Fiber-based Laser Interferometry Array for Ultrasonic Vibration Sensing

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Background, Motivation and Objective

Piezoelectric ultrasound transducer dominates ultrasound sensing in medical ultrasound imaging. However, piezoelectric transducers perform relatively low bandwidth and sensitivity. On the contrary, fiber-based laser Interferometry exhibits very high sensitivity on vibrations, which potentially acts as a new ultrasound imaging technique. Furthermore, optical fiber-based system is immune to electromagnetic noises. Fiber optic array holds great potential for the next generation ultrasonic sensing systems. In this research, we designed an optical fiber array for ultrasonic vibration sensing based on 7-channel laser Interferometry.

Statement of Contribution/Methods

The ultrasonic sensing array consists of 7 laser Interferometry channels. The 1310 nm laser was split to a reference channel and 7 sensing channels by a 1 × 8 splitter (Fig. 1A). The 7 sensing channels was arranged as hexagon close packing with a protecting layer wrapped around it (Fig. 1B). The surface of the measuring head was coated with a layer of vibration film, the vibration of which generates frequency variation due to Doppler Effect. In the reference channel, the light frequency was shifted by an acoustic-optic modulator, which is 40 MHz higher than the original light wave. After frequency shifting, the reference wave was split to 7 channels to interfere with each sensing beam individually (Fig. 1A). After amplification, the intensity of the interference wave was digitized for data processing. Phase demodulation was used to recover the vibration signal.

Results/Discussion

The performance of the system was evaluated with a 10 MHz ultrasound signal source. In the preliminary test, the sensor captured the vibration at the surface of the ultrasound transducer (Fig 1C). The sensitivity of the sensor was 1.52×10^{4} rad/(s·nm). Detailed characterization of array will include the receiving beam steering, beam width and so on. In conclusion, the proposed a fiber-based laser Interferometry array performed good measurement on the ultrasonic vibrations.

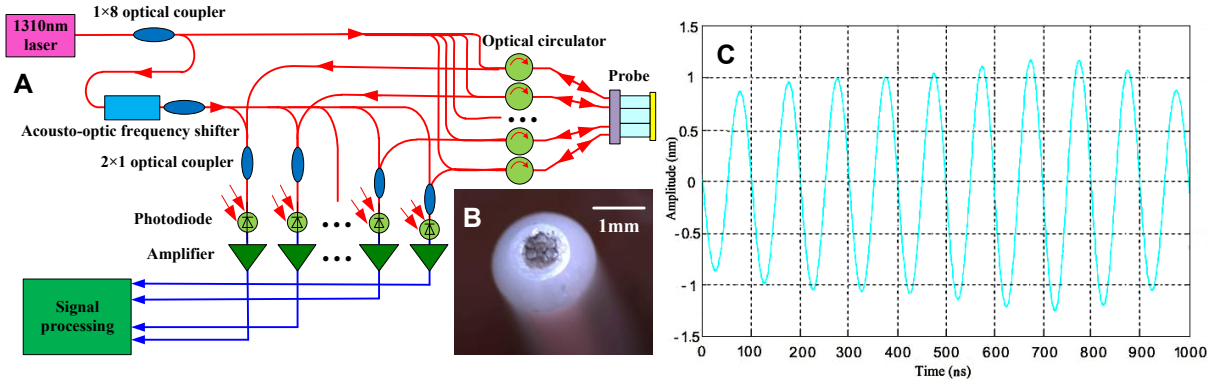

Fig. 1. A. Schematic diagram of the 7-channel fiber-based laser Interferometry array, B. Photograph of the 7-channel optical fiber sensor, C. Experiment results of the vibration amplitude.