energy, and reach 30 dB and 40 dB at pump energies of 10 pJ and 30 pJ, respectively. This means an on/off ratio enhancement of more than 20 dB in comparison with the value obtained from the device itself.[1] The inset of Fig. 2 shows the response time of 300 fs. Figure 3 shows the polarization dependence of the scheme. In spite of changing the polarization states of the signal pulses by a Babinet-Soleil compensator the output is almost constant at both the on-state and the off-state, which means polarization-insensitivity to the signal pulses.

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10 GHz Boolean XOR with semiconductor optical amplifier fiber Sagnac gate

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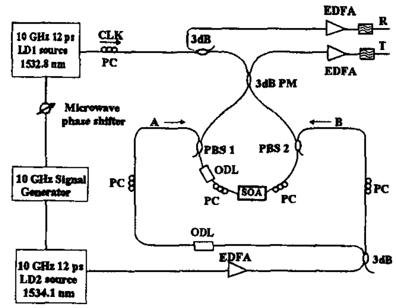
The ability to perform high speed, bit serial switching operations has attracted the interest from a number of research groups.[1] A low switching energy device operating on the principle of the Sagnac interferometer (TOAD/SLALOM) and using the nonlinear saturation of a semiconductor optical amplifier (SOA) has been central to these efforts.[2-4] In this communication we describe the demonstration of Boolean XOR operation at 10 GHz using this device configured as a three input terminal all-optical gate. It is the first to our knowledge demonstration of two control beam switching with this device and is significant because it proves the ability of the gate to pass to the second interference fringe simply by introducing twice as much energy per pulse as is required for the first. Two control beam switching demonstration is important because it will allow the full complement of Boolean logic to be performed on ultra high speed optical signals. In particular Boolean XOR is central in the design of decision and comparator circuits that are required for all-optical logic.

In the present experiment the performance of the SOA-assisted Sagnac as an XOR gate was verified, using two optical control beams A and B that may take a logical 0 and 1. The logical output is imprinted on a third optical beam (CLK) which is held on input continuously to a logical 1. The experimental configuration is shown in Fig. 1.

The two logical control inputs were produced by a single, gain switched and com-

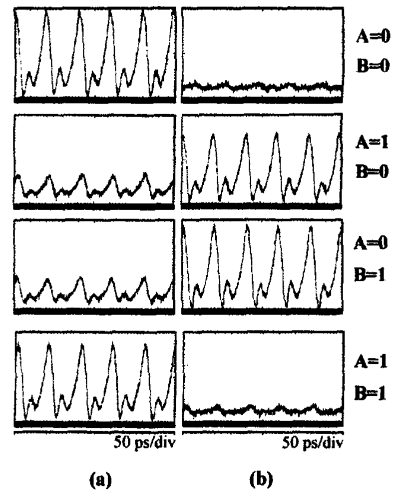


CThF5 Fig. 1. Experimental setup.

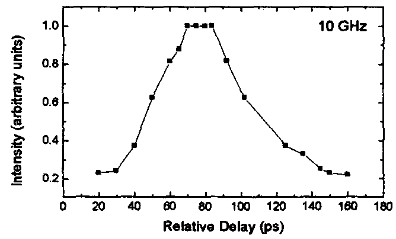
pressed DFB laser source (LD) at 1534.1 nm providing 12 ps pulses at 10 GHz. The pulse trains were amplified in a single EDFA and split in a 3 dB coupler, to be fed into the control ports A and B of the gate. The optical clock signal (CLK) was provided by a similar DFB source (LD) at 1532.8 nm. The gate was constructed using a 3 dB polarization preserving coupler (3 dB PM) via which the CLK signal was inserted. Polarization selective fiber couplers (PBSs) were used in the loop to couple in and out the orthogonally polarized pulses of the two control beams. Polarization controllers (PC) were used in the circuit to define the polarization state of the pulses before entry into polarization sensitive components. The nonlinear interaction between the control and CLK pulses was performed in a 1000 μm long, bulk SOA with a recovery time below 100 ps. Optimum switching was obtained by spatially offsetting the SOA from the center of the loop with a variable optical delay line (ODL), for maximum differential phase change between the two counter propagating CLK beams. Precise synchronisation between the three optical beams in the SOA was provided with microtuning of the frequency of the rf signal generator and a variable optical delay in the path of one of the control beams.

Figures 2(a) and 2(b) show the logical XOR output from the reflection (R) and transmission (T) ports respectively of the gate at 10 GHz for the four control input logic combinations A and B.

The optical power required for the logic inputs A and B was as low as 500 μW and 400 μW respectively, corresponding to 50 fJ and 40 fJ switching pulse energies. This switching energy is indeed low, making the device practical for use with low average power EDFA amplifiers. The gate was also operated at 2.5 and 5 GHz with similar switching energies, indicating that 10 GHz may not be the switching speed limit of the device. The contrast ratio between the on-off states at the R and T ports of the gate was 5:1 and 14:1 respectively. Even though this contrast ratio may be low for telecommunications switching applications, it is adequate for optical logic operations since the ability for the gates to be cascaded is more important. This device has been shown to be cascadable up to 10 GHz.[5] Of the parameters that control the performance of the gate, the most easily adjustable is the width of the control pulses. In order to assess whether the pulsewidth of the controlling pulses was appropriate, the switching window of the device was measured. Figure 3 shows a 15 ps temporal



CThF5 Fig. 2. (a) and (b), outputs at R port and T port respectively of the gate at 10 GHz for the four control input logic combinations A and B. The timebase is 50 ps/div.



CThF5 Fig. 3. Switching window at 10 GHz.

window over which switching can be obtained. This is short compared to the 12 ps pulsewidth of the control pulses and explains the relatively low contrast ratio obtained from the gate. Finally it has been also possible to switch out different pulse patterns from CLK signal using appropriate modulated A and B control inputs, with low data pattern—dependent effect on its output.

In conclusion, we have demonstrated for the first time the implementation of Boolean XOR logic at 10 GHz using an all-optical semiconductor optical amplifier-assisted Sagnac interferometer gate. This demonstration opens the possibility to implement other logic functions that require simultaneous presence of two control beams.

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