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First Demonstration of Direct UV Written Bragg Gratings in Collapsed Fibre Planar Samples

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Abstract *First demonstration of planar Bragg gratings UV written into collapsed fibre planar samples with >200µm cladding thickness is presented. Multiple gratings were written across the sample profile to accurately determine core layer flatness and uniformity.*

Introduction

The collapsed fibre fabrication technology is a novel approach in producing low cost and robust planar samples for integrated optic devices. The method employs a combination of MCVD preform fabrication process and a novel way of collapsing the fibre during the drawing phase to produce planar samples. The substrate was fabricated by depositing doped silica layers on the inside of a circular substrate tube, which was then collapsed during the fibre draw into a planar geometry.

Direct UV Writing is a channel definition technique involving the 'writing' of a pre-designed waveguide structure by translating a photosensitive sample beneath a focused UV beam [1]. Consequently, the technique proves to be a simple, rapid-prototyping approach for waveguide fabrication with the considerable benefit that it does not require a clean room facility and is significantly simpler compared to the traditional photolithography and etching option.

A more advanced technique called Direct Grating Writing (DGW) allows single-step simultaneous definition of channel waveguides and Bragg gratings by modulation control of the interference pattern created by crossing two UV beams [2] and an image of this set up is shown in Fig. 1. The versatility of this advanced technique has been proven in the demonstration of several functional devices including directional couplers, Y-splitters, rare-earth doped planar lasers [3] as well as applications in accurate sensing and measurement methods [4].

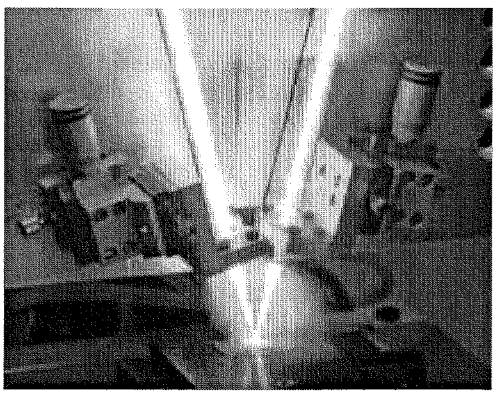

Figure 1 Image of the Direct Grating Writing (DGW) or crossed-beam set up for simultaneous channel and planar Bragg gratings definition

Using UV writing in defining waveguides in the collapsed fibre planar sample is advantageous in many respects. Firstly, as mentioned earlier, the technique involves no photolithography or etching. Due to the 'bow-tie' profile of the collapsed fibre samples (shown in Fig. 2), mask alignment and accurate etching of structures onto the sample would prove difficult. Also, the cladding layer surrounding the core is >200µm thick, which is more than ten times the layer thickness of typical planar samples and thus etching down such thick layer would be very difficult.

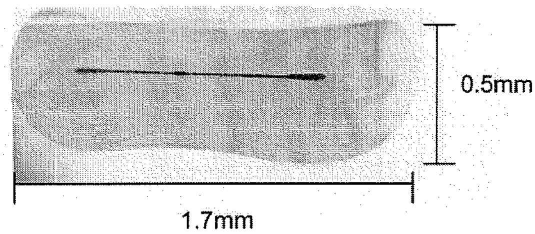

Figure 2 Image of the end face of the collapsed fibre sample illuminated with He-Ne laser (633nm) showing a channel. Notice the bow-tie profile of the sample

We have fabricated Bragg gratings as a first proof of principle. The successful demonstration of planar Bragg gratings leads us to believe that the core layer of the samples is flat along the propagation axis. We have also fabricated a series of gratings across the profile of the sample to accurately assess the lateral core layer flatness.

Experimental Work

For this work, fluence matched Bragg gratings were fabricated with fluence of 15.3kJcm^{-2}. The design Bragg wavelength is 1550nm with gratings period of 529.37nm. The gratings were 1.5mm long. To characterise the reflected signal from the gratings, an ASE input signal source was used. The ASE signal was passed via a flat cleaved SMF-28 input fibre tipped with index matching oil. The reflected signal was recorded using an optical spectrum analyser via a 3-dB coupler.

Figure 3 shows the reflection spectrum of the first ever demonstration of Bragg gratings in the collapsed fibre planar sample with a peak wavelength of 1556.8nm and a FWHM bandwidth of ~0.8nm. To successfully define gratings using the DGW technique places a stringent need for the core layer to be flat so as to ensure that the beams overlap throughout the duration of grating writing. Despite the 'bow-tie' profile of the sample, the fact that gratings have been successfully demonstrated leads us to believe that the core layer of the sample is flat along the direction of propagation. The inset shows the grating reflection and the ASE spectra from the source.

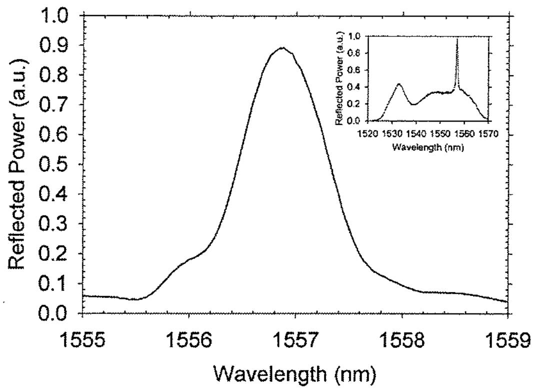

Figure 3 First demonstration of Bragg reflection in collapsed fibre sample. The inset shows the ASE spectra of the input light and the Bragg gratings reflection

We also chose to fabricate Bragg gratings to prove that the UV writing technique works despite the fact that the cladding layer of the structure is typically >200µm which is more than ten times that of the typical silica-on-silicon samples we usually use, making accurate beam focusing onto the core particularly sensitive. It is also worth noting that no parts of the cladding were etched in order to define the gratings.

To assess accurately the flatness of the core layer laterally across the profile of the sample, we have fabricated 7 gratings written with identical conditions. The gratings were spaced 100µm apart. Thickness variation will affect the effective index value of the fabricated structure and this is reflected in a shift in Bragg wavelength. Fig. 4 depicts the variation of effective index laterally across the sample core layer and the location of each grating. Note that gratings 6 and 7 display multi mode behaviour and this could be attributed to the core layer progressively increasing in thickness approaching the edge.

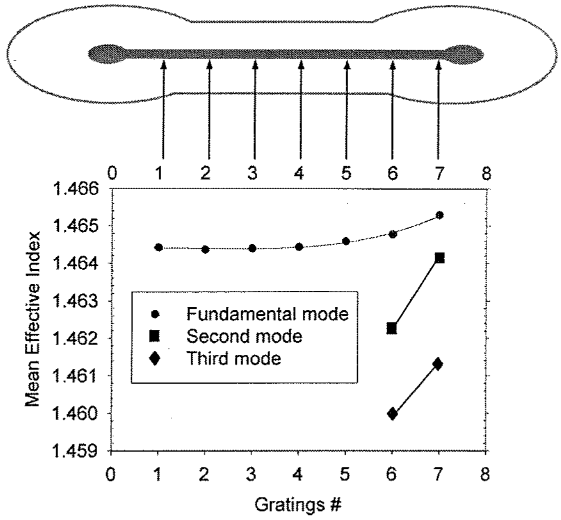

Figure 4 Mean effective index variation laterally across the sample profile (solid line: curve of best fit). The location of each grating is shown. Gratings 6 and 7 exhibit multi mode behaviour as the core layer progressively increases in thickness approaching the edge

As can be seen from Fig. 4, there is a region where the sample is flat laterally, with mean index variation of the order of 10^{-4}. However, regions within ~120µm of the edge display thickness variation. This would place an upper limit to the workable area of the sample. Nonetheless in the future, by changing fabrication parameters, samples with larger lateral cross section could be fabricated, overcoming the problem.

We will also report the use of gratings to characterise the birefringence of the sample.

Conclusions

We have demonstrated UV written Bragg gratings in collapsed fibre planar samples. Collapsed fibre planar sample fabrication offers a potential alternative for the production of low cost and robust planar samples. The samples are flat along the direction of propagation and within a finite region laterally. Successful demonstration of planar Bragg gratings highlights the potential for more complex devices and applications.

References

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