INVESTIGATION OF PLANAR SENSING STRUCTURES FOR GAS DETECTIONS BY MEANS OF SCATTERED LIGHT METHODE

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Due to the variety of waveguides in planar structures, the measurements of attenuation are characterized by a considerable variety of applied methods, developed for given type of waveguides. The method of measuring scattered light is, therefore, of much importance in the case of waveguides with a rather high attenuation, because it is an exceptionally fast and simple method, which is doubtlessly the effect of the development of numerical detection systems. The paper presents the process of measurements basing on scattered light, combined with an analysis of its application, as well exemplary results concerning the planar structures of waveguides achieved by means of ion exchange on soda-lime glass.

1. INTRODUCTION

The development of integrated optics in domain of sensors in planar systems requires attempts to facilitate the methods of measurements, connected with the parameters of the developed systems. One of the fundamental parameters taken into consideration in the choice of the proper technique is attenuation, which is of essential importance in the transmission of light in the obtained structures. In recent years various methods have been developed in the field of measurements of attenuation, as for instance: the cut-back method [1], prism coupling [2,3], photothermal deflection [4], the Fabry-Perot interferometer method [5] and measurements of scattered light [6-10].

The latter was applied making use of a photocamera, where the distribution of the beam was recorded on a black-and white photographic plate, whose sensitivity permitted to detect light with a wavelength below 1μm [6]. The development of the technique for detecting of an image permitted to optimize considerably the process of attaining results by substituting the was of detection use so far by numerical device or photocamera, where the obtained image can be immediately processed by means of various graphic tools.

Measurements attenuation by the detection of scattered light in planar structures is based on the relation in witch the intensity of the scattered light is proportional to the intensity propagated light [6]. This method displays many advantages if compared with other methods, because among others the measurements are carried out without any invasion, and the results are obtained quickly thanks to the automation of the considered process at the level of application. Scattered light is applied in the case of planar waveguides whose attenuations is rather high; in the case of lower values of attenuation the application of this method is considerably limited. A too small amount of scattered light due to the low possibilities of attenuation hampers the proper detection, as the level of the analysed signal approaches the level of the background. This problem may be partially solved by increasing the power of the beam introduced into the waveguide.

An important element distinguishing this method is the absence of mechanical interference in the course of taking measurements, which is the case of bi-and tri-prism methods, where a change of the position of prism involves an unavoidable change of the quality of coupling due to changes of the paths of propagation.

2. EXPERIMENTAL MEASUREMENTS

In order to ensure convenient conditions for the considered method the test stand must be able to adjust its position in all directions in compliance with the coupling, i.e. both the position of the investigated waveguide and the source of the coupled light. The source of light, i.e. a semiconducting edge laser, emitting a wave with a length of λ=0.663 μm, was mounted on a rotary arm, which warranted the introduction of the beam at an adequate angle corresponding to the best conditions of coupling. For this purpose prisms of SK-1and SK-5 glass were used, depending on the type of the investigated structure, as well as output prism situated at the end of the waveguide and verifying the correctness of mode excitation. The input polarization of the laser beam was adjusted in such a way that either the TE or the Tm mode was excited. The choice of proper polarization was accomplished by the proper rotation of the polarizer P. the image was detected by means of a black-and-white camera GKB(CB23803SA 1/3” IR BW CCD) and the obtained images were gathered in form of a Bitmap, making use of the Dscaler programme. The test stand has been presented in Fig. 1.

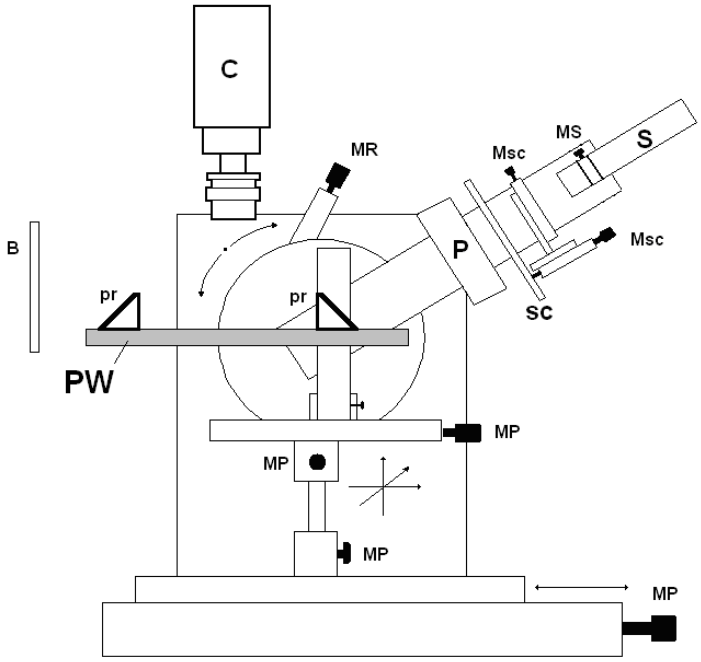

Fig. 1. The construction of the test stand for measurements of attenuation by means of the detection of scattered light. C - camera, Pr – prism, MP – manipulators of the base, MR– manipulators of the arm, Msc – manipulators of the diaphragm, MS manipulators of the source of light, S – source of light, B –screen, P – polarizer, PW planar waveguide.

The beam of laser light leaving the source S is limited by the aperture of the mobile diaphragm SC positioned on the optic path of the input beam, eliminating in this way the amount of light highly scattered at the input. Then the beam is passed into the polarizer P, which by its rotation permits to excite the mode TE and TM. The light is introduced into the investigated waveguide through the input prism PR. The synchronic angles and most favorable conditions of coupling may be found by manipulating the waveguide in three planes applying the manipulators MP and preciser MR of the arm on which the source S is placed. The beam propagating in the investigated medium is decoupled from the waveguide by the prism PR onto the panels B behind the waveguide in order to determine correctly the mode excitation.

The waveguides was attained in soda-lime glass in result of the standard process of ion exchange K^+ -Na^+ at 400°C in half an hour. Fig. 2. presents the recorded image of polarizations TE. The determined distributions of the intensity of scattered light are to be seen in Fig. 3.

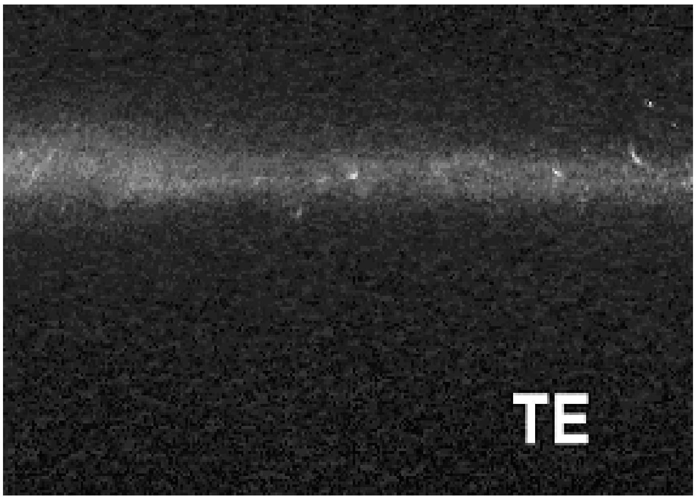

Fig. 2. Analyzed images of the propagated mode (polarization TE).

The obtained data were analyzed, so that we can determine the attenuation of the investigation structures. The dependence of the intensity on the path of propagation, which may be assumed basing on this definition can be expressed as fallows [1, 11]:

$$I(x) = I_0 e^{-\alpha x} \tag{1}$$

where:

x – patch of propagation, Io – power rating introduced into the waveguide at the point x=0,

α – attenuation index of the waveguide.

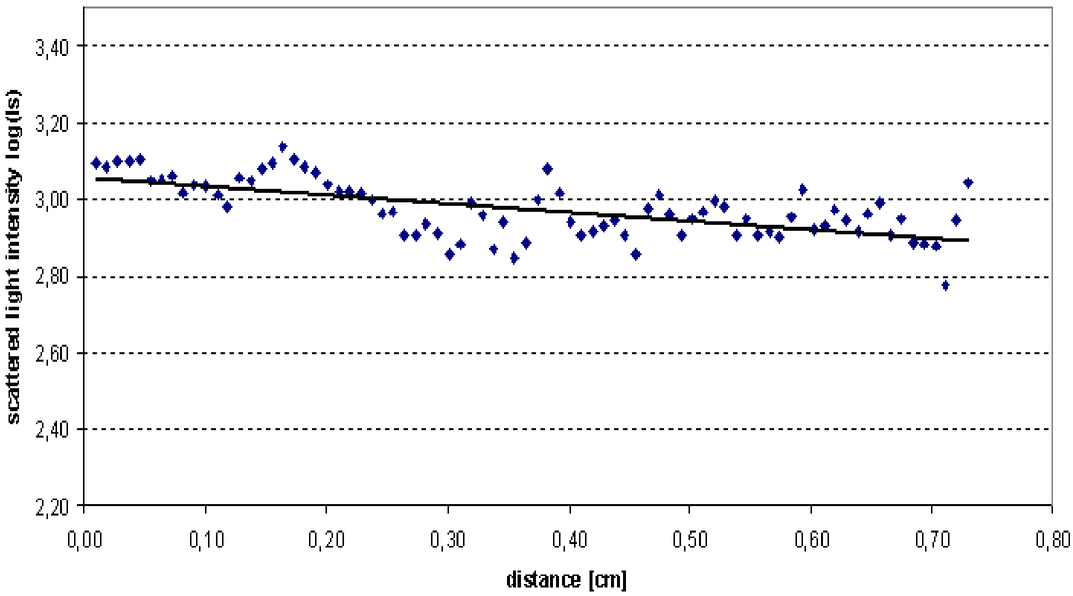

Fig. 3. Logarithmic dependence of the intensity of scattered light on the path of propagation (polarization TE).

In order to facilitate the interpretation of the committed error, the following relation was applied to determine the attenuation index:

$$\log\left(\frac{I_s}{I_0}\right) = -0{,}1\alpha_{dB}L + C \qquad (2)$$

where: I_s – measured value of the intensity of scattered light, L – path of propagation, α – attenuation index expressed in decibels, C – constant.

The obtained partial results of the attenuation index of the investigated structure were average basing on the weighted mean, from which the attenuation for the polarization TE = 2,06(25) dB/cm.

3 CONCLUSIONS

In the given problem of measuring scattered light provides vast possibilities connected with the interpretation of result. The fundamental problem in the possibility of observing in the phenomena occurring along the path of propagation of the beam and interpreting the influence of the background and the change of geometry of the beam. Such a possibility is provided by the computer processing of the scanned bitmap, prevailing other methods. An example of this id the measurement of the background surrounding the beam and correlation with measurements where by means of the programme procedure we can obtain a more precise result of the investigated object.

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