Integrated waveguides and Bragg gratings UV written with 213nm light

Paul C. Gow, Rex H.S. Bannerman, James C. Gates, Paolo L. Mennea, Christopher Holmes, Alexander Jantzen, Peter G.R. Smith

Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, UK

Direct UV writing is capable of fabricating low-loss channel waveguides, couplers and Bragg gratings in planar silica by translation through a focused UV beam. Devices are typically fabricated using 244nm laser light, relying on the photosensitivity provided by doping to induce sufficient refractive index change necessary to form waveguides. However, these devices also require hydrogen and deuterium loading prior to writing to induce sufficient refractive index change to form waveguides [1]. Hydrogenation not only requires additional processing but over time the hydrogen present within the silica depletes, which can cause variation of the final written structures. Deep UV light at 213 nm has previously been used to inscribe strong fibre Bragg gratings (FBGs) in hydrogen-free Ge-doped fibres achieving an index change of $1.2x10^{-3}$ [2]. Here we present the first use of a 213 nm UV laser to induce index change sufficient to simultaneously define waveguides and Bragg gratings in planar silica without hydrogenation. This would potentially allow writing of large area or two-dimensional devices without variation due to outgassing.

Flame Hydrolysis Deposition (FHD) was used to deposit doped silica layers on to a silicon substrate, forming a photosensitive core and a separate overclad layer. Individual planar chips were diced from this wafer. A 5th harmonic solid state laser operating at 213 nm wavelength was used for defining the waveguides and Bragg gratings within the core layer.

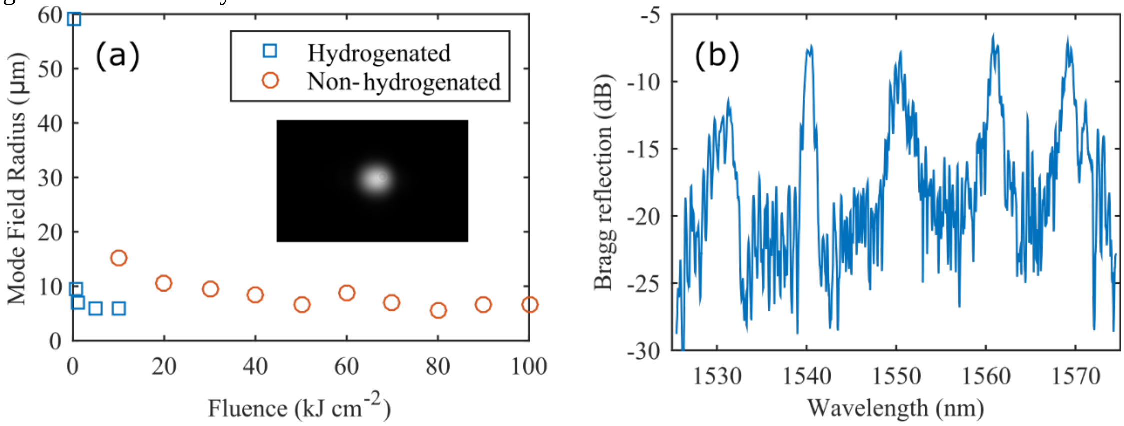

Fig. 1 (a) shows the mode field radius of 213nm UV written waveguides as a function of writing fluence for both hydrogenated and non-hydrogenated samples. Inset shows an image of the mode supported in one of the waveguides. (b) shows an OSA measured spectrum of Bragg gratings written simultaneously with single mode waveguides in non-hydrogenated samples.

Single mode waveguides in both hydrogenated and non-hydrogenated planar silica samples were fabricated with a single UV beam for different fluences (fig 1a). The NA of the waveguides was measured and propagation losses were determined through cutback measurements. Waveguides fabricated in hydrogenated silica were written 100 times faster than in non-hydrogenated samples to achieve similar mode confinement. Bragg gratings were defined simultaneously within single mode waveguides in non-hydrogenated silica through the dual-beam, small spot direct UV writing technique detailed in [3]. An OSA trace of these gratings are shown in fig 1b, achieving an index contrast $>10^{-3}$.

We will present the full characterisation of 213nm UV written single mode waveguides and Bragg gratings in both hydrogenated and non-hydrogenated planar silica, including fluence and NA characterisation, as well as propagation losses determined through cutback measurements and the Bragg grating technique [4]. A direct comparison will also be made with 244 nm fabricated devices.

References

[1] M. Fokine, and W. Marguli, "Large increase in photosensitivity through massive hydroxyl formation," Opt. Lett. **25**, 302 (2000).

[2] M. Gagné, and R. Kashyap, "New nanosecond Q-switched Nd:VO_4 laser fifth harmonic for fast hydrogen-free fiber Bragg gratings fabrication." Opt. Commun. **283**, 5028 (2010).

[3] C. Sima, J. C. Gates, H. L. Rogers, P. L. Mennea, C. Holmes, M. N. Zervas, and P. G. R. Smith. "Ultra-wide detuning planar Bragg grating fabrication technique based on direct UV grating writing with electro-optic phase modulation." Opt. Express **21**, 15747-15754. (2013)

[4] H. L. Rogers, S. Ambran, C. Holmes, P. G. R. Smith, and J. C. Gates. "In situ loss measurement of direct UV-written waveguides using integrated Bragg gratings." Opt. Lett. **35**, 2849-2851. (2010)