NEW LIGHT VALVE BASED ON PHOTOINDUCED SPACE CHARGE FIELDS IN BSO-CRYSTALS

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Abstract

The combined photoelectric and electrooptic properties of the BSO-crystal lead to a new possibility of realizing a real time spatial light modulator. Under certain geometrical conditions the crystal becomes birefringent in dependence on the local illuminance. Together with a suitable polarizer setup the crystal works as well as an incoherent to coherent converter as for contrast inversion.

1. Introduction

Photorefractive crystals have become interesting for practical application with the development of the polybismuthites and $BaTiO_3$ (1,2) which were much more sensitive to light than crystals known before (3).

The new light valve's function is based on the combination of two different effects in one material :

1. Photons excite electrons into the conduction band. These electrons are trapped in dark areas.
2. The BSO-crystal is electrooptic, that means the refractive index depends on the size of the local electric field caused by the distribution of photo-electrons.

Both effects together produce the photorefractive effect. The light valve to be presented is based on the fact that under some crystallographic orientations birefringence in dependence on the local illumination of the crystal is obtained (4).

References

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4. F.Höller & H.J.Tiziani, Opt.Comm. 58,20-24(1986)

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Such a "photobirefractive" light valve has several applications :
1.It is possible to use it as an incoherent to coherent converter.
2.It can be used for contrast inversion.

2.Incoherent to Coherent Conversion

Speckling and other phase disturbencies can be elliminated when using an incoherent to coherent converter in coherent optical image processing. Figure 1 shows the arrangement we used. The object O was projected on the crystal with blue incoherent light. The crystal was illuminated by a plane wave from a HeNe-laser. The lens L_2 performs the Fourier-transform of the pattern written into the crystal incoherently. The original object is O, where O' is the incoherent image of the object in the crystal and $\tilde{\mathcal{F}}$(O') is the Fourier-transform of O'.

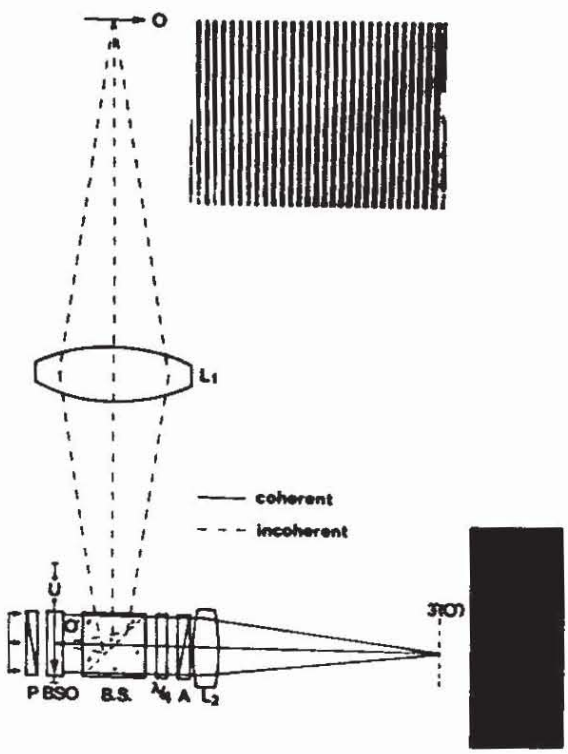

Figure 1. Incoherent to Coherent Conversion

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3. Contrast Inversion with the Light Valve

For image storages working on the principle of modulated birefringence the contrast of the picture stored can be inverted depending on the orientation of analyzer and quarter-wave-plate. Figure 2. shows the basic arrangement. The object O is stored by blue incoherent light and read out by incoherent red light. The dark spring on the bright background is converted to a bright spring on a dark background.

This basic function can be used for the technical application of image subtraction. The reference object is stored with blue light into the crystal. The test object is imaged with red light, which is not absorbed when passing through the crystal. When the image stored in the crystal combined with the polarizer setup is compensated for contrast inversion the difference of both objects is obtained in real time.

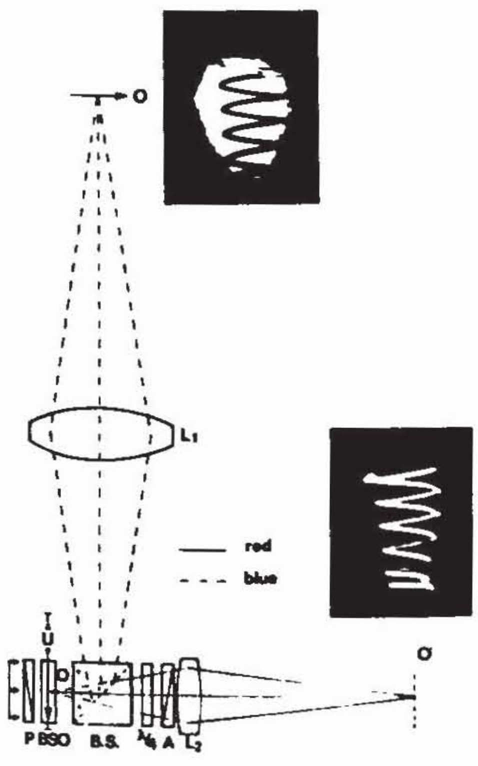

Figure 2. Contrast Inversion

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The method can be used for different problems such as :

1.Testing for identity, completeness etc.

2.Adjustment of both objects in a defined position to each other.

Figure 3. shows the subtraction of two almost identical circuit boards. The image shows modulation when the images of the two boards are not superimposed. When the images of both circuit boards are superimposed no modulation can be seen. In order to demonstrate the effect we have adjusted the quarter wave plate in a way that the contrasts of the two images are slightly different.

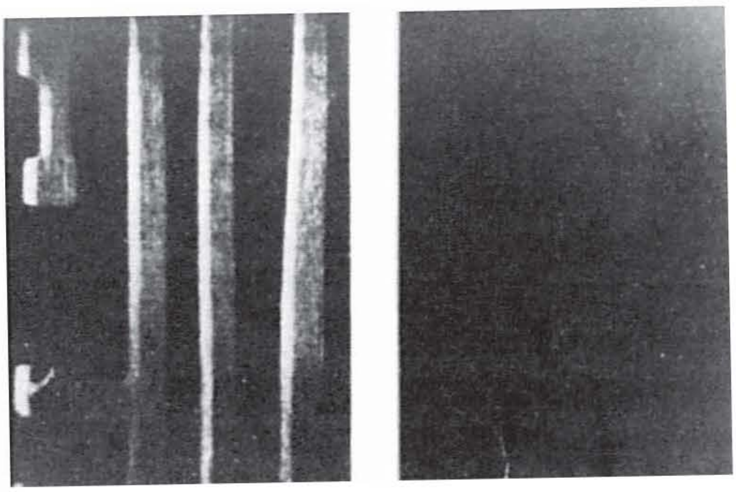

Figure 3. Image subtraction