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Temperature dependent photorefractive properties of Ce-doped KNSBN crystal

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Abstract Two-wave coupling and four-wave mixing phase conjugation properties of Ce-doped KNSBN crystal are investigated at 632.8nm as the temperature increases from 30℃ to 95℃. Two-wave coupling experiment shows that both two-beam coupling gain coefficient Γ and the response speed of the crystal can be enhanced by several times when the temperature is elevated to 95℃. The four-wave mixing phase conjugation reflectivity increases from 4% to 14% in this temperature range.

Key words: photorefractive effect　temperature dependence　two-wave coupling

掺铈 KNSBN 晶体光折变效应的温度特性

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摘要: 研究了掺铈的 KNSBN 晶体在 632.8nm 的光束下, 当温度从 30℃升高到 95℃过程中, 两波耦合和四波混频相位共轭的性质。两波耦合实验表明, 当温度达到 95℃时, 增益系数和晶体的响应速度能增加数倍。在温度变化范围内, 四波混频相位共轭反射率从 4% 增加到 14%。

关键词: 光折变效应　温度特性　两波耦合

Introduction

The effect of temperature on photorefractive process is a significant problem in photorefractive nonlinear optics. The role of the temperature in photorefractive effect has been investigated in different photorefractive crystals such as $BaTiO_3$[1,2], $LiNbO_3$[3], GaAs[4], CaP[5] and InP[6]. Various behaviors of temperature dependence have been observed in these crystals. Earliar work on $BaTiO_3$ shows that the time response of the crystal always increases or decreases with temperature, while its two-beam coupling gain coefficient may, depending on the samples used, increase or decrease with temperature[1,2]. Liu Jinsong investigated the temperature dependence of two-wave coupling and four-wave mixing phase conjugation of Ce: $LiNbO_3$[7,8], showing that both two-beam coupling gain coefficient and four-wave mixing phase conjugate reflectivity can be enhanced by several times when the temperature is elevated from room temperature to 70℃.

In this letter, we report investigations about the temperature dependence of the two-wave coupling gain and response time in a Ce-doped KNSBN crystal. A decrease by several times in response time and A 2.3-fold increase in gain coefficient are obtained as the temperature increases from 30℃ to 95℃. The reflectivity of this crytal as four-wave mixing phase conjugator also increases in this temperature range.

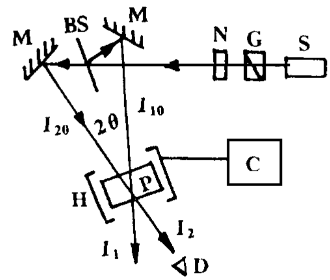

Fig.1　Experimental setup of two-beam coupling in Ce∶KNSBN

1　Experimental results

Fig. 1 shows our experimental setup used to study the effect of temperature on two-beam coupling in Ce∶KNSBN P. The Ce-doped KNSBN crystal we used is grown at Institute of Crystal Materials, Shandong University. It is normally cut with dimensions of 10mm × 10mm × 2mm[3]. Its 10mm edge is along the *c*-axis. It was put in a small stove H. The temperature of H was controlled by a thermal monitor C (WMNK-402), its resolution temperature and controlling precision were 1℃ and 0.1℃, respectively. S was a 30mW TEM_{00} He-Ne laser at 632.8nm. G, N, BS, M and D are the Glan prism, neutral decay filter, beam splitter, mirror and detector respectively. In the two-wave coupling measurement, we use O-polarized beams to diminish the fanning effect. The signal beam I_{20} is two times thinner than the pump beam I_{10}. The intensity of the pump I_{10} is 320mW/cm^2. The pump and signal beams are symmetrically incident on the *a*-face with a crossing angle 2θ = 20°.

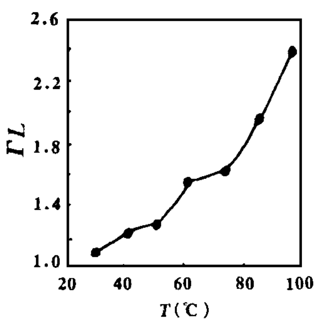

Fig. 2　Beam coupling stregth ΓL of two-wave coupling in the Ce∶KNSBN crystal vs temperature *T*

The experimental results are given in Fig. 2. It can be seen that the beam coupling strength ΓL (*L* is the interaction length which is a constant, but cannot be determined precisely) and the two-beam coupling coefficient Γ increases with temperatare. ΓL increases from 1.1 to 2.4 when the temperature is elevated from 30℃ to 95℃. As shown in Fig. 3, the response time measured in the two-wave coupling experiment decreases monotonically with temperature. Here the response time is defined as the time duration between $t = 0$ and the moment the amplified signal rises to the $(1-e^{-1})$ level of its saturation value. In the above temperature range, the time is reduced by more than two times.

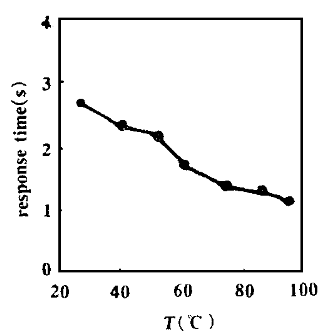

Fig. 3　Respone time of two-beam coupling in the Ce∶KNSBN crystal vs temperature *T*

In the next experiment, we investigated the variation of four-wave mixing phase conjugation properties of the crystal when the crystal temperature was elevated. Fig. 4 shows our experimental setup used to study the effect of temperature on four-wave mixing phase conjugation. Three beams of 632.8nm coherent light from a 30mW He-Ne laser are incident on a Ce∶KNSBN sample and enter the crystal as the extraordinary rays. The beam intensities are measured by a detector. The thickness of the sample is nominally 2mm and the two polished surfaces have cross sections of 10mm × 10mm. The power densities of single $I_4(0)$, forth pump $I_1(0)$ and back pump beams $I_2(d)$ are 16, 25 and 1050mW/cm^2 in the crystal, respectively. The cross sections of the three beams are all 0.15cm^2. The angle between single and forth pump beams in the crystal is 20°. The sample P is put in a small electric stove H. The temperature of the stove is controlled by a thermal monitor. Its resolution temperature and controlling precision are 1℃ and 0.1℃, respectively.

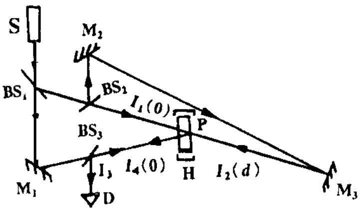

Fig. 4 Experimental setup of the four-wave couping phase conjugate in Ce∶KNSBN

Fig. 5 gives our experimental results. The data clearly show that the effect of temperature on the four-wave mixing phase conjugation of Ce∶KNSBN is very large. When the temperature is elevated from 30℃ to 95℃, the four-wave mixing phase conjugation reflectivity increases from 4% to 14%.

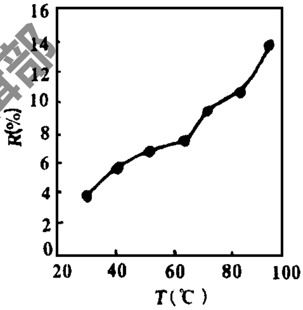

Fig. 5 Temperature dependence of reflectiving R of the Ce∶KNSBN four-wave mixing phase conjugate

The origin of temperature dependence of photorefractivity of Ce∶KNSBN is unknown yet. D. Rytz et al[3] have observed that the effective electric-optic coefficients of their undoped and Mn-doped $BaTiO_3$ crystal increase with temperature, resulting in enhanced two-beam coupling gain coefficients of these crystals at elevated temperature. This may also be the cause in our Ce∶KNSBN crystal. The increase of electric-optic coefficient at elevated temperature may be due to thermal-induced lattice distortion.

2 Conclusion

In conclusion, we have shown the temperature dependence of pthotorefractive properties of a Ce-doped KNSBN in two-wave coupling and four-wave mixing phase conjugation experiments. Our experimental results show that both the photorefractivity and time response of the crystal can be significantly enhanced at elevated temperature. This property of temperature dependence provides a useful means for us to improve the performance of Ce∶KNSBN crystals in practical applications.

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MATLAB 用于激光光束质量分析

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摘要: 介绍了利用 CCD、计算机并基于 MATLAB 开发的激光光束质量分析的软件, 详细地介绍了该软件的组成、实现的基本功能及其特点。
关键词: 激光质量分析参数　MATLAB　图像处理　CCD

A software for laser beam analysis

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Abstract: This paper describes a laser beam quality analyzer based on CCD, computer and MATLAB. The detailed composition, basic function and characteristics of the software are presented.
Key words: laser beam quality　MATLAB　image processing　CCD

引　　言

激光谐振腔输出光束的质量是决定激光实际性能的关键因素, 同时也是设计激光器光束链和聚焦系统的重要参数。通过分析激光光束的光强分布, 可获得评价激光光束质量的基本特征, 如: 峰值点位置, 峰值点功率, M^2 因子, 从而为改进激光器设计, 提高光束质量提供充足而可靠的理论依据。但是, 目前对激光光束质量的分析方法主要采用专用仪器, 配专用软件。这种成套设备虽然精度高, 操作方便, 但却存在相对成本较高, 灵活性较差, 功能不完备, 不便于特殊的用户获取一些额外的信息等问题。自行开发激光光束质量分析的软件可降低成本, 灵活地获取所需信息, 但主要困难是对于矩阵的巨大计算量和三维图形的可视化。MATLAB 是实现这两大功能最理想的软件, 它自 1984 年问世以来, 历经十几年的发展和竞争, 现已成为国际公认的最优秀的高科技数值计算应用软件。结合该软件对矩阵的强大数值计算能力、计算结果可视化功能和友好的语言界面, 针对激光光束分析的主要困难, 我们开发了基于 MATLAB 的激光光束质量分析的软件。

1　软件的组成原理及功能

1.1　系统组成

系统由衰减系统、导轨、CCD 摄像头、

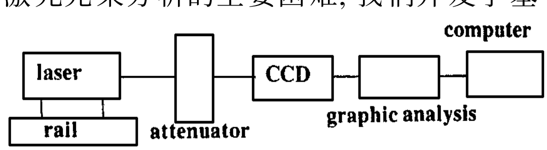

Fig. 1　System structure

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