ECIO 2016
18TH EUROPEAN CONFERENCE ON INTEGRATED OPTICS 2016
18–20 MAY | WARSAW | POLAND

Sol-gel derived rib waveguides for evanescent wave spectroscopy

Cuma TYSZKIEWICZ*, Paweł KARASIŃSKI, Roman ROGOZIŃSKI
Department of Optoelectronics, Silesian University of Technology, ul. B. Krzywoustego 2, Gliwice, 44-100, Poland
* cuma.tyszkiewicz@polsl.pl

Planar evanescent wave sensors (EWS) are important tools for detection of the presence of (bio)chemical compounds as well as for studying kinetics of biochemical reactions [1]. Planar EWS have wide application spectrum including: biomedicine, pharmaceutical industry, biotechnology, diagnostics as well as in-situ environmental monitoring. Planar EWS offer high sensitivities, reliability, stability of their parameters, mechanical resistance, ability for miniaturization and mass production [1]. Achievement of high sensitivities is conditioned by application of waveguides having high refractive index contrast [2]. Achievement of EWS parameters stability is conditioned by application of chemically resistant waveguide films [3]. Slab or channel waveguides are used for development of planar EWS [1]. Channel waveguides are fundamental elements of planar interferometric EWS structures.

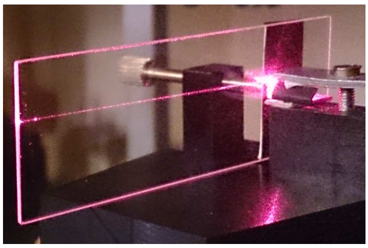

Fig. 42. Image of excited slab SiO_2:TiO_2 waveguide on BK7 glass substrate (26×76×1 mm^3).

The rib waveguides fabricated using sol-gel derived SiO_2:TiO_2 waveguide films, optical contact photolithography and chemical etching, are the subject of our presentation. These waveguide films, whose fabrication technology has been developed in our research group, are characterized by high refractive index (~1.81), homogeneity, very high smoothness, chemical resistance and stability of their parameters over long time period [4]. In our technological route, sol films are deposited on glass substrates using a dip-coating technique. In the Fig. 1, there is presented an image of the excited slab SiO_2:TiO_2 waveguide fabricated on a BK7 glass substrate. One can see the narrow streak of scattered light which proves high homogeneity of this waveguide film. We are able to fabricate SiO_2:TiO_2 waveguide films having both: thickness a little higher than cut-off thickness and attenuation lower than 0.2 dB/cm for λ=677 nm.

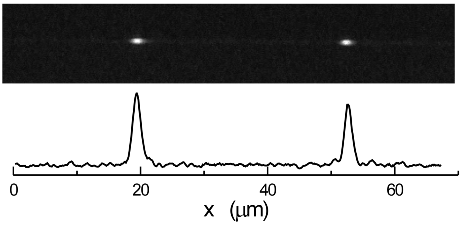

Fig. 2 Near-field picture of a 1×2 directional couplers outgoing rib waveguides and related distributions of optical power. λ=677 nm, waveguide high *h*=219 nm, rib width w=2 μm, rib high *t*=6 nm, rib separation *s*=1.5 μm, coupler length *L*=1.5 mm.

The elaborated technological route is composed of the following, subsequent stages: deposition of a photoresist film on a SiO_2:TiO_2 waveguide film using a spin-coating method, hardening of the photoresist film by curing, selective UV exposure of the structure throughout a positive photolithographic mask, developing and hardening of a pattern reproduced in the photoresist, chemical etching and removal of the photoresist. The in this way fabricated optical channel structures: rib waveguides and directional couplers, were theoretically analyzed using commercial solver FIMMWAVE 6.1 [5]. The results of theoretical analysis allowed design of single modal channel structures. The near-field picture of outgoing rib waveguides of a 1×2 directional coupler as well as related distributions of optical power are show in Fig.2. We have achieved to fabricate rib waveguides having optical losses of ~1.5 dB/cm [6]. A scattering on rib sidewalls is their main source, so they can be decreased by decreasing a roughness of rib sidewalls.

Elaborated rib waveguide structures are suitable for application in fabrication technology of planar interferometric EWS.

This work was supported by the National Science Centre on the basis of decision DEC-2011/03/B/ST7/03538.

References

[1] P. Kozma, F. Kehl, E. Ehrentreich-Förster, C. Stamm, F.F. Bier, *Integrated planar optical waveguide interferometer biosensors: A comparative review*. Biosensors and Bioelectronics, vol. 58, pp. 287–307, 2014
[2] P. Karasiński, R. Rogoziński, *Characterization and sensor properties of sol-gel SiO_2:TiO_2/ion-exchange glass waveguide*, Opt. Commun. vol. 281, pp. 2472-2480, 2008
[3] J.J. Ramsden, *Review of new experimental techniques for investigating random sequential adsorption*, J. Stat. Phys., vol. 73, pp. 853-877, 1993
[4] P. Karasiński, C. Tyszkiewicz, A. Domanowska, A. Michalewicz, J. Mazur, *Low loss, long time stable sol-gel derived silica-titania waveguide films*, Mater. Lett. Vol. 143 pp. 5-7, 2015
[5] C. Tyszkiewicz, P.Karasiński, R.Rogoziński, *Directional couplers fabricated via a sol-gel route and conventional optical lithography*, Opt. Quant. Electron, vol. 48, paper 19, 2016
[6] P. Karasiński, C. Tyszkiewicz, R. Rogoziński, J. Jaglarz, J. Mazur, *Optical rib waveguides based on sol-gel derived silica-titania films*, Thin Solid Films vol. 519 pp.5544-5551, 2011