producing up to 25 bits with RZ format at 100 Gb/s.

Other applications of this device are an electronically controlled pulse delay generator and a correlator. More detailed modeling of the device and study of its potential for higher bit rate and longer word lengths is in progress.

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CThF2 **10:45 am**

Optical time-division demultiplexing with surface-emitted second-harmonic generation

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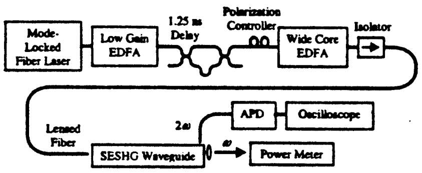
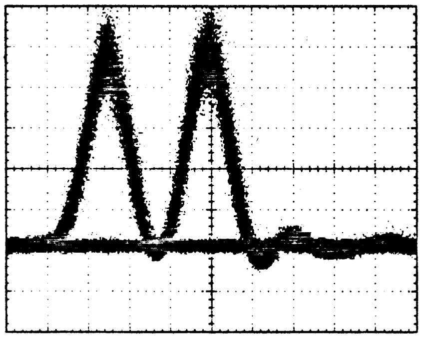
We have previously proposed an ultrafast all-optical demultiplexer[1] based on surface-emitted second-harmonic generation (SESHG)[2] for optically time-division multiplexed (OTDM) communications. This scheme is advantageous in that it provides a serial-to-parallel functionality, allowing all of the multiplexed channels to be recovered with a single device. Here we report a new structure which virtually eliminates linear and two-photon absorption and thereby allows the efficient use of a vertical cavity resonant at the second-harmonic.[3] The combination of reduced loss and the resonant cavity enhancement is expected to yield efficiencies suitable for 160 Gb/s operation.

The new SESHG waveguide has $\mathrm{Al_{0.61}Ga_{0.39}As}$ cladding layers and a nine-layer core, which consists of alternating $\mathrm{Al_{0.2}Ga_{0.8}As}$ and $\mathrm{Al_{0.9}Ga_{0.1}As}$ layers that are $\lambda^{SHG}/2$ thick to achieve quasi-phase-matching (QPM) in the vertical direction. $\mathrm{Al_{0.2}Ga_{0.8}As}$ was used for the high-$\chi^{(2)}$ layers instead of GaAs to avoid deleterious two-photon absorption effects and to minimize linear absorption of the second-harmonic. A 30 period $\mathrm{Al_{0.2}Ga_{0.8}As/AlAs}$ distributed Bragg reflector (DBR) is located beneath the core to reflect downward-propagating SESHG back towards the surface. The entire structure was grown on (100) GaAs by molecular beam epitaxy. Strip-loaded waveguides of various widths were defined by photolithography and reactive ion etching.



CThF2 Fig. 1. The experimental configuration.



CThF2 Fig. 2. APD voltage vs. time for SESHG signal. The vertical scale is 20 mV/division and the horizontal scale is 500 ps/division.

The experimental configuration is shown in Fig. 1. Individual 1.2 ps pulses from a mode-locked fiber laser are split and recombined using 3 dB couplers with different fiber lengths to produce two pulses separated by 1.25 ns. The pulses are then passed through a polarization controller and amplified with a specialized wide-core EDFA before being coupled into the SESHG waveguide with a lensed fiber. The wide-core EDFA allows amplification of the pulses with minimal distortion; the pulsewidth is 1.6 ps at the waveguide input. Each pulse is allowed to reflect through itself at the exit facet of the waveguide ($R \sim 30\%$), accomplishing the required counter-propagating geometry without the use of a separate timing pulse. The resulting SESHG is collected with a 100 μm core multi-mode fiber and detected with a 1 GHz avalanche photodiode (APD). Figure 2 shows the performance at 1535 nm, the optimal EDFA wavelength, with each SESHG peak generated by a 160 pJ fundamental pulse. Reflectivity measurements for the integrated DBR and QPM layers are correlated with the SESHG wavelength response, and show that the structure is three times more efficient at its optimum wavelength of 1525 nm; thus a 12 pJ data pulse and a 100 pJ timing pulse can produce the same SESHG signal-to-noise performance shown in Fig. 2.

For a sixteen channel device operating with 10 Gb/s channels, average power constraints require the data and timing pulse energies to be on the order of 1 and 10 pJ, respectively. Therefore, Fig. 2 shows that a vertical resonant cavity enhancement of 1–2 orders of magnitude is sufficient to provide the performance needed for a 160 Gb/s demultiplexer. Importantly, the structure exhibits minimal absorption, so this level of performance should be attainable in the vertical cavity device.

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CThF3 **11:00 am**

All-optical polarisation switching at 1.5 μm in $\mathrm{In_{1-x}Ga_xAs_y(P_{1-y})}$-InGaAsP multiple quantum wells

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All-optical polarisation switches based on the excitation of spin polarised electrons in GaAs multiple quantum wells (MQWs) have been demonstrated previously[1] with recovery times in the range 20 to 80 ps at wavelengths around 850 nm.[2] In this work, we have studied the well width dependence of spin-dependent optical nonlinearities and spin relaxation times in InGaAsP MQWs and demonstrated all-optical polarisation switching with a recovery time as short as 5.5 ps at wavelengths compatible with all-optical soliton communication systems.

Interband selection rules in multiple quantum well (MQW) semiconductors can be used to create 100% spin-polarised electrons when circularly polarised light is resonant with the heavy hole exciton. The resulting optically induced circular dichroism can be used to identify and quantify spin-dependent phase space filling (PSF) and spin-independent Coulomb contributions to exciton saturation.[3,4] Takeuchi *et al.*[5] showed that spin relaxation is faster in InP based quantum wells. Here we have examined the relative contributions of PSF, screening and broadening in InGaAs(P)-InGaAsP multiple quantum wells (MQWs) with four different well widths at 1.5 μm.

To explore these effects we have used a colour centre laser producing 150 fs pulses in three separate pump probe polarisation configurations of linear and circularly polarised light. Electron spin relaxation times were measured directly by comparison of pump-probe configurations with the two beams having the same and opposite circular polarisations. Figure 1 gives results of spin relaxation rate measurements in the four samples plotted as a function of the electron confinement energy of the $n = 1$ level. The spin relaxation rates were found to be strongly well width dependent and significantly faster than in GaAs MQWs, consistent with the D'yakonov-Perel model. The fastest observed relaxation time was 5 ps in the narrowest quantum well sample.

Spin polarised electrons cause a refractive index difference between left and right circularly polarised light as it propagates through the MQW because of the spin-dependent PSF nonlinearity. Hence, the summation of the two circular components of linearly polarised light