Enhancing Chemical Sensitivity of a Tilted Planar Bragg Grating Using a Thin Gold Layer

C. Holmes[1], K.R. Daly[1], L.G. Carpenter[1], J.C. Gates[1], I.J.G. Sparrow[2], G. D'Alessandro[1], P.G R. Smith[1]

1. *University of Southampton, Hampshire, SO17 1BJ, UK.*
2. *Stratophase Ltd., Hampshire, SO51 9DL UK.*

The use of weakly tilted Bragg gratings to couple light from core waveguide modes to plasmon resonances within thin gold layers has gained increased interest over recent years [1-3]. Chemical sensing using such techniques has a multitude of advantages, including access to developed gold based chemistry for surface functionalisation and an enhancement of chemical sensitivity, particularly for the biochemically ubiquitous solvent, water (1.33). Despite the obvious benefits of such devices, fabrication has principally been limited to optical fibre platforms, with little fabrication development being made in the planar regime [4]. This work reports the use of a thin (50 nm) sputtered gold layer to enhance the chemical sensitivity of a weakly tilted planar Bragg grating (TPBG), illustrated in Figure 1 (a). Therefore, allowing access to the benefits of planar integration for this newly emerging technology.

The reported device is fabricated using a combination of physical micromachining [5] and direct UV writing [6]. To compare the sensitivity of the structure to similar devices in fibre [1], the tilt of the blazed grating was designed to be 10^{o} and the physically machined trenches defined a lateral cladding width of 125 μm. The direct UV writing technique fabricates waveguides that are mode matched to SMF 28.

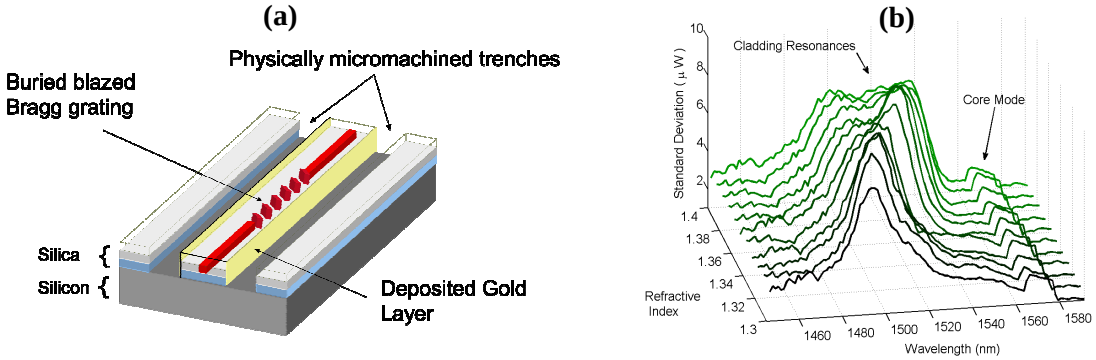

Fig. 1 (a) A schematic of the fabricated silica-on-silicon device and (b) the response of the transmission spectra to a change in external refractive index (TM polarisation).

Prior to the deposition of a gold enhancement layer the maximum refractive index resolution between refractive indices of 1.3 and 1.38 was ~$1x10^{-3}$ RIU (refractive index units) for the transverse electric (TE) polarization (TE mode having the electric field vector parallel to the side walls of the trenches).

After sputtering 50 nm of gold onto the device, the TE polarization was observed to have a negligible sensitivity to external refractive index. However, the transverse magnetic (TM) polarization demonstrated increased sensitivity, illustrated in Figure 1 (b). This data shows the standard deviation of the transmission spectra, which represents the strength of the cladding mode resonances. The value is taken for transmission intensity values over a 1 nm spectral range (20 data points). The significance of 1 nm is that this is the approximate periodicity of the cladding mode resonances. Thus, the standard deviation value is an indication of the resonance strength.

Monitoring the wavelength of strongest resonance as a function of external refractive index [1], yields a linear relation (gradient 478 nm/RIU). This is comparable to sensitivities observed in a fibre platform [1] and improves the maximum resolution of a device without gold enhancement by an order of magnitude. Fabrication procedures and device design for increased sensitivity shall be presented.

References

[1] Y. Y. Shevchenko, J. Albert, "Plasmon resonances in gold-coated tilted fiber Bragg gratings", Optics Letters, 32, 3 (2007).
[2] L-Y, Shao, Y.Shevchenko and J.Albert, "Intrinsic temperature sensitivity of tilted fiber Bragg grating based surface plasmon resonance sensor", Optics Express **8**, 11 11465-11471 (2010)
[3] Y. Shevchenko, C. Chen, M. A. Dakka and J. Albert, "Polarization-selsctive grating excitation of plasmons in cylindrical optical fibres", Optics Letters **35**, 5 657-639 (2010).
[4] G. Nemova, R. Kashyap, "Theoretical model of a planar integrated refractive index sensor based on surface plasmon-polariton exciting with a long period grating", J. Opt. Soc. Am. B, 24 10 (2007).
[5] E. B. Brousseau, S. S. Dimov and D. T. Pham, "Some recent advances in multi-material micro- and nano-manufacturing", Int J Adv Manuf Technol **47**, 161-180 (2010).
[6] S. Watts, "Optical microchip sensors", Nature Photonics **4**, 433-434 (2010).