Combining Physical Micro-machining and Direct UV Writing to Fabricate Novel Planar Tilted Bragg Grating Refractometers

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Tilted Bragg gratings (TBG) offer discrimination between different environmental perturbations, such as localised strain (including thermal expansion) and external refractive index [1]. Discrimination can usually be made in this way as the external refractive index is not in direct contact with the core mode. Such technology has been primarily exploited in optical fibre [1-3], with some recent progress demonstrating multiplexed multi-point sensing networks [2], and the employment of enhancement layers to increase external refractive index resolution [3]. Despite significant developments made in fibre, relatively few reports have been made for such components in a planar geometry, which have the added advantage of compact integration and offers ready integration with microfluidics. A recent patent application for a refractometer device [4], has proposed the use of planar tilted Bragg gratings (PTBG) but it only describes geometries in which the measurand is in direct contact with the core of the waveguide. This work details a novel PTBG structure whose core mode is not in contact with the external refractive index.

This work achieves a set of discreet cladding mode resonances, in a silica-on-silicon planar platform, by fabricating a pair of vertical side walls either side of a tilted Bragg grating, illustrated in Figure 1 (a). The strength of the resonances is dependent upon the surface quality of the side walls. Through a combination of physical micro-machining [5], and Direct UV Writing (DUW) [6] we present a PTBG refractometer.

In the demonstrated device a pair of physically micromachined trenches (with a 30 μm width) form a 134 μm ridge with smooth surface side walls (Ra roughness of < 20 nm). A waveguide containing a weakly tilted (7^o) Bragg grating is DUW along the middle of the ridge, illustrated in Figure 1 (a). The waveguide properties are such that it is mode matched to SMF-28. To measure refractive index sensitivity a variety of fluids of known refractive index were placed over the structure, the transmission spectra is shown in Figure 1 (b).

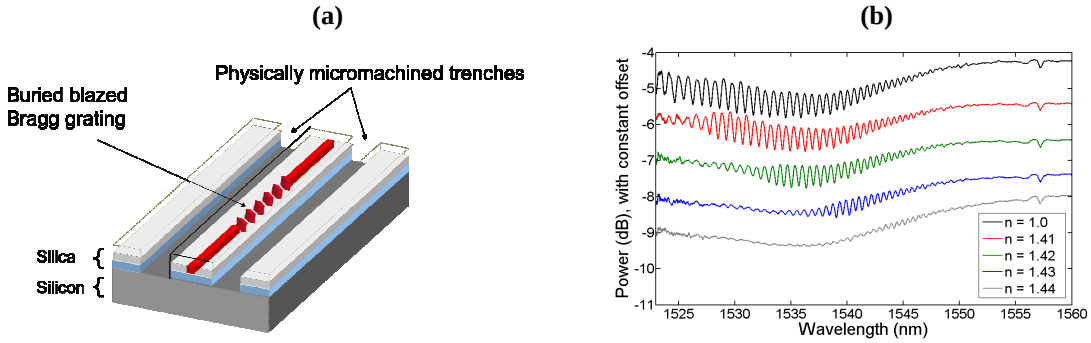

Fig. 1 (a) Schematic of the fabricated planar refractometer (b) Transmission spectra of a tilted planar Bragg grating subject to liquids of different refractive index (n).

Using a normalised area technique [1], the maximum sensitivity of the device was calculated to be -41.5 normalised area units per change in refractive index unit. The standard error of a five measurement average is $<3x10^{-3}$ normalised area units, resulting in a maximum refractive index resolution of better than $1x10^{-4}$, which is comparable to reported sensitivities in fibre TBG [1].

A novel planar TBG based refractometer has been demonstrated in silica-on-silicon. The novel integrated planar component displays comparable sensitivity to existing fibre TBG with additional benefits of integration and 2D integrated circuit design. Fabrication processes and more compact multiplexed multi-element sensing circuit designs shall be presented, in addition to reporting the use of enhancement layers to increase sensitivity.

References

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