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Nonlinear propagation in an integrated AlGaAs Bragg grating

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Abstract

Nonlinear propagation and gap soliton formation in integrated AlGaAs Bragg gratings is examined. The low powers and high repetition rates demonstrate the potential for all-optical switching in such materials.

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Nonlinear switching in Bragg gratings resulting in the formation of gap solitons has been well examined theoretically [1] and more recently experimentally [2] in fibre Bragg gratings(FBG). Nonlinear switching in fibre Bragg gratings requires extremely high powers due to the small nonlinearity of silica and hence if practical devices, which utilise the functionality of nonlinear Bragg gratings, are to be built then new materials must be found.

Particularly attractive in this regards are AlGaAs waveguides which have low loss and a high nonlinearity at 1.5 μm and into which long high quality Bragg gratings can be directly etched with refractive index modulations as high as 0.02. For our experiments we used AlGaAs wafers grown by molecular beam epitaxy and with a three layer structure. Light was guided in the middle layer which was 1.5μm thick and contained 18% Al. The two cladding layers each contained 24% Al to provide the refractive index difference. The waveguide and 4mm long grating were written using electron beam lithography which allowed precise control over the grating parameters. The grating's spectrum is shown in Fig. 1 with our pulse spectrum superimposed on it, note that the peak reflectivity is $\sim$ 97%.

Our pulse source is an externally modulated diode seeded erbium fibre amplifier chain. It produces 400ps pulses with a bandwidth of $<$ 0.05 nm and a peak power of 800W at a repetition rate of 100kHz. The transmitted pulses were detected using a fiberised PIN photodiode and a sampling oscilloscope. Initially the diode was tuned to the centre of the bandgap (see Fig. 1) and we measured a 10-fold nonlinear increase in the transmission at high powers (from 3% to 30%). This is the result of soliton formation as seen in Fig. 2.

In conclusion we have examined nonlinear propagation in integrated AlGaAs gratings. Significant nonlinear switching was observed at powers below the damage threshold of AlGaAs and this was due to the formation of gap solitons within the grating's bandgap.

REFERENCES

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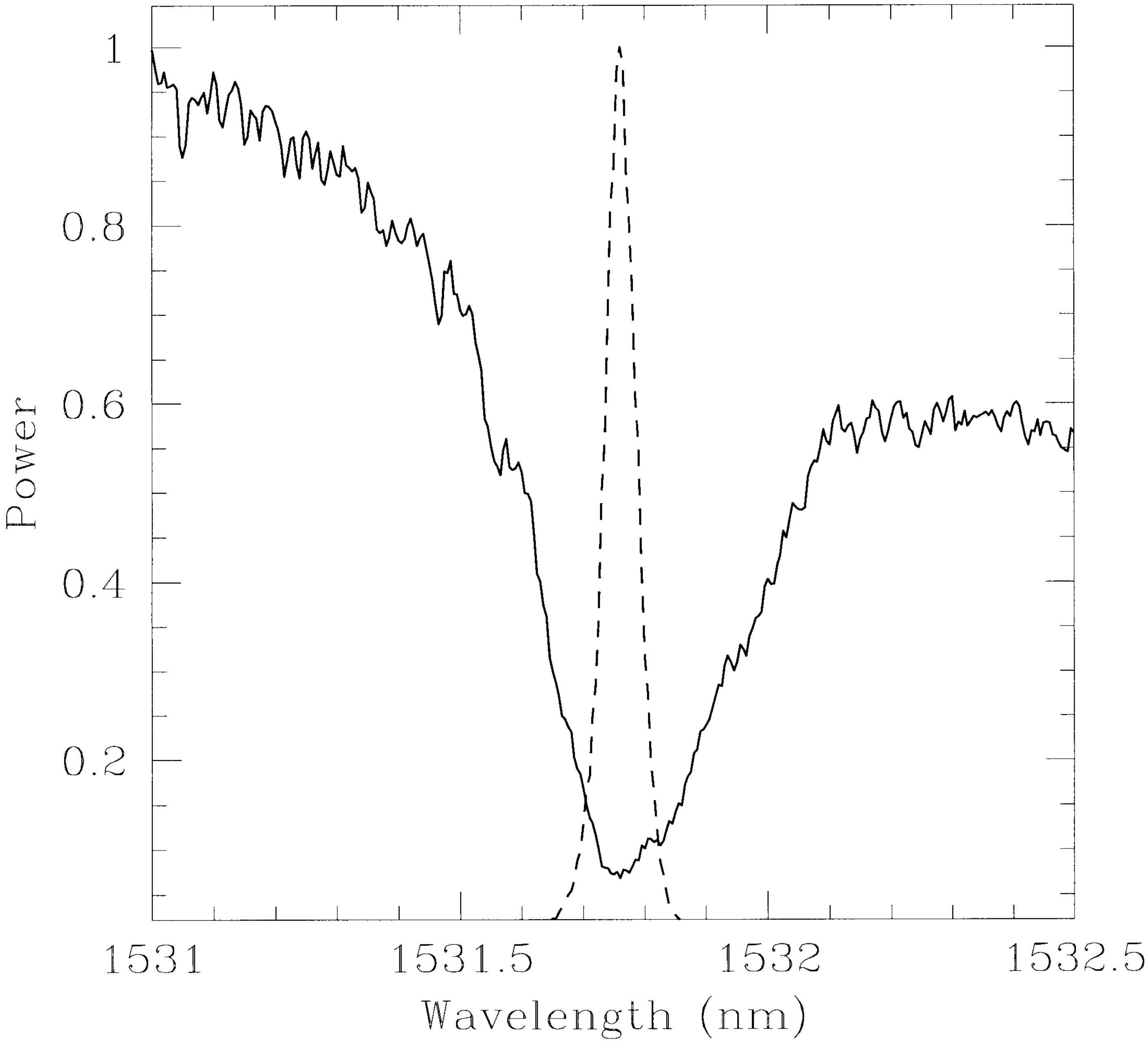
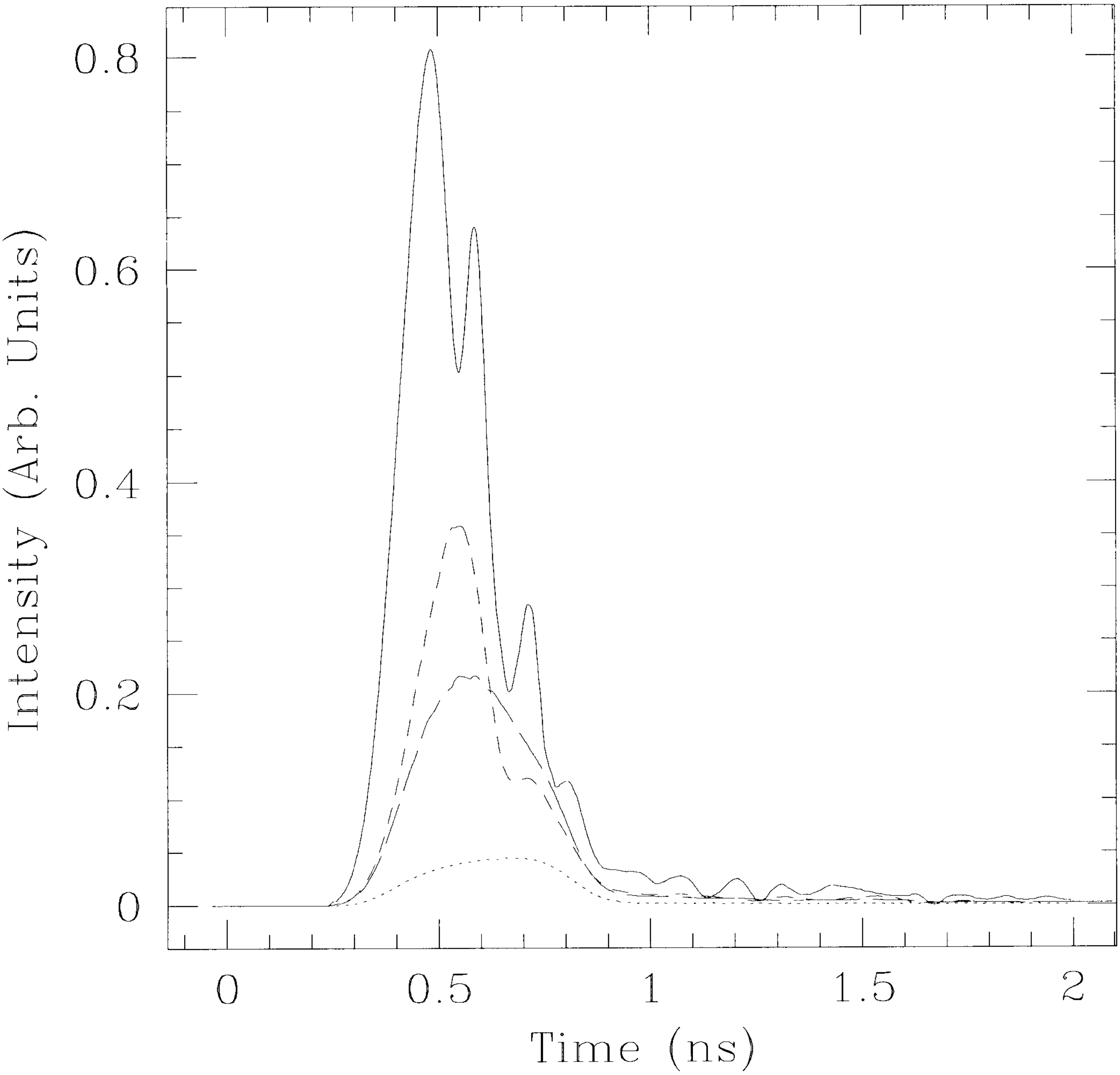
FIGURES

FIG. 1. Transmission spectrum of the AlGaAs grating measured using the ASE from the pulse source. The dashed line shows the measured pulse spectrum which below the resolution limit of the optical spectrum analyzer. The asymmetry in the transmission spectrum is due to the asymmetry in the background ASE.

FIG. 2. Pulse shapes as a function of increasing energy. The incident peaks powers are 833W, 536W, 432W and 10W in order of decreasing pulse height. Note that the 10W trace has be increased by a factor of 10 to render it visible. Note that there is clear evidence of pulse compression and additional pulse shaping as the power increases.



1
0.8
0.6
0.4
0.2
Power
1531
1531.5
1532
1532.5
Wavelength (nm)



0.8
0.6
0.4
0.2
0
Intensity (Arb. Units)
0
0.5
1
1.5
2
Time (ns)