A Hollow Waveguide Michelson Interferometer

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In earlier work we demonstrated the use of hollow waveguides to guide light between the individual components of an optical circuit integrated into a common substrate [1]. The approach leads to compact rugged systems with excellent optical performance. As illustrated in Fig. 1a, we propose the application of the concept to a Michelson interferometer. Here hollow waveguides are used to guide the input radiation to an integrated 45° beam splitter/combiner, then to the arm mirrors of the interferometer and ultimately to an external detector. In practice the hollow waveguides are formed as square-section channels in the substrate in conjunction with a lid.

Compared with a free-space implementation of the Michelson interferometer, the light guidance provided by the hollow waveguides (albeit of a weakly guiding nature) makes the interferometer's performance far less sensitive to angular misalignment of: (i) the input beam, (ii) the beam splitter, and, (iii) the arm mirrors. As an example, the calculations in Fig. 1b show predicted peak-to-peak power modulation as a function of angular misalignment of one of the arm mirrors. Fig. 1b (upper), relates to an interferometer operating at a wavelength $\lambda = 1.06$ μm with hollow waveguides of cross-section $w = 0.5$ mm, and Fig. 1b (lower), to an interferometer with $\lambda = 10.6$ μm and waveguides of cross-section $w = 1.0$ mm. In both cases the four hollow waveguide arms are 100 mm long and the well-aligned mirror is mounted on a PZT to provide phase modulation. The other interferometer arm mirror is in a mount that facilitates accurate angular misalignment (tilt) about a single axis.

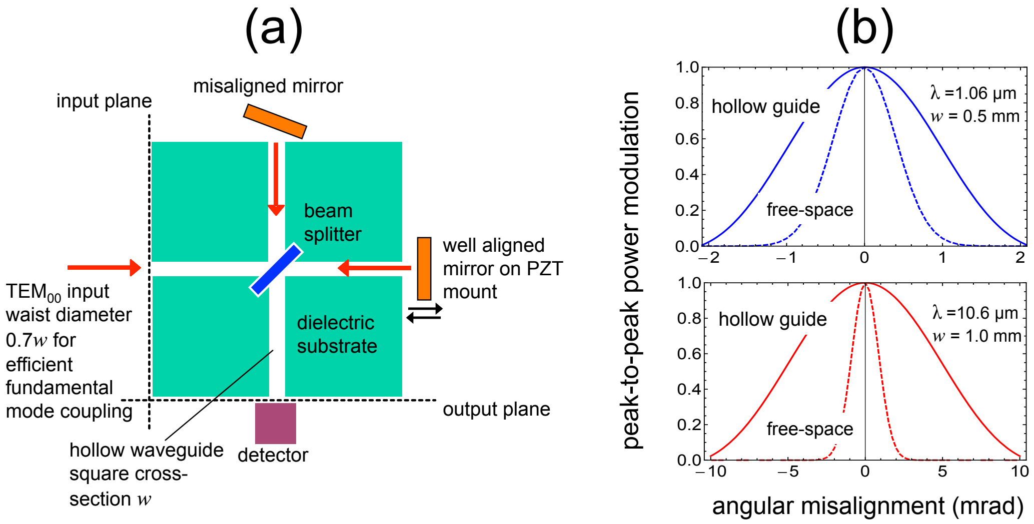

Fig. 1 (a) Schematic of a hollow waveguide based Michelson interferometer, (b) Predictions of peak-to-peak power modulation (homodyne sensitivity) as a function of angular misalignment for hollow guide Michelson configurations (solid lines) with $\lambda = 1.06$ μm and $w = 0.5$ mm (upper plot), and $\lambda = 10.6$ μm and $w = 1.0$ mm (lower plot). For each case, the equivalent free-space Michelson calculations (dashed lines) are shown for the same physical parameters.

The results clearly indicate the hollow waveguide implementation is significantly less sensitive to angular misalignment than the free-space equivalent. Separately we have calculated that for a given operational wavelength the sensitivity to angular misalignment decreases with waveguide cross-section and is independent of interferometer arm length. The concept has the potential to provide a valuable advance in Michelson interferometer technology for sensing, metrology and spectrometry. It should also be broadly applicable to other forms of interferometer for a wide variety of applications. Details of the design concepts, the calculations that have been undertaken and the plans for a practical demonstration of the approach, will be described.

References

[1] R. M. Jenkins, B. J. Perrett, M. E. McNie, E. D. Finlayson, R. R. Davies, J. Banerji, and A. R. Davies, "Hollow waveguide devices and systems," Proc. SPIE **7113**, 71130E, 71130E-8 (2008).