SPECTRAL INTERFEROMETRY-BASED DETECTION OF OPTICAL RESONANCES OF MICRO-CAPILLARIES

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We propose a spectral interferometric method for the detection of the wavelength position of the optical resonances of low-cost micro-resonators. Measurements were carried out with a Michelson interferometer and a broadband light source.
Keywords: optical resonators, optical interferometry

Rectangular glass micro-capillaries are interesting low-cost devices that can be envisioned as optical resonators. In previous works [1,2] their optical resonances were measured by illuminating them with a broadband light source and performing the spectral analysis of back-reflected light from the capillaries. In this work, we propose a spectral interferometry-based technique for the recognition of the wavelength position of the optical resonances. The investigated devices are borosilicate glass hollow tubing with rectangular longitudinal section (VitroTubes™ by VitroCom, NJ, USA). They are constituted by a front wall, an inner channel and a back wall with thicknesses $t_f = d = t_b = 50$ µm, respectively. They have width $W = 1$ mm and length $L = 5$ cm. They were positioned at the end of a Michelson interferometer (Fig. 1). In this setup, light in the NIR region is generated by an Er^{3+}-doped fiber broadband source (EBS) emitting at 1550 nm (FWHM = 40 nm). The radiation is guided through an optical isolator and a 2x1 fiber coupler towards an aspherical lens, which shines the light on a glass slab acting as a beam splitter. Most of the readout radiation is transmitted towards the capillary, traveling along the measurement arm of the interferometer. A smaller fraction (~ 4%) of the impinging radiation is reflected at 90° towards a mirror (reference arm). Beams back-reflected by the capillary and the mirror are recombined and light is detected with an optical spectrum analyzer (OSA), connected to a PC for spectra acquisition. Typical experimental results are reported in Fig. 2. The cosine signal was retrieved by applying the formula

$$\cos[\varphi(\lambda)] = [I_{tot}(\lambda) - I_{cap}(\lambda) - I_{mirror}(\lambda)]/[2\cdot(I_{cap}(\lambda)\cdot I_{mirror}(\lambda))^{1/2})]$$

where I_{cap} is the signal reflected by the capillary only, I_{mirror} is the signal reflected by the mirror and coming from the reference arm only and I_{tot} is the complete interferometric signal with both contributions. The cosine signal (Fig. 2a, black trace) exhibits sharp phase jumps at the wavelength where the minima of the capillary reflection spectrum (Fig. 2a, red trace) are located. To better enhance steep variations, the derivative of the cosine signal with respect to the wavelength was computed (Fig. 2b, black trace). Therefore, the wavelength positions of the resonances can be determined with a much better resolution as peaks on the derivative signal than as minima on the spectral reflectivity (Fig. 2b, red trace). In future works, micro-capillaries combined with phase-based detection could be exploited for label-free measurement of the refractive index of ultra-low volumes of fluid samples.

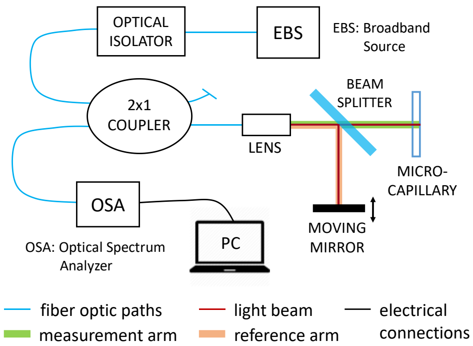

Fig. 1 Instrumental setup for experimental measurements.

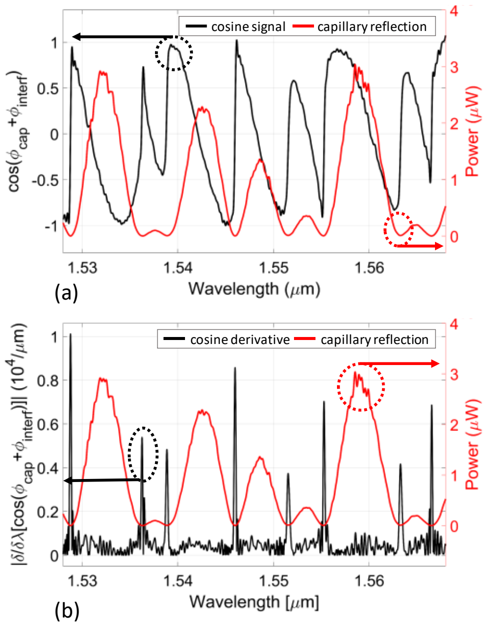

Fig. 2 Experimental results.

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References

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