Integrated optic glass microcantilever with Bragg gratings forming a Fabry-Pérot interferometer for force sensing

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Microcantilevers are the workhorse for ultra sensitive force sensors and are used in applications such as atomic force microscopy, sensing forces as small as 10pN [1]. In previous work [2] we have demonstrated the first integrated optical glass microcantilever, and we now show for the first time Bragg gratings forming a Fabry-Pérot interferometer acting to increase the force-sensitivity of the device. The fabrication of the glass microcantilever is based on a novel physical micromachining and etching approach, combined with UV written Bragg gratings. The advantages of the in-situ Fabry-Pérot interferometer will also be discussed.

Our glass microcantilever's fabrication procedure starts with a silica-on-silicon substrate, grooves are cut through the silica into the underlying silicon using micromachining using a precision dicing saw. Direct UV writing is then used to create optical waveguides containing pairs of Bragg gratings at wavelengths shifted from one another by a predetermined amount. The glass microcantilevers are then freed from the silicon substrate via wet etching to remove the underlying silicon [2], see Fig. 1 (a). By releasing the glass from the silicon, the Bragg grating positioned in the microcantilever is spectrally shifted by the release of thermal mis-match stress while the second Fabry- Pérot grating remains unshifted. The shift in central Bragg wavelength of the Bragg grating within the cantilever overlaps the two grating spectrally and thus forms a Fabry-Pérot interferometer between the Bragg grating within the bulk substrate and the Bragg grating within the microcantilever. Reflection spectra taken before and after the wet etching are shown in Fig 1 (b), and show the creation of the cavity.

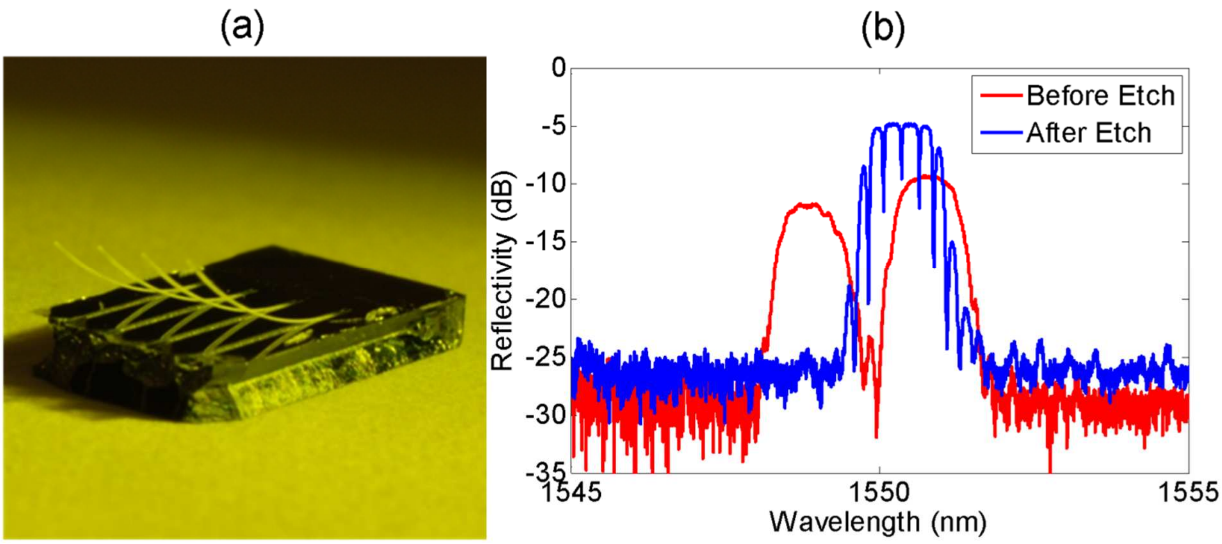

Fig. 1 (a) micrograph of microcantilevers having a length of 5mm, a width of 60µm and thickness 40µm, (b) TE reflection spectra of microcantilever before and after etching, the 6dB of loss depicted can be accounted for by coupling loss.

The addition of a Fabry-Pérot interferometer to the microcantilever device increases the spectral sharpness compared to a Gaussian apodised Bragg grating. The spectral sharpness provides a large change in reflectivity with small spectral displacements. A secondary advantage of a Fabry-Pérot interrogation is the sensitivity of the response to the entire integrated induced strain in the cavity, unlike the response previously reported [2] for a single Bragg grating where the strain is sensed only along the grating length.

In order to accurately characterise the overall sensitivity of the microcantilever, a surface profiling instrument was used [3] to apply µN forces along the length of the microcantilever. We shall present our latest results in the fabrication and characterisation of a microcantilever utilising Fabry-Pérot interferometers.

References

[1] Martin Munz, "Force calibration in lateral force microscopy: a review of the experimental methods", J. Phys. D: Appl. Phys. **43**, 063001 (2010).

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[3] Christopher Holmes, Lewis G. Carpenter, Helen L. Rogers, James C. Gates and Peter G.R. Smith, "Physical Sensitivity of Silica Micro-Cantilevers Fabricated using Direct UV Writing and Micromachining," Proceedings of LPM2010 - the 11th International Symposium on Laser Precision Microfabrication, (2010).