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Silica microfiber for wearable strain and temperature sensors

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Abstract

Silica microfibers have been emerging as a novel sensing platform owing to their outstanding properties including low waveguiding losses, tight optical confinement, strong evanescent fields, and small bending radius [1]. When a silica microfiber is embedded in a thin layer of PDMS film, the PDMS film not only provide natural protection of the microfiber, but also serve as an effective external stimuli transducer due to its low Young's modulus, high Poisson's ratio coefficient and large thermooptic coefficient [2]. Enabled by the transition from guided modes into radiation modes of the waveguiding microfibers upon external stimuli, one can detect human physiological signals in real time by attaching a microfiber sensor to skin or cloth. Herein, we demonstrate highly sensitive wearable microfiber sensors for monitoring respiratory rate and body temperature.

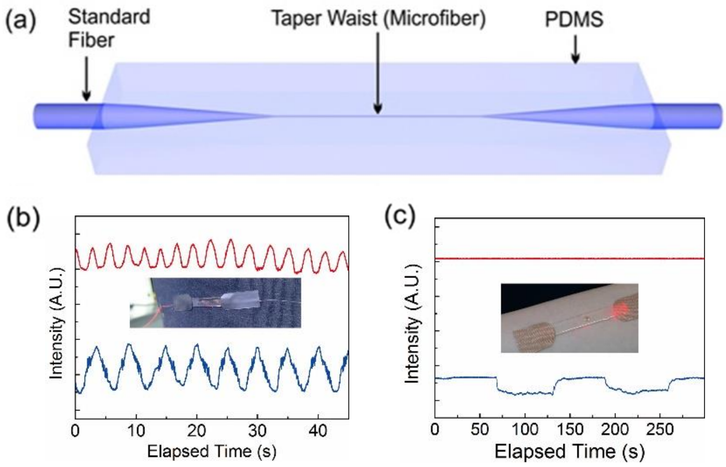

Figure 1: (a) Schematic illustration of a microfiber sensor. (b) Intensity change as a volunteer breathe normally(red line) and deeply (blue line). Inset: Photograph of a microfiber sensor attached to the volunteer's T-shirt. (c) Stability of a temperature sensor (red line) and intensity change of temperature sensor with/without a droplet of enthanol (blue line). Inset: Photograph of a microfiber sensor with a droplet of enthanol attached to the volunteer's arm.

Figure 1 (a) shows a schematic illustration of a microfiber sensor. It can be attached to a substrate or human skin. In order to work as a strain sensor, a microfiber was embedded in PDMS film with a zigzag structure, archiving a gauge factor of 750. When the sensor was fixed on the T-shirt of a volunteer as shown in the inset of Fig. 1(b), normal and deep breathing can be easily distinguished based on the recorded transmission. To investigate the sensor's stability, we placed a sensor on a hotplate with a constant temperature of 37°C, no obvious intensity change was detected as shown in the red line of Fig. 1(c). To demonstrate the capability to detect subtle body temperature change, we dipped a droplet of ethanol onto the sensor (see inset of Fig. 1 (c)), a decrease in transmission was caused by the evaporation of the enthanol. When the droplet was removed from the sensor, the transmission returned to the original value immediately. Based on the calibration curve and the stability of the sensor, the resolution of the temperature sensor is about 0.01℃ in the range of -20-130℃.

References

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[2] Yang, R., Yu, Y. S., Zhu, C. C., Xue, Y., Chen, C., Zhang, X. Y., Zhang, B. L., Sun, H. B.: PDMS-Coated S-Tapered Fiber for Highly Sensitive Measurements of Transverse Load and Temperature," IEEE Sensors Journal, vol. 15, no. 6, pp. 3429-3435, 2015.