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Gain reversal studies in photorefractive waveguides

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Abstract

We report on low-loss photorefractive $BaTiO_3$ H^+ implanted waveguides exhibiting reversal of two-beam-coupling gain direction, caused by induced colour centres. The anomalous two-beam-coupling gain has been investigated as a function of the input beam ratio.

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Recent advances in developing photorefractive waveguides have enabled the observation of photorefractive effects [1] on a much shorter time scale [2] than that obtained in bulk crystals

We present investigations on 15 μm $BaTiO_3$ planar waveguide, fabricated by implantation with 1.5 MeV H^+ ions. Whereas the first waveguides obtained via this method exhibited quite high losses [2], subsequent experimentation on varying the implant parameters have enabled a significant reduction of the losses. Several waveguides have been produced using different doses in the range between 10^{15} to 10^{16} ions/cm^2, and the magnitude of the losses measured for each dose (Fig. 1). Ion implantation affects the magnitude of the two-beam-coupling gain, and the response time via a change in the ratio of the Fe^{2+} to Fe^{3+} concentration [1, 3]. Optimisation of implant parameters has, therefore, involved three factors - maintaining high gain, but reducing the response time and the propagation losses.

An important feature of photorefractive gain observed in ion-implanted waveguides is that its direction is reversed as compared with bulk crystals [1, 4]. We report the evidence for the presence of the colour centres in ion-implanted waveguides, indicating their influence on reversing the gain direction. The absorption spectra of both bulk and waveguide materials, measured using e-polarised light, have revealed a shift in the UV absorption edge, about 20 nm towards longer wavelengths in the waveguides (fig.2). This is a characteristic feature of colour centres, which are generated in waveguides owing to the ionising effect of the implanted ions.

The analysis of the two-beam coupling gain has involved measurements of its dependence on the input beam power ratio. In our case, in order to launching light into a waveguide, the two incident beams had to be tightly focussed. The results obtained have been compared with the standard theory and showed an excess of an order of magnitude discrepancy.

In order to investigate the origin of this difference we performed the same two-beam-coupling experiment with focussed beams in the bulk crystal. The gain has shown a similar behaviour as in the waveguide. We will discuss the factors affecting two-beam-coupling, including a modification to the existing theory to take account of the presence of secondary photorefractive centres. The existence of shallow traps, in addition to deep traps, affects such photorefractive parameters as effective number of empty traps or the concentration of carriers [5]. The effect of high power density in the waveguide region will be examined in order to estimate its contribution to the anomalous two-beam coupling gain.

References

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Figure captions

Figure 1 Magnitude of losses in $BaTiO_3$ waveguides for different doses of implanted ions

Figure 2 Absorption spectrum of $BaTiO_3$: bulk crystal (solid line) and waveguide (dashed line)

Fig.1

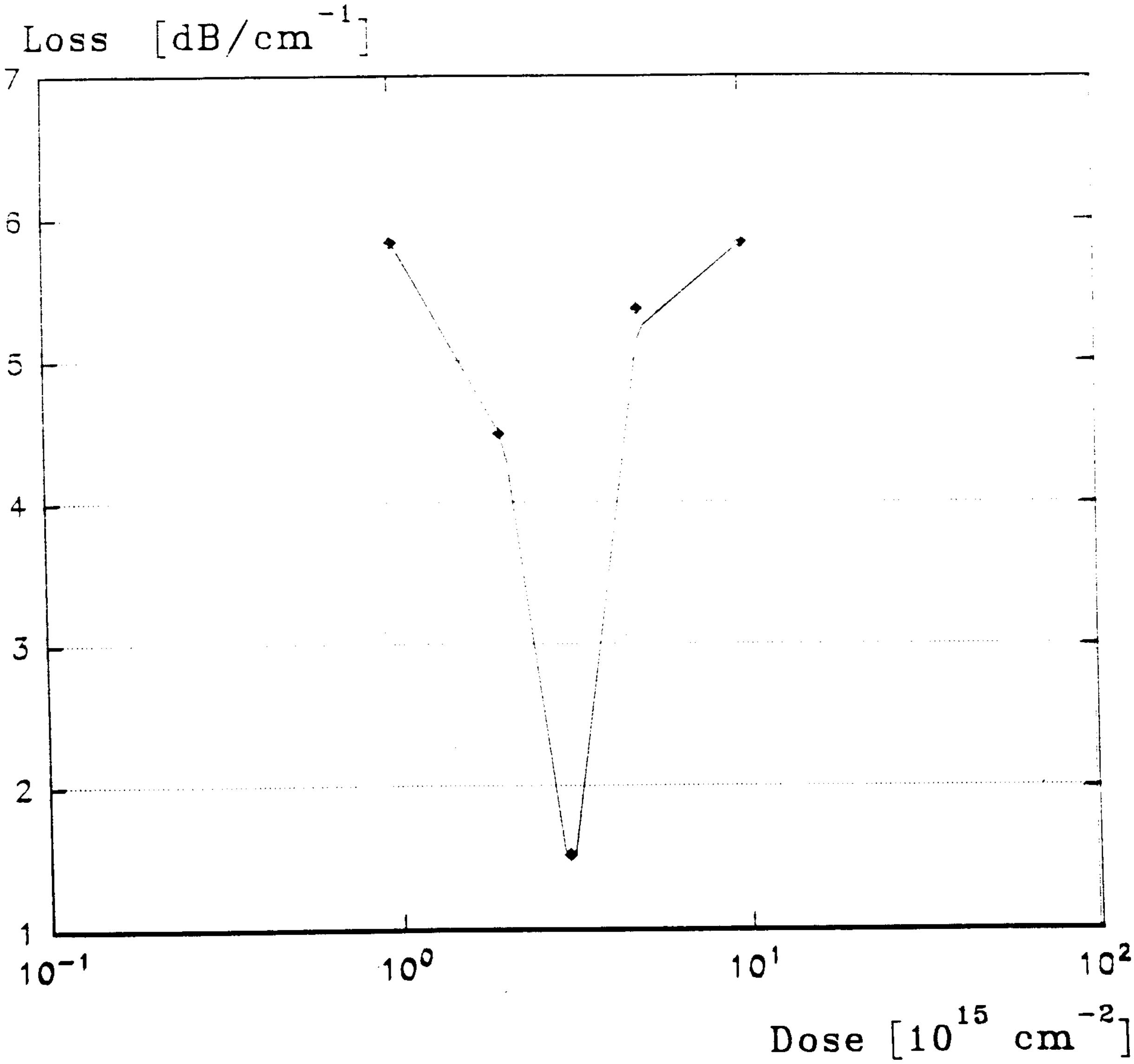

Fig.2