Single tapered fiber tip for simultaneous measurements of thickness, refractive index and distance to a sample

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Abstract: We demonstrate the capability of an air cavity Fabry-Perot interferometer (FPI), built with a tapered lead-in fiber tip, to measure three parameters simultaneously, distance, group refractive index and thickness of transparent samples introduced in the cavity. Tapering the lead-in fiber enhances the light coupling back efficiency, therefore is possible to enlarge the air cavity without a significant deterioration of the fringe visibility. Fourier transformation, used to analyze the reflected optical spectrum of our FPI, simplify the calculus to determine the position, thickness and refractive index. Samples made of 7 different glasses; fused silica, BK7, BalF5, SF2, BaF51, SF15, and glass slides were used to test our FPI. Each sample was measured nine times and the results for position, thickness and refractive index showed differences of ± 0.7%, ± 0.1%, and ± 0.16% respectively. The evolution of thickness and refractive index of a block of polydimethylsiloxane (PDMS) elastomer due to temperature changes in the range of 25°C to 90°C were also measured. The coefficients of the thermal expansion and thermo-optic estimated were $\alpha = 4.71 \times 10^{-4}$/°C and $dn/dT = -4.66 \times 10^{-4}$ RIU/°C, respectively.

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Although, we have just measured the n_g and t along one axis of the samples under test, the small dimensions of the interrogation beam allow us to carry out measurements in the 3 axis of a sample.

4. Conclusions

A simple and versatile extrinsic fiber FPI is reported. The tapered fiber minimizes the divergence of the output beam of the optical fiber and couples the reflected light more efficiently than an un-tapered optical fiber. As a result, extrinsic FPIs with long cavities can be implemented which allow the insertion of thick samples inside the cavity. We demonstrated that our FPI can be used to measure simultaneously, group refractive index and thickness of a sample as well as distance to the sample. Differences between our measurements and the actual values are less than 0.16% for the three measurements. The simultaneous measurements performed with the PDMS sample to obtain dn/dT coefficient present a difference of $1x10^{-5}$ RIU compared with previous reported value. On the other hand the result for the coefficient of linear expansion (α) presents a difference of $1.7x10^{-4}$ compared to the value provided by the manufacturer.

The interferometer here reported has several important advantages including flexibility, miniature size and multiplexing capability among others. We have demonstrated that our FPI can simplify the measurements of CTE or dn/dT of some materials.

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