N. Rutt, and D.J. Richardson, University of Southampton, U.K.

Active semiconductor microdisk switching devices using gain and electroabsorption effects

The USC researchers previously reported an approach for fabrication of passive semiconductor microdisk devices relying on thermal wafer-to-wafer bonding techniques for building vertical-coupled structures. Here they report on active switching semiconductor microdisk devices with gain and electroabsorption active regions. They found that the devices exhibited high-Q operation (Q > 5,000) and high finesse (F ~ 40). They also demonstrated low current and voltage switches.

The epi-structure of the devices consisted of two vertically stacked waveguides with a common cladding/coupling layer 0.8 μm thick. Growth started in a buffer layer followed by two etch-stop layers and p-cladding layers with decreased doping close to the disk core layer. The researchers said the gain and electroabsorption trimming of transmission characteristics employed here mean the devices could be useful as building blocks for future photonic integrated circuits. Among the possible applications they foresee are resonant detectors, modulators, laser sources, tunable filters, switches, and routers.

Kostadin Djordjev, Seung-June Choi, Sang-Jun Choi, and P.D. Dapkus, University of Southern California, Los Angeles.

Insertion loss reduction by optimization of waveguide perturbations

Current approaches to reducing waveguide losses in planar lightwave circuit-based devices include minimizing the extent of each perturbation and adjusting the waveguide core dimensions and core/cladding index contrast to reduce light sensitivity to the perturbations. The team took a different approach to the waveguide loss problem by discounting the assumption that the loss through a series of waveguide perturbations accumulates in a linear combination of losses that act independently at each break. Instead, they considered several breaks in series, showing that the total loss depends not only on intrinsic loss at each break, but also on the spacing of the breaks. By optimizing dielectric perturbations, their method reduced insertion loss in waveguide-based devices, including optical cross connects, by as much as 3 dB in 32 x 32 switches. They concluded that the new method could be used to improve device performance in existing optical switches and allow for larger port-count switches.

Shalini Venkatesh and Marshall DePue, Agilent Labs, Palo Alto, California, and Hiroaki Okana and Hisato Uetsuka, Hitachi Cable Ltd., Japan.

Fast, digitally variable differential group delay module using polarization switching

Differential group delay (DGD) refers to the relative delay time between two orthogonal polarization states. Tunable DGDs have been found to improve performance in a number of applications including microwave signal processing and phased array beam forming. Polarization mode dispersion (PMD) has also become a critical challenge for high data rate systems.

The investigators report on the first compact, programmable DGD module based on a novel polarization-switching approach. By use of a binary tuning mechanism, the device was able to generate any DGD value from -45 ps to +45 ps in < 1 ms with a resolution of 1.36 ps (6-bit). They showed that the repeatable DGD generation capability can be used to generate any DGD distribution with tunable average values for first-order PMD emulation.

The researchers reported that the module exhibited negligible transient-effect-induced power penalty (< 0.2 dB) in a 10-Gbit/s non-return-to-zero transmission link. Along with good static performance, including low insertion loss (< 11.4 dB), low polarization-dependent loss (< 0.2 dB) and small high-order PMD (< 85 ps^2), the device showed negligible transient effects on system performance. For this reason, they concluded that it is a candidate for PMD compensation. Negligible power penalties because of fast polarization switching, or jogging, were also obtained. They believe that this feature could enable applications of the DGD element in PMD emulation and compensation of microwave photonic networks.

L.-S.Yan, C.Yeh, G.Yang, L. Lin, Z. Chen, Y.Q. Shi, and X. Steve Yao, General Photonics Corp., Chino, California.

Ultrawideband tellurite-silica fiber Raman amplifier and supercontinuum lightwave source for 124-nm seamless bandwidth DWDM

Ultrawideband technology is emerging in the U.S. following recent government approval of limited use of the technology. Once interference concerns are worked out, the technology could become pervasive.

One hurdle is the development of optical amplifiers and optical sources capable of using the intrinsic ultrawideband transmission window of optical fibers. The NTT researchers report on a series of 120-nm optical elements, including hybrid tellurite-silica fiber Raman amplifiers, a supercontinuum lightwave source, and an interleave filter. Their 120-nm-gain-bandwidth post and inline amplifiers consist of laser-diode-pumped, gain-flattened hybrid Raman amplifiers and a 200-nm-bandwidth supercontinuum lightwave source. The source is seen as a promising technology for generating 100-plus-channel optical carriers for wavelength-division-multiplexed photonic networks. The researchers also reported details of a 140-nm bandwidth interleave filter with loss under 2.2 dB.

Together, these ultrawideband optical elements produced a 124-nm seamless bandwidth transmission of 313 x 10Gbit/s signals over 160 km. The ultrawideband transmission could help simplify transmission lines, as well as eliminate gaps between bands and excess loss of demultiplexers multiplexers.

H.Takara, H. Masuda, K. Mori, K. Kohtoku, Y. Miyamoto, T. Morioka, and S. Kawanishi, NTT Corp., Japan.

Third-order cascaded Raman amplification

Previous reports on cascaded Raman amplification involved second-order pumping in a bidirectional pumping configuration to add Raman gain. The utility of this scheme had been limited to relatively short spans (~80 to 90 km). The researchers report on the implementation of third-order cascaded Raman amplification and a comparison of the resulting performance with both first- and second-order pumping. They also demonstrated single- and dual-wavelength third-order pumping schemes requiring a single active pump source. The amplification scheme provided a 2.5 dB improvement in optical signal-to-noise ratio (OSNR) and receiver sensitivity compared to conventional first-order distributed Raman pre-amplification.

Further, third-order pumping was shown to provide a broader and flatter gain profile than conventional first-order Raman pumping. The OSNR advantage for third- versus first-order pumping was found to be a function of the on/off Raman gain.

The researchers found that as gain decreased, the extra OSNR improvement provided by third-order pumping gradually increased. For gains of ~10 dB (typical of gain levels applied in links with repeaters), it reached a value of ~2.8 dB.

S.B. Papernyi, V.I. Karpov, and W.R.L. Clements, MPB Communications Inc., Point Claire, Québec, Canada.

Wavelength agile, photonic integrated circuits using a novel, quantum-well intermixing process

The quantum-well intermixing (QWI) technique developed by the investigators was reported to provide the design flexibility required to manufacture wavelength-agile InP-based photonic integrated circuits. The QWI process also allows for the simultaneous optimization of active region design for high modal gain while providing good tuning efficiencies in QWI material.

Using a simple processing technique based on QWI, they report the technique was integrated to fabricate a widely tunable multisection laser for the first time. They also integrated a backside absorber to provide multiple active sections and multiple tuning sections. Higher modal gain was achieved using an optimized active region structure to increase the confinement factor by 50%, while the QWI material was used for tuning via current injection. Hence, they report the first tuning characteristics using current injection in QWI material, providing more than a 1.5% change in the modal group index, a 37-nm tuning range and a 14-mW output power at 100 mA. The researchers said the QWI process is suited to general application and can be applied to a variety of optoelectronic components.

Along with the design flexibility needed to improve sampled-grating DBR laser characteristics, they said the technique also clears the way for further integration of photonic ICs.

Erik J. Skogen, Jonathon S. Barton, Steven P. DenBaars and Larry A. Coldren, University of California-Santa Barbara.

Record highest sensitivity of -28.0 dBm at 10 Gbit/s achieved by a newly developed, extreme-compact, superlattice-APD module with TIA-IC

Large data transmission requirements are driving both speed and capacity requirements for emerging metropolitan area networks. Ten Gbit/s/channel dense-wavelength-division multiplexing (DWDM) is expected to be the mainstream networking technology to handle data rates measured in Tbit/s. The photodetector modules used in these networks must be compact and highly sensitive as 10 Gbit/s transponders move to smaller size and higher performance. With that in mind, the NEC team developed a compact and highly sensitive APD optical receiver module with an integrated transimpedance-amplifier (TIA) for 10 Gbit/s/channel DWDM applications.

The highest receiver sensitivity of -28 dBm was achieved by a combination of a superlattice APD with a large-gain-bandwidth product (110 GHz) and a high-gain HJFET TIA chip. More than -26.5 dBm sensitivity was also demonstrated over the wide wavelength range covering the C and L bands by use of an extremely small module measuring 9.8 x 7.5 x 4 mm.

The researchers said their optical receiver module offers features suitable for use in 10 Gbit/s transponders as those components of metropolitan area networks move to smaller size and higher performance, including sufficient sensitivity over wide wavelengths (1500 to 1607 nm).

K. Sato, T. Hosoda, Y. Watanabe, S. Wada, Y. Iriguchi, K. Makita, A. Shono, J. Shimuzi, K. Sakamoto, I. Watanabe, K. Mitamura and M. Yamaguchi, NEC Corp., Kanagawa, Japan.