2D Holographic Transmission Gratings UV Written in a Suspended Silica Membrane

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Abstract: Bragg gratings were written into planar doped-silica membranes with a 213nm laser. These were written over large areas using cylindrical lenses, and the resulting gratings and diffraction orders were investigated.

1. Introduction

Volume Bragg gratings (VBG's) are a periodic index change in a bulk medium. They are primarily used as dispersive elements, novel photonics, and filters, with chirped VBG's allowing for tuning of the filter [1,2]. Here we demonstrate the preliminary steps for fabricating VBG's in doped silica layers through direct ultraviolet writing (DUW) [3] in a quasi-small-spot regime. This technique allows for control over the writing to allow for grating detuning, chirping, and phase manipulation.

2. Method and results

Substrates used were fabricated on silicon wafers with a 15µm thermal oxide. Upon the oxide, a silica layer doped with germanium and boron was deposited through flame hydrolysis deposition before undergoing furnace consolidation. This process is then repeated to form a cladding layer on top, but doped with phosphorus and boron. The layer thickness, refractive index, and photosensitivity can be modified through control of the dopants and deposition. These substrates are then singulated into chip-scale devices by dicing with a Loadpoint Microace 3 saw. These chips are then left in a pressurized Hydrogen cell for several days prior to writing to increase photosensitivity [4].

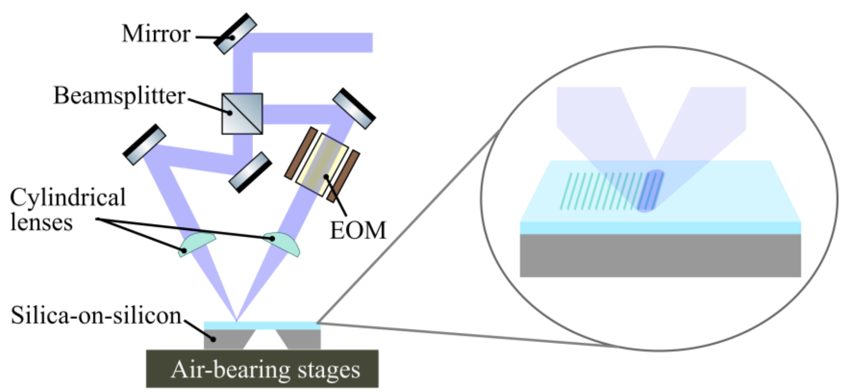

Fig. 1. Direct UV-writing technique using cylindrical lenses to illuminate an area instead of a small spot.

Next, a UV laser operating at a wavelength of 213nm and power of 30mW was used to UV write Bragg gratings within the photosensitive core layer using a method similar to the small spot technique [3,5]. The beam is split and one arm is passed through an EOM to allow control of the phase (figure 1). The two arms of the beam are then focused by 80mm focal length cylindrical lenses to two overlapping spots approximately 5µm x 4mm in diameter. This interference forms an intensity variation across the narrow width of the focal spots (figure 1 inset). This technique allows for 'detuning' of the Bragg wavelength, as well as the possibility for easily chirping or introducing arbitrary phase shifts within the resulting Bragg grating whilst writing a large area.

This technique was used to write a series of 1mm long gratings sequentially, with wavelengths between 1520 and 1590 nm, within the photosensitive core of a planar silica sample. The written chip was then aligned with a fiber v-groove assembly and broadband infrared light from an ASE source was coupled into the planar core layer. Light reflected from the gratings was collected by the same fibre and delivered to an optical spectrum analyzer (OSA). The OSA trace showing the reflected signal from the gratings is shown in figure 2(a). Figure 2(b) shows the visible diffraction of a white light source from the gratings.

To produce a transmission device, devices were partially masked on the underside of the silica-on-silicon samples, and the silicon was etched in a KOH solution to produce a suspended silica membrane, measuring approximately 5mm x 5mm [6]. These devices were then UV-written using the previous method to create a 10mm long by 4mm wide grating with a Bragg wavelength of 534 nm, giving approximately 1872 lines per millimeter. The resulting sample was mounted on a rotation stage so that its angle towards an incident collimated 663nm beam could be adjusted (figure 2c). The sample was rotated to find the strongest grating transmitted order, which occurred when the surface normal was ~36 degrees to the collimated beam. This was a low power diffracted order (~1%), due primarily to the small index change (~10^{-3}) and thin core layer in this sample (5μm). In the future, new flame hydrolysis depositions will be used to generate thicker layers and improve photosensitivity, which will address the low diffraction efficiencies observed here.

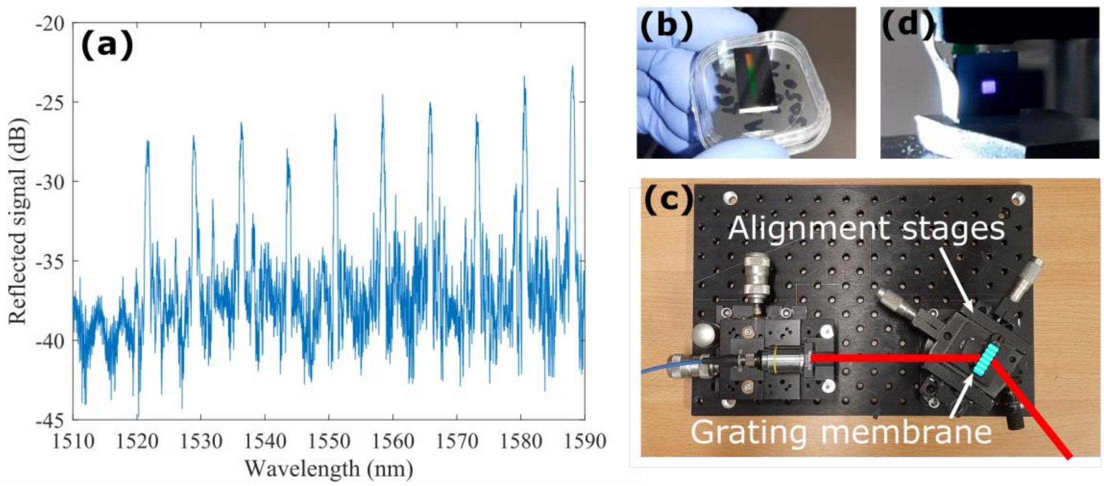

Fig. 2. (a) Reflection from gratings written in the photosensitive planar layer. (b) White light diffraction from an un-etched device. (c) Plan view photograph of the simple grating transmission setup. (d) Whitelight scatter from the gratings within the membrane.

3. Conclusion

Holographic transmission gratings were fabricated with a 213nm laser using a quasi-small-spot UV-writing technique. Back reflections from the gratings were collected to show the ability to detune gratings even with an alternative focusing configuration. A 2D grating was then written in a suspended silica diaphragm and measured using a collimated 663nm source. The authors will show these results, as well as gratings fabricated in thicker samples to improve efficiency and demonstration of chirped gratings, progressing towards true volume Bragg gratings.

References

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