Supporting Information

Environment-friendly carbon nanotube based flexible electronics for noninvasive and wearable healthcare

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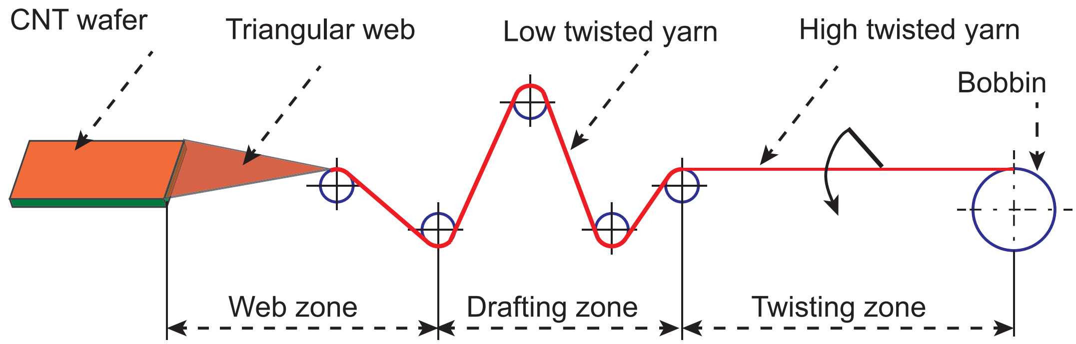

Figure 1: Schematic sketch of CNT yarn spinning process.

Firstly, the web was formed from the CNT forest on the wafer, which had various poorly aligned bundles. The web was then stabilised using both tension and torque generated from a tensioning system with a number of capstan effect rods. This system adjusted the radial pressure of the yarns on the rods via contact angles, which can improve the tenancity of CNT yarns.

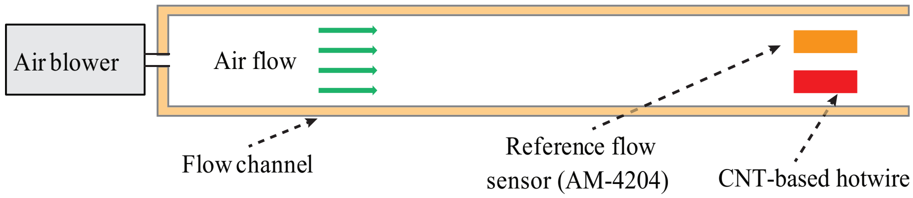

Figure 2: schematic sketch of flow measurement setup (not to scale).

The air blower generates air flow ranging from 0.8 to 2.5 m/s at room temperature (25 °C) and under atmospheric pressure. The Reynolds number $R_e = D\upsilon\rho/\mu$ of the experimental setup was larger than 5200 when the flow velocity υ changed, indicating that the flow passing the CNT-based hotwire was turbulent. As the air flow can affect the electrical resistance of the CNT hotwire due to the piezoresistive effect, we measured the resistance of unheated CNT hotwire at different flow velocities. We observed a very small resistance change of less than 0.1% for the maximum applied air flow velocity. This indicates that the impact of strain induced by air flow on the performance of the CNT sensor is negligent.

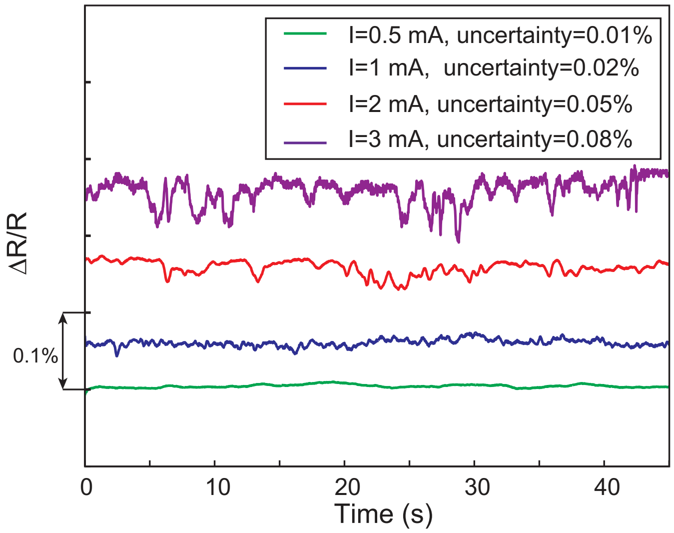

Figure 3: Uncertainty of the sensor with different applied currents.

It is evident that the uncertainty rises with increasing input power/applied current. As such, the uncertainty was only 0.02% at an applied current of 0.5 mA, implying that the temperature rise in the CNT wire was insignificant. The uncertainty increased to 0.08% at an applied current of 3 mA. This is due to the fact that, the Joule heating effect is significant at a higher power level, leading to a high temperature rise for the hotwire. As the surrounding environment has a fluctuation of air flow, the electrical resistance of the CNT hotwire varies owing to its temperature-dependent resistance with a negative TCR.

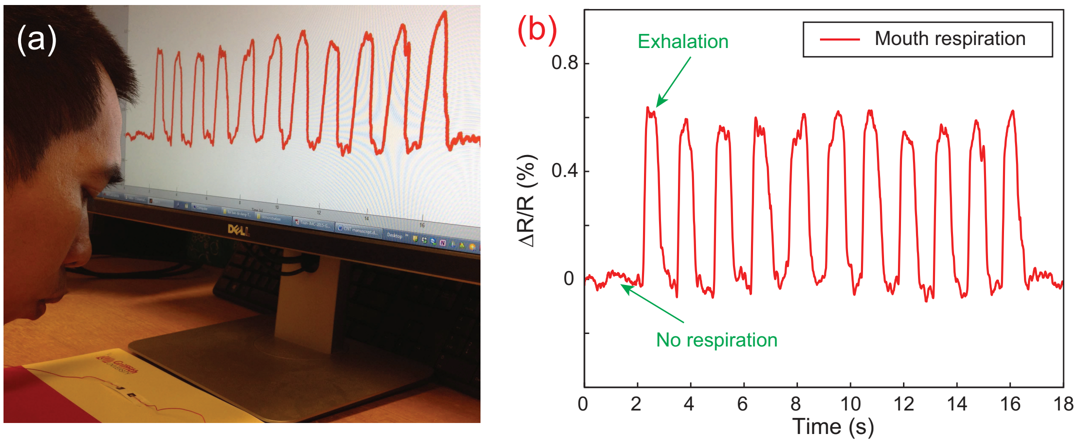

Figure 4: Noninvasive monitoring of mouth respiration. a) Photograph of a CNT-based flow sensor attached on a desk for monitoring mouth respiration. b) Measure of mouth respiration.

We demonstrated the feasibility of using the CNT thermal flow sensor for mouth respiration monitoring by fixing it on a desk to avoid agitation of the sensor as shown in Figure 4a. Figure 4b shows the response of the sensor measured with high signal-to-noise ratio, which can be controlled by alternating the speed of mouth respiration. Multiple tests were also conducted, showing a good repeatability of the sensor.

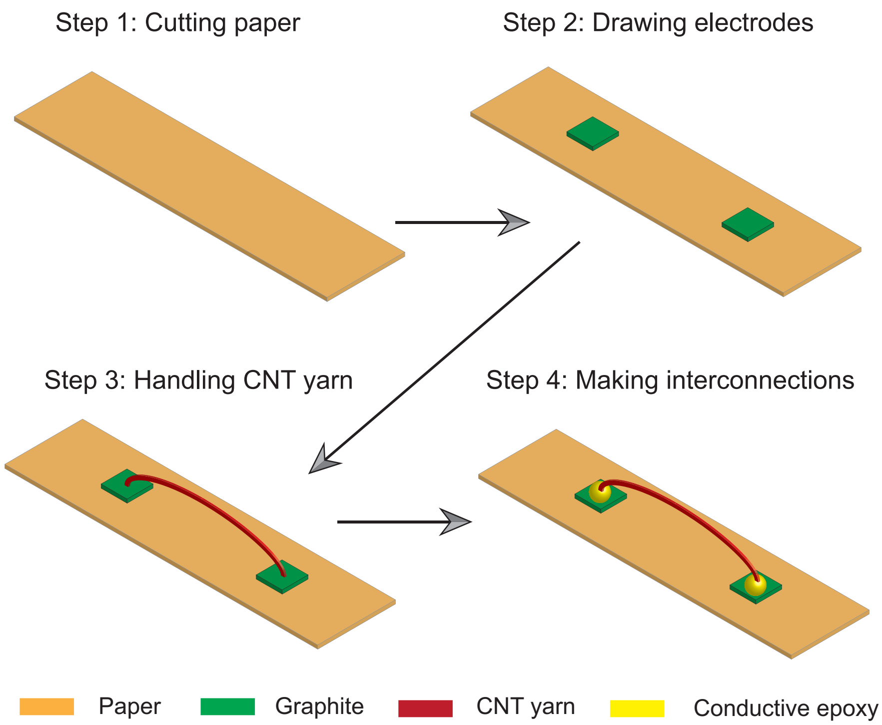

Figure 5: Fabrication of a CNT-based device.