Rewritable filter in a photorefractive BCT crystal

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We propose an experimental setup for writing of a photorefractive soliton with a grating within the soliton in a photorefractive BCT-crystal. Different cases of simultaneous and separate writing of the soliton and the grating are considered.

1 Introduction

In this paper we show the first rewritable filter (REFIL) based on a photorefractive soliton with a grating within the soliton in a BCT-crystal and propose two methods of the creation of the REFIL. In the first method both grating and soliton are written separately, while in the second method both grating and soliton are written simultaneously, whereas in the first case the grating can be generated either before or after the soliton. The grating vector is directed parallel to the soliton propagation.

2 First case

One of the most interesting cases is the counter propagation of solitons (Fig. 1).

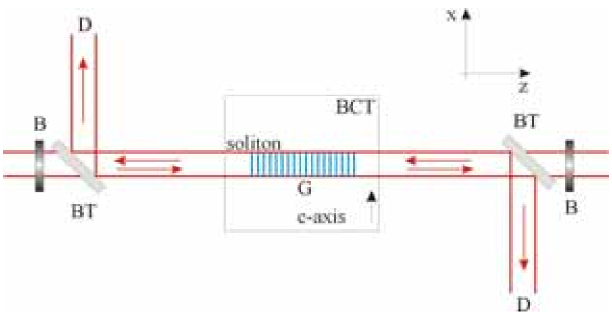

Fig. 1 *Scheme of the generation of the wavelength REFIL with two-wave-mixing. D detector, G grating, BT beam splitter, B diaphragm.*

For the measurement of the DE we use two beam splitters from both sides, whereas the angle between the grating vector and the c-axis of the crystal amounts about 89 degrees so that the beams reflected on the crystal surfaces do not cross the interfering beams. We have noticed that there are no differences between the diffraction efficiencies from both sides. For the measurement of the diffraction efficiencies one wave is blocked by one of the diaphragms B. If the diameter of the incident beam reaches 65 µm, the x-sizes of the incident and output beams become equal, what corresponds to a 1D solitary state. Since the grating is available due to the two-wave-mixing, the wavelength filter REFIL is generated automatically. The maximal DE of such a system reaches about 3% in our experiments, whereas the saturation time lays in the order of 5 s (Fig. 2).

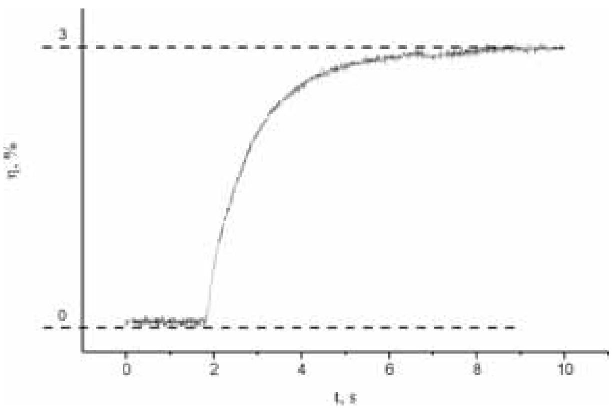

Fig. 2 *Temporal development of the DE η obtained by generation of the REFIL with two-wave-mixing.*

3 Second case

The second method for the formation of the REFIL is to write the solitary wave and the grating in it separately. This means that the waveguide is written by one wave and the grating is generated due to the interference of two other waves (Fig. 3).

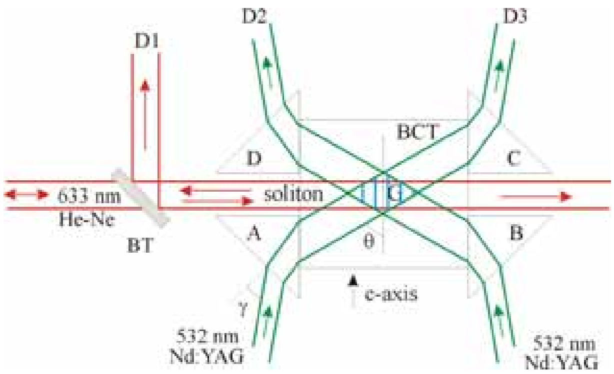

Fig. 3 *Scheme of the generation of the REFIL by separate generation of the soliton and of the grating. D1, D2, D3 detectors, G grating, A, B, C, D prisms, BT beam splitter.*

One can write the grating before and after the solitary wave is written. In the first case the solitary wave is written in above the existing grating, in the second case the grating is written into the existing waveguide. We carried out both experiments and have not observed any differences in experimental results. The maximal DE remains independent on the writing method and equals to ca. 1%. The width of the waveguide equals to 65µm. The generation time of the grating can be measured by the saturation time of the reflected signal in the waveguide. Its value lays in the order of 5 s (Fig. 4).

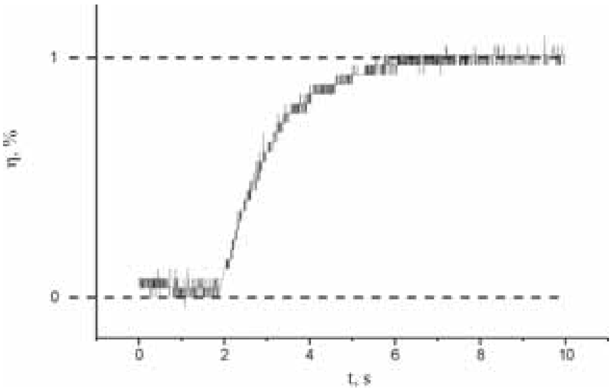

***Fig. 4** Temporal development of the DE (signal reflection) η obtained by generation of the REFIL with separate generation of the soliton and of the grating.*

4 Refractive index modulation

A reflection grating is defined uniquely by its period, length and refractive index modulation. On base of these parameters one can find the DE for a definite wavelength under a corresponding Bragg angle as well as the deviation of the DE from its maximal value in dependence on the grating period.

Since we can obtain the DE, the grating period and the grating length from the experiments, we can estimate the corresponding refractive index modulation for the cases of the simultaneous and separate generation of the waveguide and the grating.

For the DE of a reflection grating there is a valid formula

$$\eta = \tanh^2(\kappa L) \tag{1}$$

with the grating length L and the proportionality coefficient

$$\kappa = \frac{\pi n_1}{\lambda \sin(\vartheta)}, \tag{2}$$

where n_1 is the refractive index modulation, ϑ is the reflection angle, which corresponds to the Bragg angle for the ideal case. In our experiments $\vartheta = 90^0$ and $\lambda = \lambda_R = 633nm$, what leads to a simpler equation for the refractive index modulation

$$n_1 = \frac{\lambda_R}{\pi L} \tanh^{-1}\left(\sqrt{\eta}\right). \tag{3}$$

In case of the simultaneous generation of the solitary wave and the grating the parameters have the values $\eta = 3\%$, $L = 1cm$, and $\lambda_R = 633nm$. Out of these parameters the refractive index modulation is derived $\approx 3.5 \cdot 10^{-6}$. In case of the separate writing of the waveguide and the grating the parameters have the values $\eta = 1\%$, $L = 0{,}5cm$, and $\lambda_R = 633nm$, what leads to the refractive index modulation of $\approx 4.0 \cdot 10^{-6}$.