COMPOSITE WAVEGUIDE STRUCTURES

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Planar waveguide in which some range of the waveguide has been modified by depositing on it a layer of some other dielectric, are called composite optical waveguides. This kind of structure is of much interest due to considerable possibilities of taking measurements, which may contribute to a further development of optoelectronic sensor. Especially required are sensor systems in chemistry, biochemistry, biotechnology, and others. Investigations on the properties of composite layers constitute a continuation of investigations concerning the construction of interferometers, witch are very sensitive, cheep and easy to be produced.

Keywords: mode beat, planar waveguide, ion exchange composite waveguide.

1. INTRODUCTION

In the process endeavoring to analyze the phenomena of the differential interference, as in the case of all interferometric waveguide systems, the most essential role is played by the values of propagation constants and their change effected by some external factor. The changes of propagation constants of the sensors can be caused by the changes of various external factors.

Technological ion exchange processes permit to modify to a certain degree the refractive profiles, and consequently, to change the difference of propagation constants of orthogonal modes. The shape of the refractive profile affects also the sensitivity of the sensor working on the basis of differential interference [1].

One of the most commonly applied methods to test planar waveguide sensors is the determination of their response to the change of the refractive index of the cover. The work also presents a method of determining the difference of propagation constants for different refractive indexes of the cover. As a result of this, the response of difference interferometer to the change of refractive indices of the cover was possible to be determined.

In recent years the addition of new layer was suggested, displaying a larger refracting index on the waveguide structure in order to increase the sensitivity of sensors. In order to minimize losses in the transformation of the mode field the thickness of the additional layer is monotonically changed [2-5].

2. COMPOSITE WAVEGUIDE STRUCTURES

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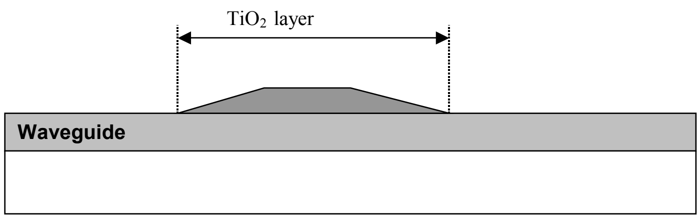

Fig.1. longitudinal cross-section of a composite waveguide structure

One of the first attempts to apply a composite structure in sensors was described in ref. [6]. The resulting structure is a combination of the waveguide obtained by means of ion exchange K^+ -Na^+ and the part of waveguide obtained by ion exchange Ag^+ -Na^+ on a glass substrate. This construction to be used as an ammonia sensor. The obtained promising results of measurements encouraged researches to continue these investigations.

Composite waveguide which are actually being investigated are structures of thin dielectric layers narrowed at their ends, deposited on the definite surfaces of the planar waveguides [2-5]. The reduced parts of the layer play the role of couplers, which have to introduce into the composite structure as much optical power as possible. Such a structure is based on planar waveguide obtained by means of ion exchange K^+ -Na^+ on a glass, and covered by an adequately profiled dielectric layer.

The application of a waveguide obtained by ion exchange as the basic structure is recommendable due to several advantages:

- a low attenuation- the possibility of detecting the output signal even after along path of propagation,
- low refracting index- the possibility of applying various materials with a higher refracting index as covering layers,
- low sensibility to polarization - the possibility of the simultaneous excitation of the TE_0 and TM_0 modes in one beam.

The principle of operation of such a coupler consists in the gradual change of the wave vectors of the coupled mode with the distance. If the coupler is to transfer the most possible power from one waveguide area to the other, the coupling zone must be sufficiently on and the angle of inclination adequate. In the case of visible light the length of the coupler ought to amount to 100-100 times of the wavelength. The diagram of composite waveguide can be seen in Fig.1.

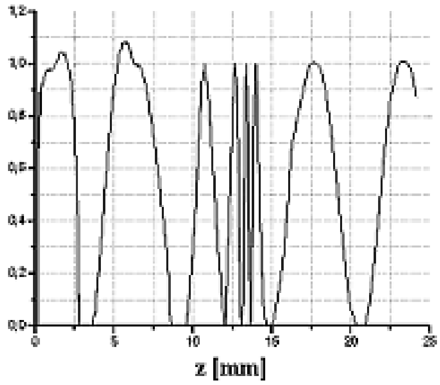

Fig. 2. Signals recorded by the detector with the waveguide with TiO_2 layer immersed in water.

The refracting index of a composite layer (TiO_2 layer) is larger then the refracting index the waveguide layer, Thanks to which the evanescent field in the composite structure is larger then the evanescent field in a waveguide obtained by means of the ion exchange technique. The dimension of the evanescent fields the crucial parameter, influencing the sensitivity of sensors basing on the absorption of the evanescent wave or interference.

If at a given refracting index n_f of the additional layer the thickness of the layer exceeds the thickness which permits the propagation of the TE_0 mode, being however smaller then the thickness permitting the propagation of the TM_0 mode, then due to the resolution of polarization the mode TE_0 penetrates from the waveguide obtained by means of the ion exchange technique into the additional layer [5].

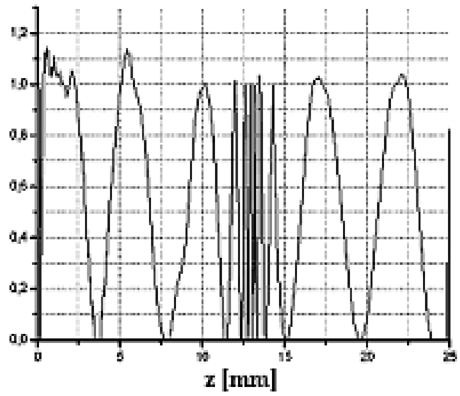

Fig. 3. Signals recorded by the detector with the waveguide with TiO_2 layer immersed in propanol

Single –mode obtained by means of ion exchange K^+ -Na^+ in soda-lime glass was obtained. Through the mask with a narrow gap situated about 2mm under the substrate a TiO_2 layer was deposited by sputtering. The rate of deposition of the layer amounted to about 2nm/min, the width of the window in the mask was about 2.5mm. in the course of the process of depositing the layer its thickness was controlled in order to obtain a layer about 18nm thick. Figs 2 and 3 show the signal recorded when the waveguide with the TiO_2 layer was immersed in water and propanol, respectively. In the central part of the characteristics (where the TiO_2 layer is to be seen) an increased number of oscillations can be observed, in compliance with a manifold increase of the sensitivity of the interferometer to changes of the refracting index of the covering layer.

3. CONCLUSIONS

The presented method of taking measurements is particularly adequate when the difference of the propagation constants changes along path of propagation.

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