#1 Submitted to BGPP California 1-3 Sept 03
2634

Direct Grating Writing as a characterization technique for Direct UV written waveguide structures

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Abstract: We use the Direct Grating Writing technique, based on Direct UV writing to define Bragg channel waveguides, investigating the relationship between the properties of the glass, the writing conditions, and the strength of the waveguide.

OCIS codes: (230.7380) Waveguides, channel; (230.1480) Bragg reflectors

Introduction

Direct UV-writing is a Planar Lightwave Circuit fabrication process based on the refractive index increase occurring in specific materials in response to irradiation in the UV. This increase in index has conventionally been used to fabricate periodic index modulations in the core of photosensitive fibers to form Bragg gratings [1]. Previously this index change has been implemented in planar technology to allow direct definition of channel waveguides and hence, complex devices in photosensitive planar layers [2]. This process results in low loss channel waveguides manufactured without the need for photolithography or etching processes. In previous work on directly written structures, planar Bragg gratings have been fabricated using a secondary exposure through a phase mask [2] onto existing channel waveguides.

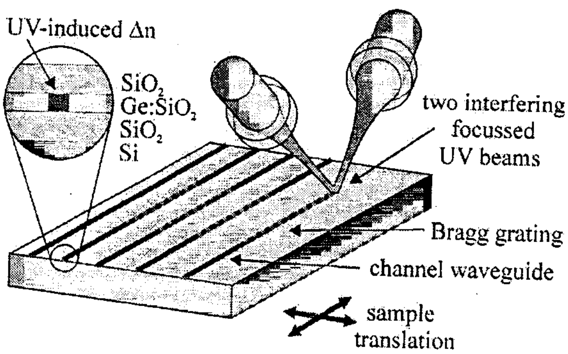

Figure 1: Simultaneous Direct UV writing of channel waveguides and Bragg gratings using focused beam interference in the photosensitive core of a 3-layer silica-on-silicon sample

Recently, we have reported the first implementation of Direct Grating Writing (DGW), a variant of Direct UV writing allowing the simultaneous definition of channel waveguides with integral Bragg gratings in a single step [3]. The DGW process is based on a writing spot with an inherent periodic modulation and was developed to allow both the grating and channel to utilize the full photosensitivity of the material with no need for a phase mask. This is achieved using two writing beams; each individually focused and aligned to create a single writing spot with an intrinsic interference pattern defined by the wavelength and intersection angle of the two beams (Figure 1).

As the sample is translated relative to the spot, the intensity of the laser is modulated with a period such that the maxima of the intensity pattern in the writing spot overlaps the maxima of the previous exposure, inducing a channel waveguide with an inherent Bragg grating index modulation. To define standard channel waveguide structures the sample is translated with the writing power held constant, and so the effect of the intra-spot intensity pattern is averaged out resulting in a uniform channel.

fluences used, becoming more pronounced in the low fluence regime. Freshly loaded samples exhibit a distinct threshold effect around fluences below 10KJcm^{-2} where channels are no longer written. The exact point where this threshold occurs varies with the power of the writing beam, again with slower translation speeds crossing the threshold effect at lower fluences.

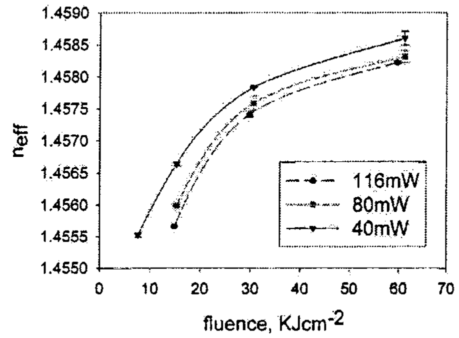

Figure 2: n_{eff} vs. fluence for a range of peak writing beam intensities in a freshly deuterium loaded sample

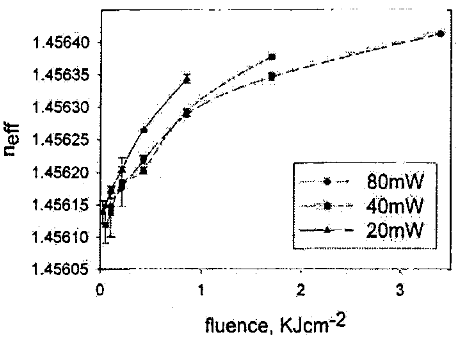

Figure 3: n_{eff} vs. fluence for a sample that has been thermally locked @1400°C for 5s

Figure 3 is the equivalent plot for a thermally locked sample, where again there is a discrepancy between fluence and the resultant index change with the similar trait of increasing index change with decreasing beam power (and decreasing velocity). However, these samples operate in a much reduced fluence regime, with the index change saturating out at levels where writing is yet to begin in the unlocked samples. Unlike the freshly loaded samples, the discrepancy over fluence decreases as the writing power is reduced, with the strength of the waveguides tending towards constant values at lower power levels. The results observed in this sample, with the smaller index change rapidly saturating out with fluence, indicates relatively low levels of GODC in comparison to the freshly loaded sample that originated from the same wafer. This clearly indicates that the current parameters used to thermally lock this sample are not optimal in activating the process of bonding the deuterium with the oxygen atoms in the glass matrix, and will be the subject of future study using this technique.

Overall these results demonstrate that the DGW technique offers a direct and rapid insight to the process of utilizing channel waveguide strength to realistically assess the native photosensitivity, processing effects and UV writing regime for photosensitive materials.

Conclusion

In conclusion, we have applied the direct grating writing technique to investigate the effect of various parameters involved when using direct UV writing to define channel waveguides. The nature of direct grating writing allows the inclusion of Bragg grating structures in the planar channel waveguides without changing the direct UV writing process. Interrogation of the grating structure provides highly sensitive information on the channel waveguide characteristics, and thus the refractive index increase. Using this technique we have compared the response of two samples to UV writing, each originating from the same wafer but subjected to differing photosensitivity enhancement processes. By analyzing the grating data, we have clearly identified that the two samples operate in entirely different fluence regimes and that there are material specific subtleties to the conditions of writing that effect the resultant index change.

References

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