P 4-87

Very high single–pass two–beam coupling gain at 647 nm under conditions of induced transparency in Rh: doped $BaTiO_3$

M. Kaczmarek, R. W. Eason,
M. H. Garrett, [1], D. Rytz [2]
Optoelectronics Research Centre
University of Southampton, Southampton SO17 1BJ
United Kingdom
telephone: +44 1703 593144
fax: +44 1703 593142
e-mail: mfk@orc.soton.ac.uk

Abstract

Two–beam coupling gain has been measured in Rh:doped $BaTiO_3$ yielding a value of the order of 20 000. We believe that this is the highest beam coupling gain reported so far. Rh: doped $BaTiO_3$ exhibits very strong intensity–dependent absorption, and this effect is considered when discussing experimental results.

Summary

Considerable interest has recently been given to photorefractive properties of 'blue' rhodium doped $BaTiO_3$. Strong intensity–dependent effects, such as light–induced transparency, have been observed at both visible and near infrared wavelengths. These changes in absorption have been successfully reproduced numerically using a model with additional secondary photorefractive centres [1]. Efficient phase conjugation has also been observed in these crystals, and high reflectivities achieved in the self–pumped configuration [2]. More recently we have demonstrated a significant coupling between incoherent beams in double–phase–conjugation and double–colour–pumped–oscillations with near infrared wavelengths 730–810 nm from a Ti:sapphire laser and the 647 nm line from a krypton ion laser [3].

[1] Deltronic Crystal Industries, Inc, 60 Harding Avenue, Dover NJ 07801-4710, U.S.A.
[2] Sandoz Huningue S.A. Centre de Recherche en Optoélectronique, Avenue de Bâle, 68330 Huningue, France

The aim of the work we present here is to explore the high sensitivity of these crystals at red and infrared wavelengths [2] and to try to measure the maximum attainable two-beam coupling gain. We observed extremely large values of gain, as high as $2\cdot 10^4$, which to our knowledge is the highest beam coupling gain reported so far. This strong gain was produced over only a 3 mm thick crystal. Using a standard beam-coupling model this magnitude of gain would indicate a coupling coefficient Γ of approximately 33 cm^{-1}. This value agrees well with the theoretical prediction of $\Gamma = 32.9$ cm^{-1} calculated using unclamped electro-optic coefficients for $BaTiO_3$. It is important to note that the high gain we observed can be achieved without any need for suppressing beam fanning. Figure 1 presents a typical dependence of gain on the incident intensity ratio.

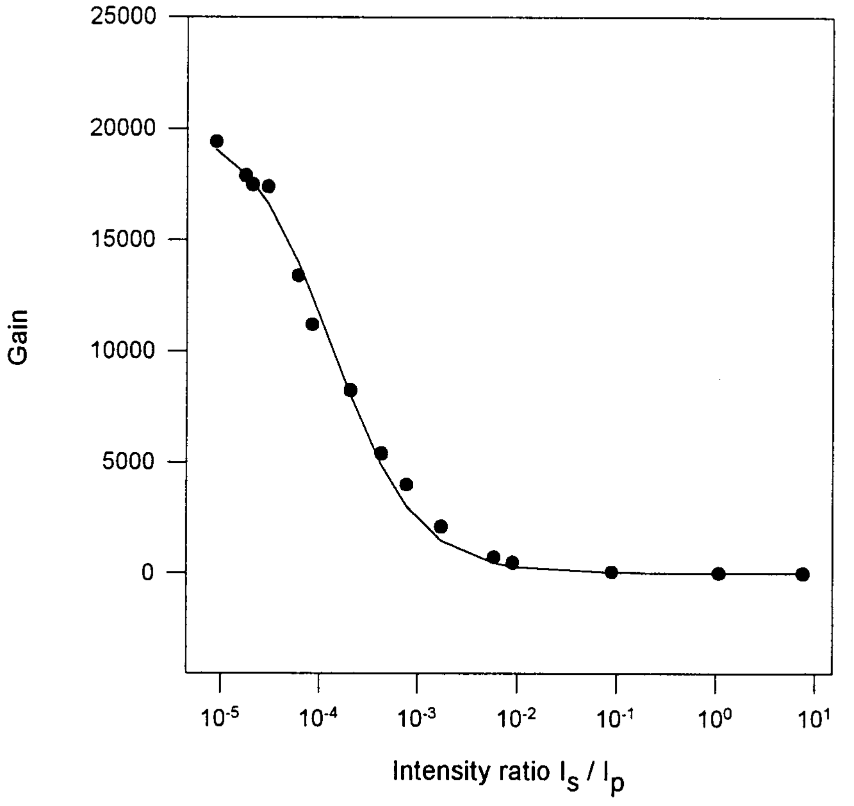

Fig.1. Two-beam coupling gain as a function of the input intensity ratio with calculated fit (solid line). The fit is based on incorporation of induced transparency parameters.

Wave mixing in blue Rh:doped $BaTiO_3$ can, however, prove difficult to observe at first. These crystals seem to be strongly influenced by their previous history. They are sensitive to illumination with white light, and their response can initially vary significantly. Depending on the temperature and storage conditions, the temporal behaviour of absorption and beam coupling can be quite different. Fortunately, their response eventually stabilises after continuous laser illumination.

We believe that a strong intensity–induced transparency plays an important role in the process of energy transfer. The maximum laser–induced change of absorption ($\Delta\alpha = 0.5\ cm^{-1}$) falls within the range of peak of absorption (630–650nm), i.e. where we investigated beam coupling. Figure 2 shows the intensity dependence of the absorption coefficient at 633 nm, exhibiting light induced transparency.

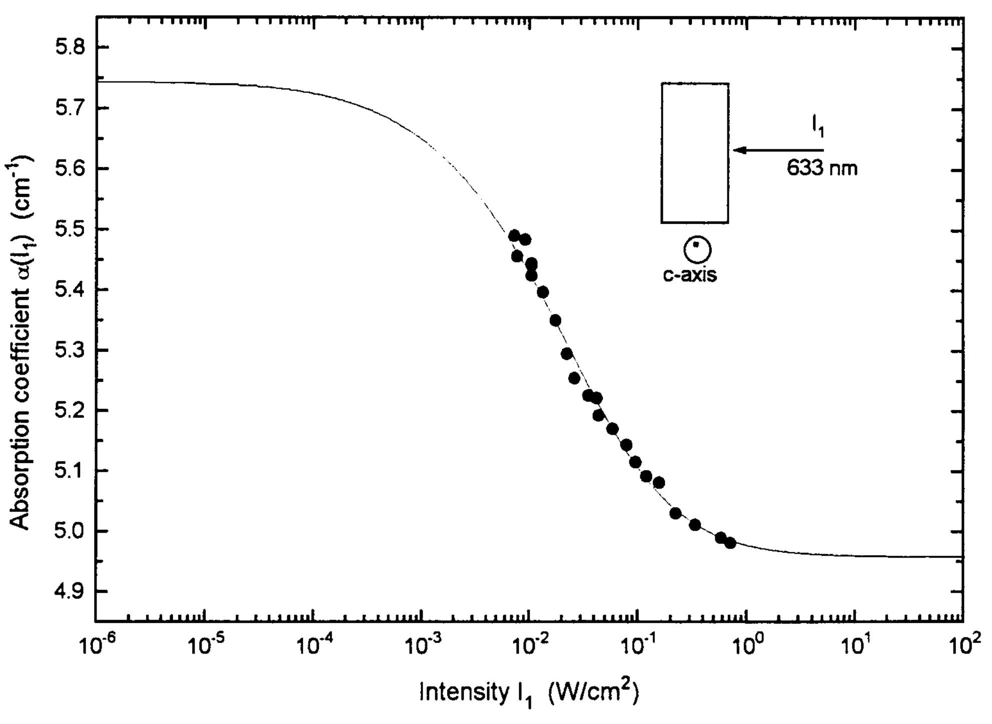

Fig.2. Change in absorption coefficient at 633 nm as a function of intensity. The filled dots are experimental data and solid curve is theoretical simulation.

We will present more detailed results of this phenomenon at 647 nm and discuss the effect of total incident intensity on the magnitude of coupling. In parallel with experimental data, the results of theoretical modelling incorporating the change of absorption with intensity into the beam coupling scheme is presented.

Finally, for comparison, we demonstrate two–beam coupling results obtained at other infrared wavelengths, where smaller gains were observed.

REFERENCES

[1] Kaczmarek M, Ross G.W. , Jeffrey P.M, Eason R.W. Hribek P, Damzen M. J, Ramos–Garcia R, Troth R, Garrett M.H, Rytz D, Optical Materials, January 1995.

[2] Ross G.W, Hribek P, Eason R.W, Garrett M.H, Rytz D, Opt. Commun. 101 (1993) 60.

[3] Kaczmarek M, Eason R.W, Anderson A. A, Hribek P. Garrett M.H, Rytz D, *paper submitted to CLEO/ Pacific Rim, Japan, 1995.*