Fiber Acoustic Sensor Based on Cascaded Taper Mach-Zehnder Interferometer

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1. Introduction

Acoustic sensors have numerous applications in many fields such as earthquake forecast, structure health monitoring and hydrophones [1], [2]. Recently, fiber acoustic sensors have attracted a lot of attentions for the advantages compared with traditional technologies, such as small size, light weight, immunity to electromagnetic interference and the ability of multiplexing.

In this paper, we propose and demonstrate an acoustic sensor consisting a cascaded single mode fiber (SMF) taper based inline Mach-Zehnder interferometer (MZI). The in-line MZI is fabricated by creating two simple tapers in SMF, separated by a small distance.

2. Proposed Structure and Working Principle

The proposed sensor setup consists cascading SMF tapers, separated by a length of untapered SMF. SMF is tapered using well established flame and brush technique. Creation of first taper couples some energy from the fundamental core mode (LP_{01}) to higher order cladding modes (LP_{0m}). These cladding modes along with fundamental core mode travel through the untapered SMF between two tapers. As soon as the second taper is created, most of the cladding mode energy gets recoupled with the fundamental core mode forming an in-line intermodal MZI [3]. With slight change in strain due to acoustic pressure, the phase of the cladding modes change and the transmission spectra of the MZI setup shifts in accordance with the applied acoustic pressure. Hence by tracking the MZI interference peaks, one can sense the applied acoustic signal.

The schematic of proposed acoustic sensor is shown in Fig. 1. Light is launched in the MZI structure by connecting one end of MZI to a SLED source. The other end of MZI is connected to the I-MON interrogator and transmission spectra is observed in the computer system connected with the interrogator. Sound waves of different amplitude and frequencies are produced using a computer controlled sound source (JBL GO speaker).

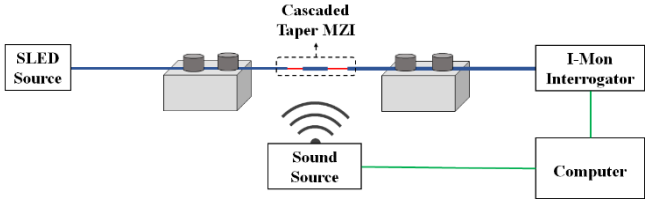

Fig. 1. Schematic of proposed acoustic sensor.

The MZI system is investigated with acoustic frequency ranging from 180 to 500 Hz. The response of the MZI system for sound wave of 250 hz is shown in Fig. 2 (a) and Fig. 2 (b) shows the FFT of the signal captured using I-mon interrogator. The FFT shows a sharp peak at 250 hz which confirms that the MZI based system is accurately detecting the acoustic signals. The average acoustic sensitivity of the proposed sensor is 54 nm/kPa over frequency range of 180-500 Hz.

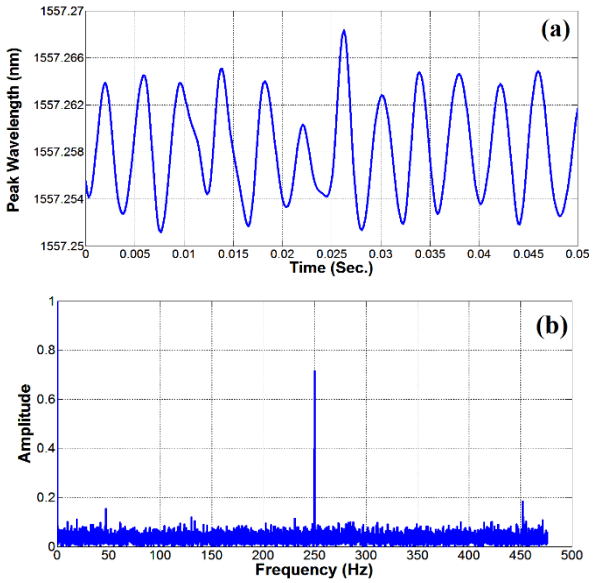

Fig. 2 (a) Time domain and (b) Fourier spectrum of the MZI based acoustic sensor at 250 Hz.

3. Conclusions

We proposed and demonstrated a cascaded single mode fiber taper based inline Mach-Zehnder interferometer as an acoustic sensor. Experimentally we verified that the average sensitivity of proposed acoustic sensor is 54 nm/kPa over frequency range of 180-500 Hz.

References

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