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Letter to the Editor

Birefringent glass rods

Tadeusz Łukaszewicz, Mirosława Bożyk

Department of Physics, Technical University of Białystok, ul. Wiejska 45 a, 15–351 Białystok, Poland.

1. Introduction

Birefringent glass rods are new a class of optical waveguides by means of which information can be transferred by polarized light. Stable enhancement of the natural birefringence of the waveguide reduces the effect of power exchange between two naturally coupled polarizants constituting the basic mode. It is thus possible to widen the information transfer band in the waveguide and at the same time to apply birefringent glass rods in a number of interesting ways, particularly in polarization sensitive waveguide elements.

2. Technique*

The method of producing birefringent glass rods consists in a two-stage process of ion exchange in isotropic glass rods 0.5 mm to 1.0 mm in diameter. These rods are obtained from alkali-borosilicate or soda lime glass by the crucible method. Such rods should be characteized by a constant distribution of the refractive index along the diameter and by a high axial symmetry.

In the first stage of birefringent glass rod production, the isotropic glass rod (n = const) is immersed in a fused salt bath containing ions which increase the glass refractive index.

In the second stage, the bath is prepared so that as a result of ion exchange, the refractive index of the glass is lowered. At the same time due to the substantial difference in the mobility of these ions and the effect of temperature at which the experiment is carried out, there probably occur in the rod stable stresses which, however, do not exceed the strength of the glass. Hence, it is possible to obtain glass rods, the refractive index of which is anisotropic along the rod diameter.

3. Optical properties

The birefringent rods obtained by the ion exchange method were observed under an interference-polarization microscope, Biolar PI [1]. When the rod is diagonally

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* The technique of birefringent glass rods production was developed by Dr T. Łukaszewicz of the Department of Physics, Białystok Technical University.

Fig. 1. Unsplitting interference pattern of the birefringent rod fringe. The refractive index of the immersion medium $n_m = 1.5062$, $\lambda = 550$ nm; objective magnification 5×, photograph magnification 70×

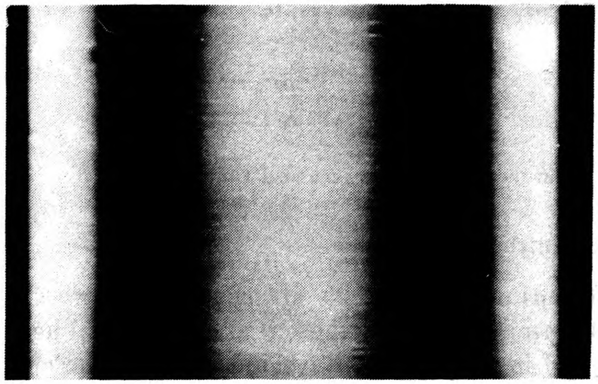

Fig. 2. Photograph of glass rod observed under an ordinary polarization microscope (after turning off the tube birefringent prism). The rod is placed in a diagonal position

oriented and a 5/0.12 objective and birefringent tube prism (No.2) are used, there appears a single splitting pattern of the rod (Fig. 1) with the interference fringes bent at its edges to the left, and in its remaining part in the opposite direction (to the right). While considering the findings given in [2] and in Fig. 1, it can be stated that the value of birefringence in this rod takes the opposite sign. At a distance of approximately $0.25 \times d$ (d — rod diameter) from the edge, the negative birefringence is compensated by the positive one, as is illustrated in Fig. 2, where two black symmetrical fringes indicate the zero optical path difference.

By applying the methods described in papers [3], [4], the rod birefringence profile was determined (Fig. 3). The value of birefringence ($n_{\parallel} - n_{\perp} = D$) on the rod axis was: $D = 0.63 \times 10^{-4}$. Its absolute value falls to zero at the distance of $r = 290$ μm (see Fig. 2), thereupon it increases towards the rod edge, where it reaches the maximum $D = 3.2 \times 10^{-4}$.

It should be noted that, apart from its stable birefringence, the rod possesses self-focusing properties (Fig. 4).

4. Final remarks

The birefringent rod presented in this paper can be successfully applied in the interferometer proposed by PLUTA [5], used for testing microscope objectives.

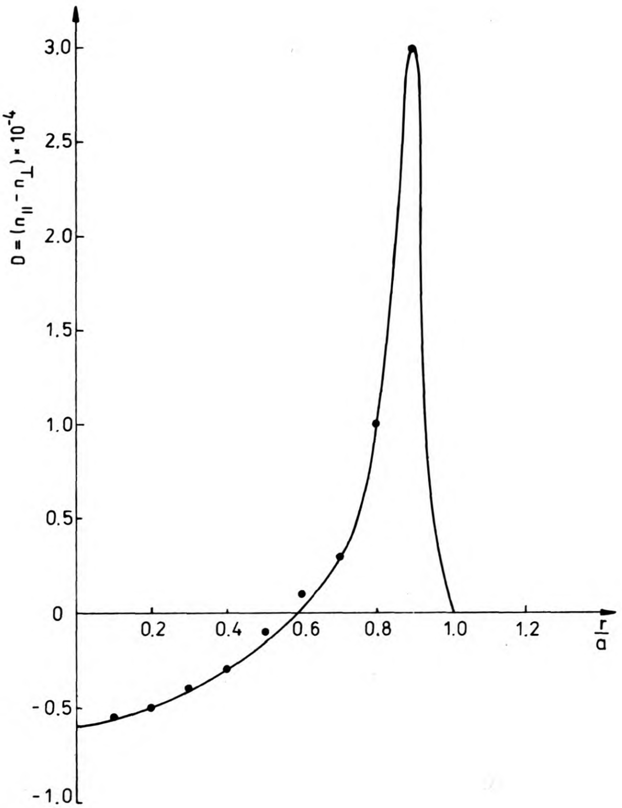

Fig. 3. Rod birefringence profile determined by the interference method

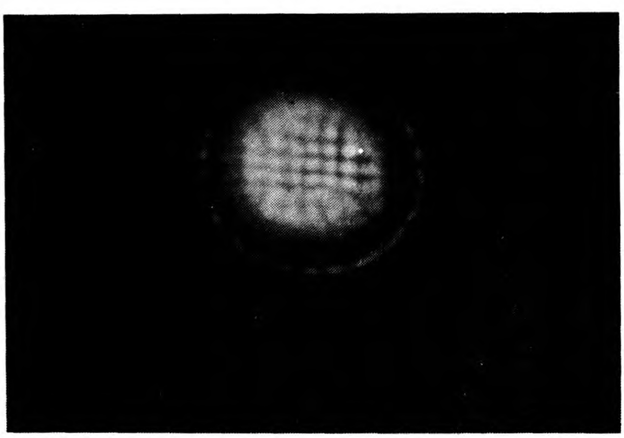

Fig. 4. Photograph of the test lattice grating enlarged by the focusing properties of the rod; magnification of the lattice grating picture by the rod 8 ×; photograph magnification 36 ×. The ellipticity of the rod seen in this photograph is due to the non-axial positioning of the camera lens in respect of the grating picture on the screen

The authors are of the opinion that this birefringent glass rod obtained by the ion exchange method will be found applicable in optics, optoelectronics and in optical-fibre techniques.

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