Optical phase conjugation in photorefractive waveguides

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Abstract

Self-pumped and mutually-pumped phase conjugator configurations have been demonstrated in a planar waveguide in $BaTiO_3$, fabricated by the technique of ion implantation. For equal input powers a two order of magnitude decrease in response time is observed in the waveguide as compared to the bulk.

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Summary

Self-aligning phase conjugate mirror configurations have been extensively investigated in high gain photorefractive materials such as $BaTiO_3$ and SBN. While many applications may be envisaged for such devices, currently available materials are perceived as having response times which are too slow to be compatible with commercial requirements. The response times of photorefractive effects scale as the inverse of the incident intensity, leading to the current interest in increasing the intensity by confining the interacting beams within a waveguide geometry.

Here we report the observation of self-pumped[1] and mutually pumped phase conjugation[2,3] in a 15μm deep ion implanted planar waveguide in $BaTiO_3$, fabricated using 1.5 Mev H^+ ions at a dose of 10^{16}ions/cm^2. Losses of the guide were measured to be 14 dB/cm. In a recent publication[4] a reversal of the gain direction in two beam coupling

interactions in the waveguide as compared to the bulk was reported, along with a two order of magnitude decrease in response time for an equal input power. The gain direction reversal is attributed to either the repoling of the waveguide region or, more probably, a change in dominant photocarrier induced by the ion implantation.

The crystal geometry used is shown in figure 1, and was chosen to facilitate previous two beam coupling measurements. For the self-pumped phase conjugation, SPPC, experiments the input was launched using a 22mm focal length lens, producing a line focus of 1.5mm x 7μm at the crystal face. Measurement of response time as a function of input power, at an angle of incidence of 30°, revealed a two order of magnitude decrease in response time in the guide as compared to the bulk, and a reduction in the threshold for SPPC to occur, as is shown in figure 2. The change of gradient evident at low input powers occurs as the waveguide approaches threshold. Phase conjugate reflectivities of 20% have been observed, which, given the 14 dB/cm losses of the waveguide, imply that stimulated photorefractive scattering is in operation here.

Mutually pumped phase conjugation in the bridge geometry has also been observed in the guide, the reflectivity as a function of input beam ratio being shown in figure 3. The reflectivity is currently limited to 8% as a result of the high losses of the guide. An order of magnitude decrease in response time is observed in the waveguide as compared to typical values obtained in bulk crystals.

Methods of reduction of waveguide losses, including annealing and optimisation of implant parameters are currently being investigated, along with optimised crystal cuts to maximise launch efficiency and allow investigation of the phase conjugate fidelity. We will report on both these aspects, and discuss applications for waveguide geometries.

References

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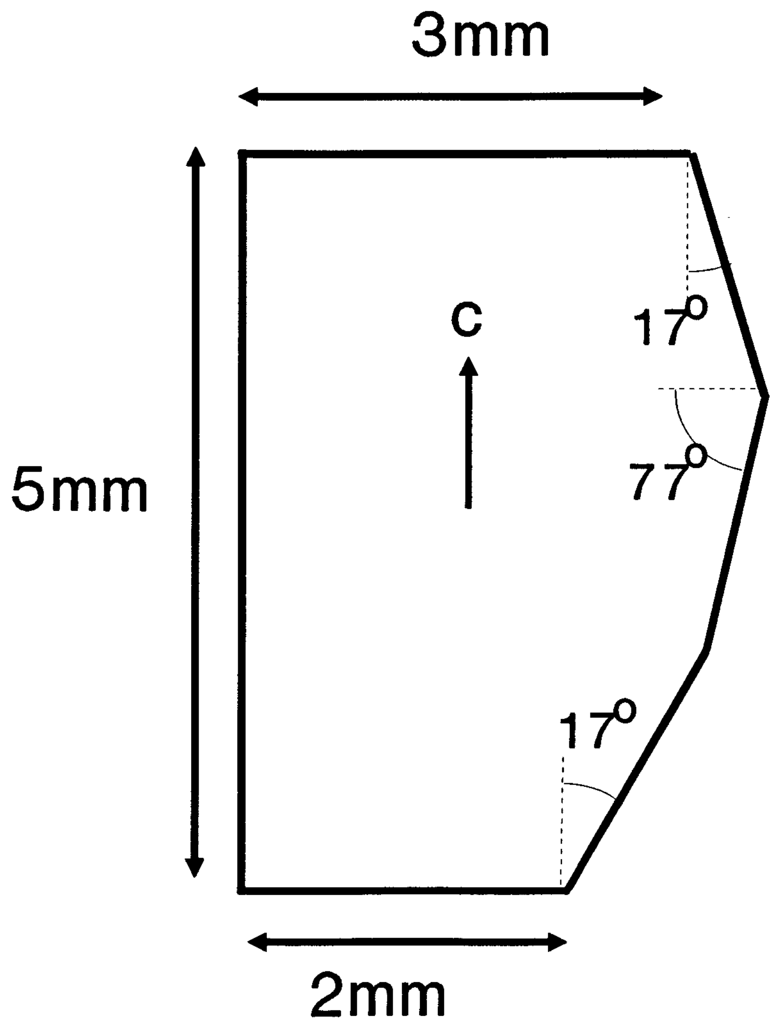
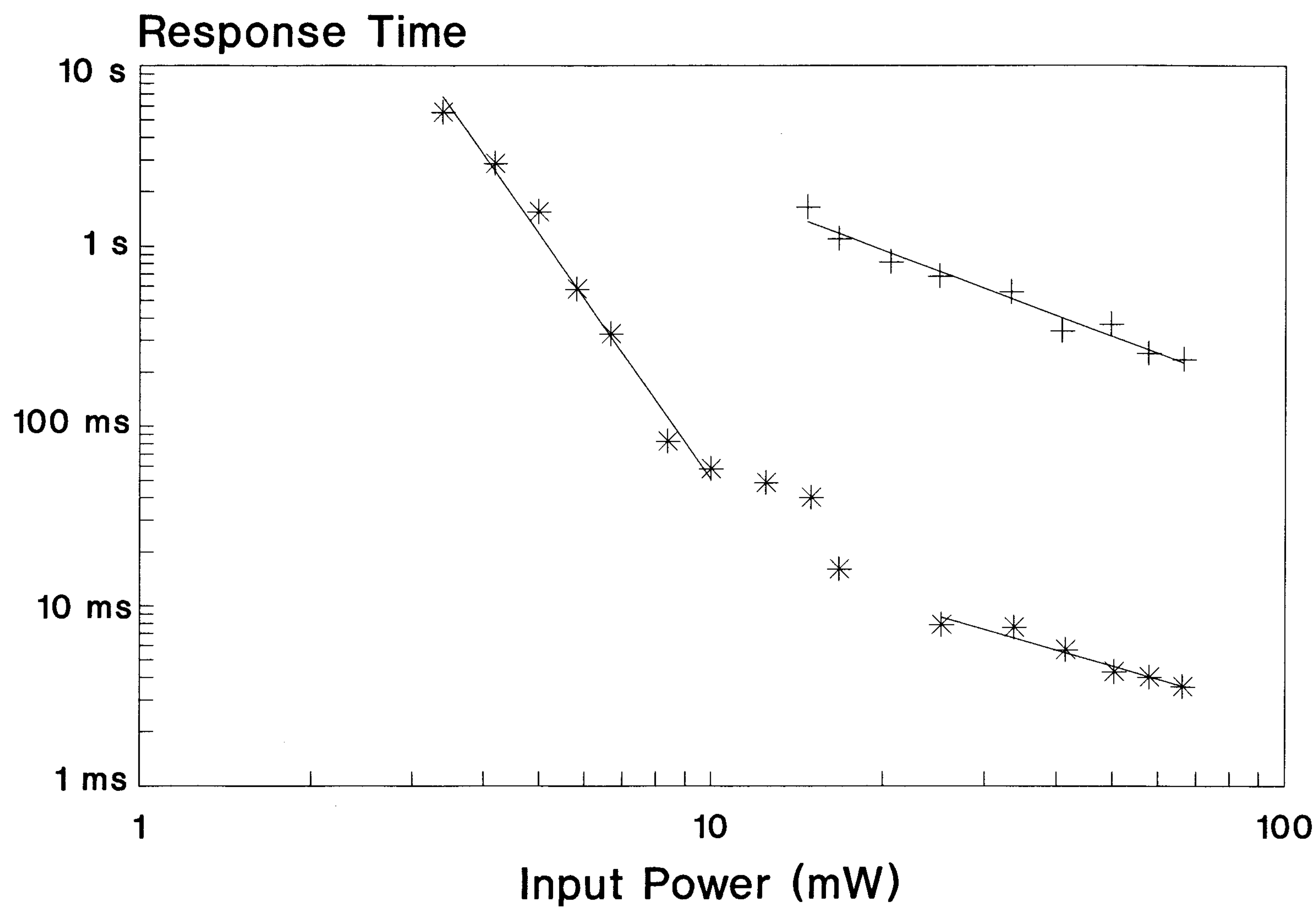
Figure Captions

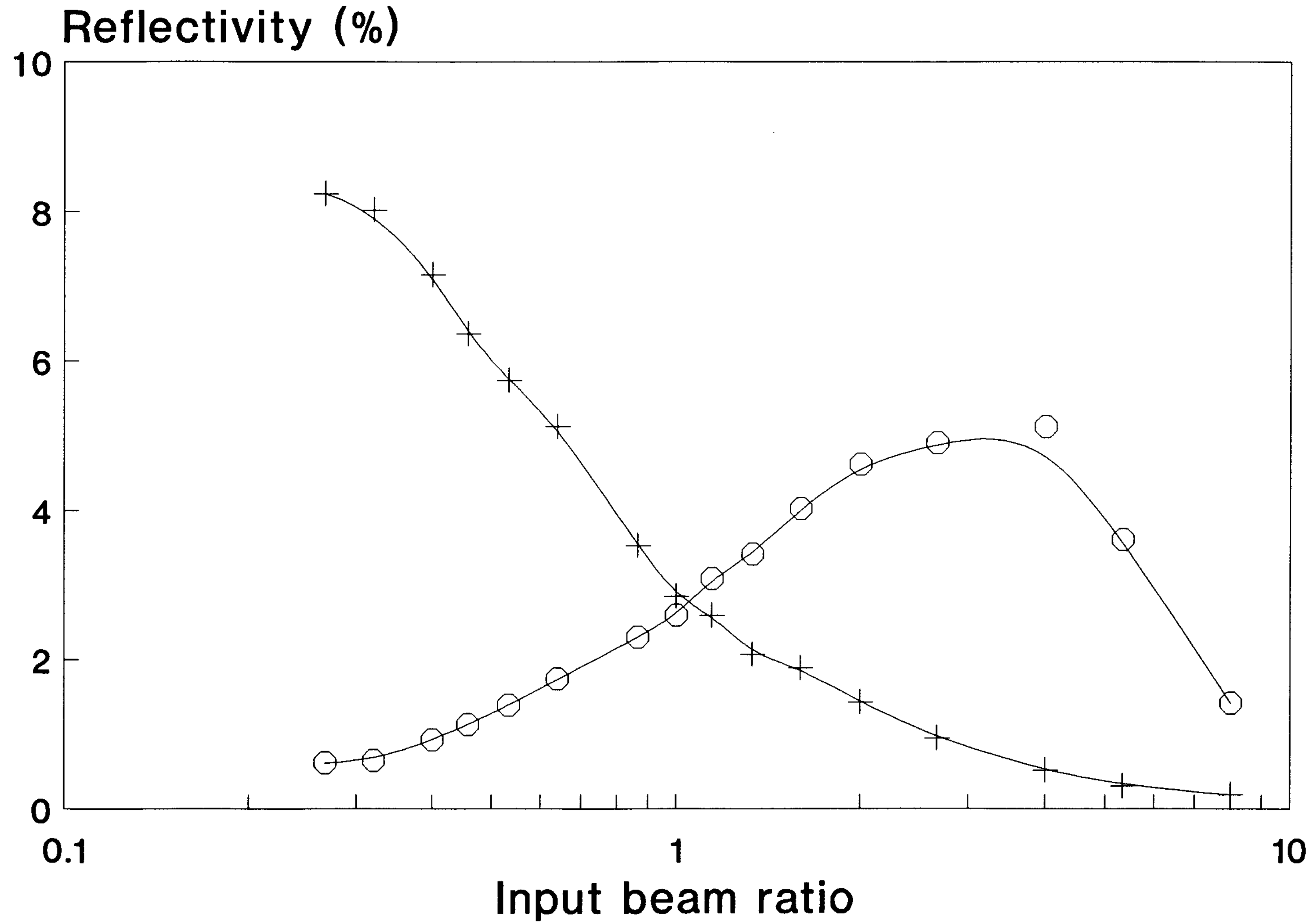
Figure 1. Crystal Geometry. The c axis direction refers to that in the bulk. The gain direction for two wave mixing was reversed in the waveguide as compared to the bulk crystal.

Figure 2. Comparison of the response times for SPPC as a function of input power (+) in the bulk and (*) in the waveguide. For a given input power the response time is reduced by two orders of magnitude in the waveguide as compared to the bulk.

Figure 3. Phase conjugate reflectivity as a function of input beam power ratio for the Bridge mutually pumped phase conjugator in the waveguide. (+) beam 1, (■) beam 2.


3mm
c
17°
77°
5mm
17°
2mm


Response Time
10 s
1 s
100 ms
10 ms
1 ms
1
10
100
Input Power (mW)



Reflectivity (%)
10
8
6
4
2
0
0.1
1
10
Input beam ratio