Amplitude Detection of Flexural Acoustic Waves in Optical Fibers by Using a Fiber-Tip Interferometer

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Fiber-optic interferometers are very interesting devices due its great variety of applications, such as pressure sensors, temperature sensors, fiber diameter variation detection, among others. High resolution, low cost, easy alignment, simplicity and stability are some advantages that offer this type of fiber-based devices. The operational principle of an interferometer involves two light beams propagating along different paths that are recombined to interfere with each other, creating an interference signal. This signal can be detected through variations of intensity, frequency, wavelength or phase. In this way, fiber interferometers can be employed to characterize flexural or longitudinal acoustic waves. Although, various fiber-based interferometers have been used to measure vibrations with nanometer scale amplitudes, the reported publications usually lack information about the optimal conditions and operational limits that are necessary for accurately sensing displacements.

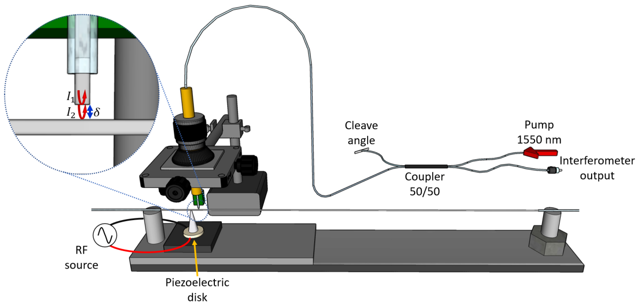

Figure 1: Experimental setup used to measure nanometer-scale displacements by using a fiber-tip interferometer

The acousto-optic effect based on flexural acoustic waves has been implemented to the development of all-fiber acousto-optic devices such as tunable filters, modulators, frequency shifters and wavelength selective switches. Usually, acoustic flexural waves are excited employing an arrangement composed of a piezoelectric transducer, a metal or silica horn and an optical fiber segment. When the piezoelectric is excited by an electrical signal, it produces vibrations that are transmitted to the optical fiber by the tip of the horn, generating an acoustic wave along the optical fiber producing a periodical perturbation that enables intermodal coupling between the fundamental core mode and some higher-order cladding modes. The effectiveness of intermodal coupling relies on the amplitude and frequency applied to the piezoelectric.

In this work, we report an experimental and theoretical study of a fiber-tip interferometer sensor for the detection of flexural acoustic waves. Figure 1 illustrates the experimental setup. The inset shows that the interference occurs in the cleaved fiber, where a beam is reflected due to the fiber-air interface, and interfere with the reflected beam from the optical fiber that vibrates because of the propagation of the travelling flexural acoustic wave. The proprieties of the acoustic wave are described by the parameters of amplitude, acoustic power, attenuation, phase and group velocity. The nanometer amplitude of flexural acoustic waves is measured under two techniques: temporal and frequency analysis. The experimental results demonstrate the effectiveness of this system for the characterization of fiber optic acousto-optic devices based on a fiber-tip interferometer.