All-Optical Switching in fibre Bragg gratings

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Fibre Bragg gratings (FBGs) are among the most promising devices for inclusion in the next generation of high speed photonic networks since they provide high reflectivity and large dispersion with low insertion losses and are readily compatible with WDM systems. An additional feature of FBGs is that they are intrinsically nonlinear devices and this nonlinearity can be used to increase their functionality in a photonic network. Recently using an all-fibre source we have successfully demonstrated all-optical switching in FBGs involving a variety of geometries[1]. Importantly both self-switching[2] and logic gate operations[3] have been demonstrated.

Central to most of our results has been the formation of a gap soliton at the front of the grating which then propagates unchanged throughout its entire length. Gap solitons are nonlinear pulses which can propagate coherently through a grating by balancing the grating dispersion with the nonlinearity[2]. Furthermore gap solitons can exist at frequencies within the bandgap of the grating, i.e. at frequencies where linear radiation is completely reflected. Under CW excitation the creation of a stationary gap soliton can alter the transmission of grating from essential zero to unity. Thus FBGs are promising candidates for all-optical switches.

To observe all-optical switching we used an all-fibre erbium amplifier chain to amplify nanosecond pulses from a directly modulated diode. The resulting pulses, with peak powers in excess of 10 kW, were coupled into an 8 cm apodised FBG. The transmitted pulse was directly detected using a PIN photodiode with a temporal resolution of < 50 ps. In the simplest configuration we measured the transmitted intensity as a function of the input power and the results are shown in Fig. 1a. In the linear regime the transmission is $\approx 4\%$ while it increases to nearly $\approx 40\%$ at higher intensities[2].

We then split the input into two orthogonally polarised beams and recombined them at the input to the grating. In this geometry the FBG functions as an 'AND' gate. When a single pulse was incident upon the grating the power was below the threshold for gap soliton formation. However if both pulses were coincident then the threshold was exceeded and a single gap soliton was formed which propagated through the grating (see Fig. 1b solid line). Contrast ratios as high as 17 dB were measured[3].

Using a pump-probe geometry all-optical switching of a weak probe beam was demonstrated. In this configuration the weak CW probe beam was tuned to the bandgap of the grating while the pump wavelength was far from resonance. When the pump was incident upon the grating it altered the Bragg wavelength resulting in optical pulse compression of the probe beam[1]. This is we believe the first demonstration of the optical pushbroom.

In conclusion we have demonstrated all-optical switching in FBGS using a variety of geometries. These results indicate the versatility of FBGs for nonlinear experiments as well as offering promise for high-speed all-optical devices in the near future.

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1. N. G. R. Broderick, *et al.* Phys. Rev. Lett. **79,** 4566 (1997).
2. D. Taverner, *et al.* Opt. Lett. **23,** (in press) (1998).
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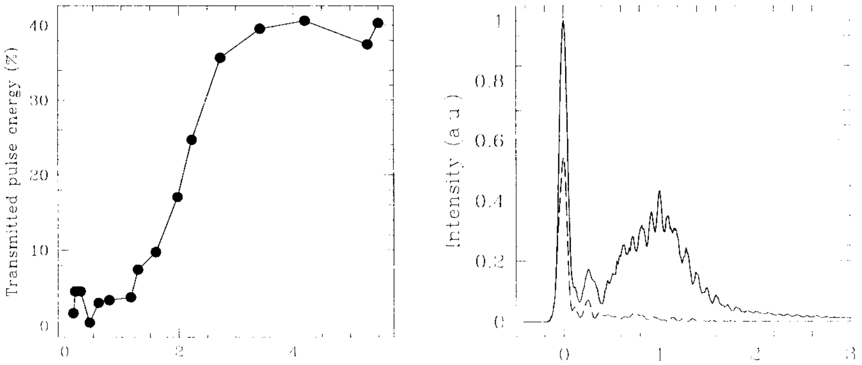

Fig. 1. (a) Self-Switching of a Bragg grating by an intense nanosecond pulse. (b) Operation of an all-optical 'AND' gate resulting in the formation of a coupled gap soliton. The dashed line corresponds to a single input while the solid line shows the switched ouput. The front spike in the traces is an artifact of the input pulse and can be neglected.