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Indium oxide overlay gratings realised on glass waveguides using excimer laser ablation

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Relief gratings overlaid on optical waveguides may be used as high-extinction ratio wavelength filters with applications in integrated optics and optical communications. Cross-patterned, high contrast relief grating waveguide structures may potentially perform as 2-D photonic band gaps if properly designed and fabricated. A new waveguide grating design process which relies on a novel grating patterning method and new materials will be presented in this paper. This design consists of the combination of a potassium ion-exchanged single-mode channel waveguide with a high-index film (InO_x) overlaid on its upper surface [1]. The high-index overlayer is deposited over a part of the waveguide length. A relief grating is patterned on the InO_x layer using 248nm interferometric excimer laser ablation [2].

Ion-exchanged waveguides were fabricated in BK-7 glass using conditions that are described elsewhere [3]. A thin film of InO_x ($n \approx 1.8$) [4] of 2.5cm length was sputtered on the top of 4cm long waveguides using DC magnetron sputtering. The InO_x was sputtered in 100% O_2 atmosphere resulting in a polycrystalline film of average grain size of 50nm. The transmission losses and the grating spectra of the composite structure were measured using the ASE spectrum of an Er-doped amplifier into the waveguide employing polarisation resolved optical apparatus and an optical spectrum analyser.

The excimer laser interferometer is described in detail in reference [2]. Gratings with a period of 514nm were ablated on waveguide chips that had InO_x overlayers. Gratings of 1.6cm length were produced using a variety of exposures. A grating that has been ablated using a fluence of 45mJ/cm^2 and 20 pulses is presented in Figure 1A.

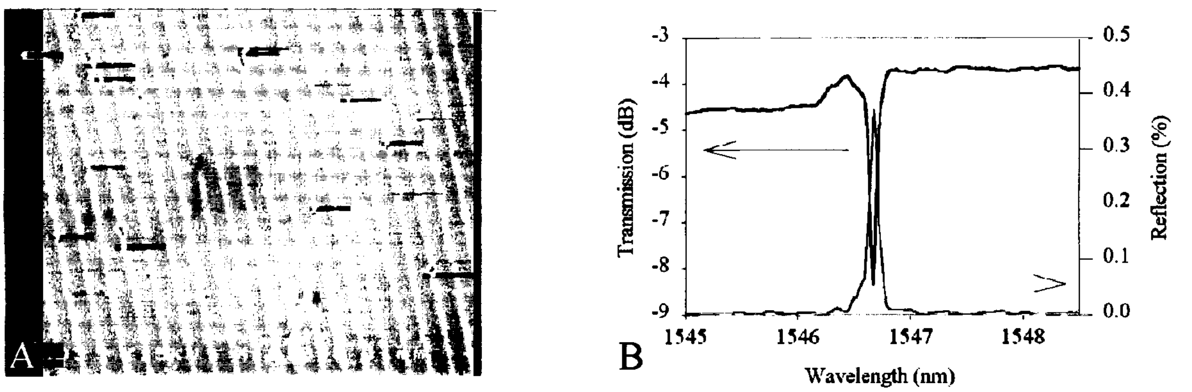

Figure 1. ***A****: SEM microscan of an ablated grating in a 100nm thick InO_x film.* ***B****: Transmission and reflection spectra of an ablated grating in a 135nm thick overlayer sputtered onto an 8μm wide waveguide. The reflection spectrum has been corrected for propagation losses.*

The TE transmission and reflection spectra of an ablated grating on a 135nm film fabricated using 5 pulses of energy density of 60mJ/cm^2, which has been overlaid on a 8μm wide waveguide, is presented in Figure 1B. Due to poor overlap with the overlayer, no detectable grating response was observed for TM polarisation. The example grating in Figure 1B has a maximum strength of about 4.7dB and a bandwidth $\Delta\lambda_{FWHM} \approx 0.08$nm. Longer exposures or higher energy densities resulted in significantly greater absorption losses and weaker grating strengths. Annealing of the waveguide chip up to 250°C for two hours in O_2 atmosphere reduced the losses by almost 1dB, without affecting the grating notch characteristics.

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