Supplementary Materials

3D-printed magnetic-based air pressure sensor for continuous respiration monitoring and breathing rehabilitation

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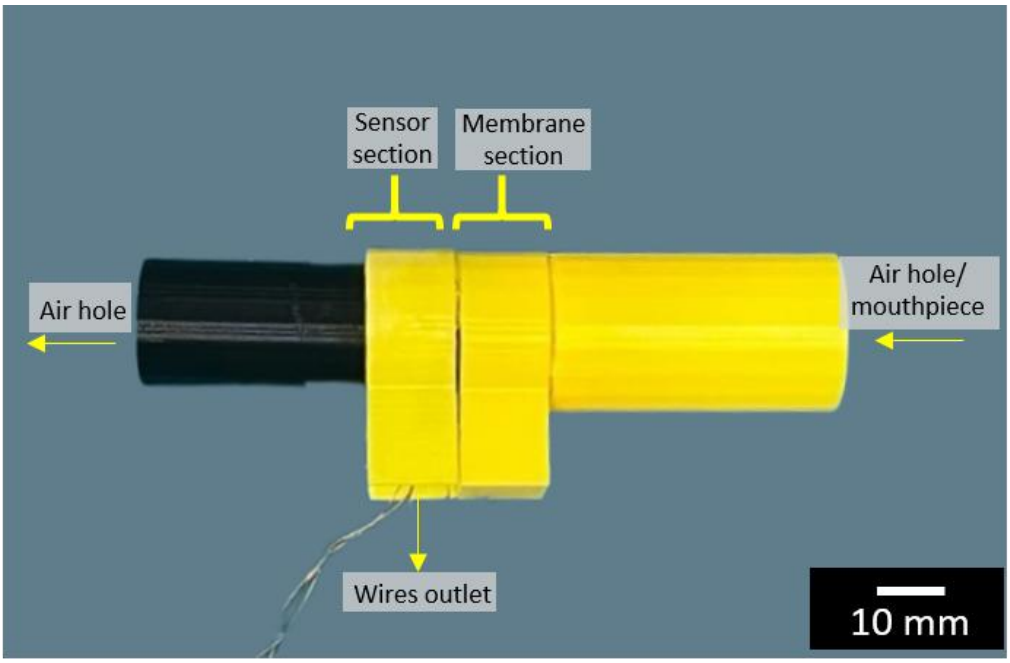
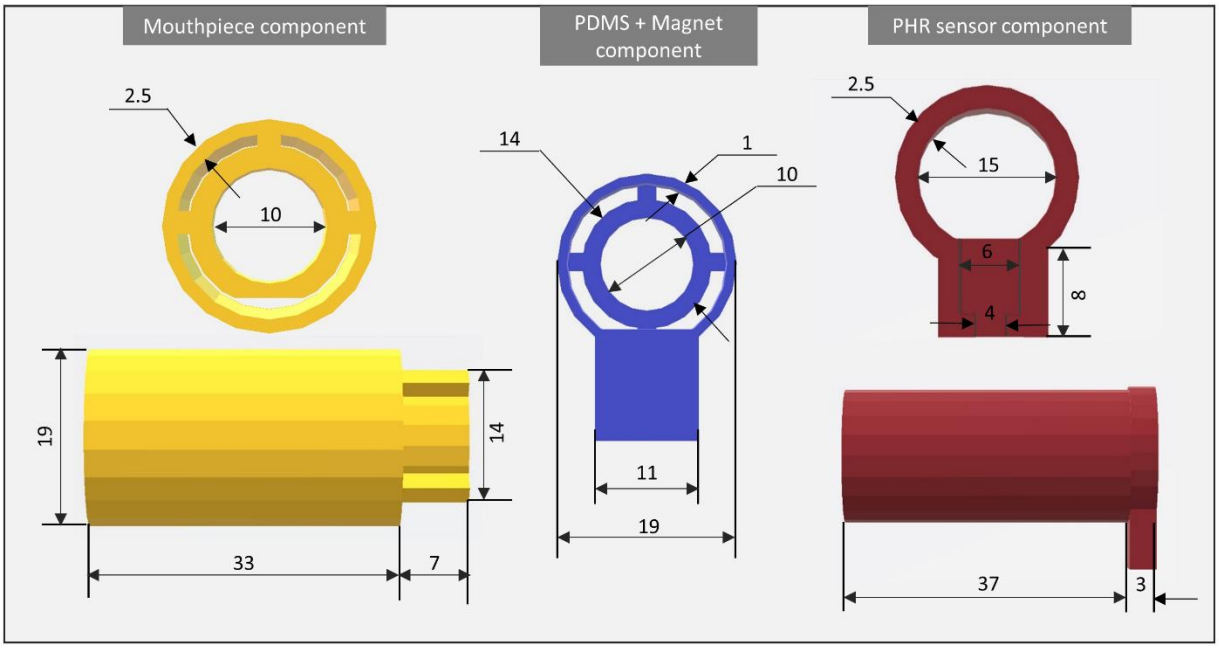
Supplementary Information 1



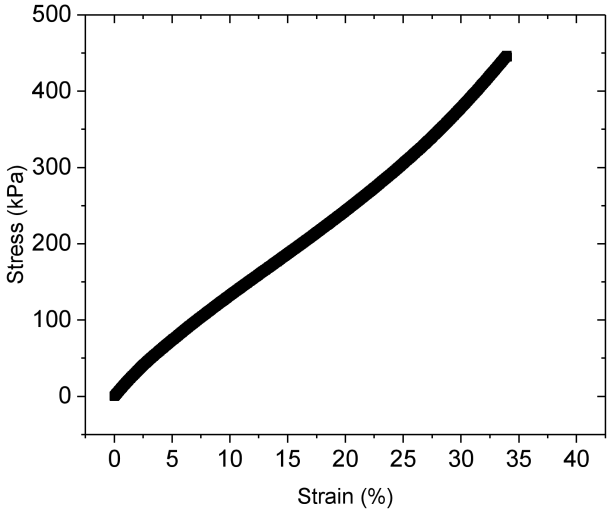
The respiration sensor is comprised of three detachable parts; the mouthpiece, the middle body (containing PDMS membrane and magnet) and the sensor body (containing PHR sensor and airhole). The figure shows an actual sample image of the fabricated and assembled respiration sensor from the outside.

Supplementary Information 2



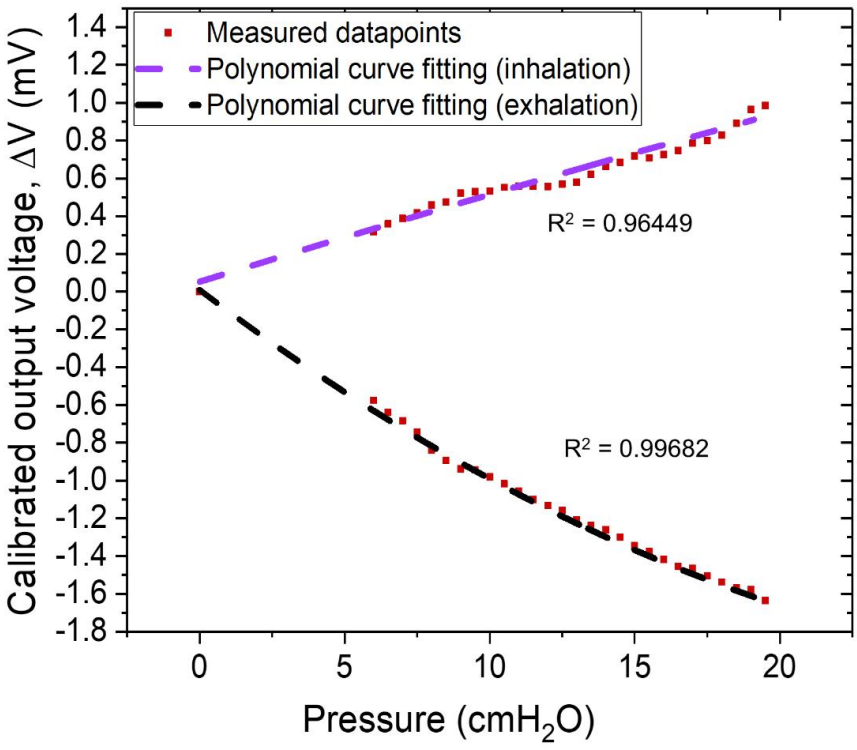
The figure shows the technical dimensions of each essential component of the respiration sensor body (excluding the PHR sensor, magnet and PDMS membrane).

Supplementary Information 3



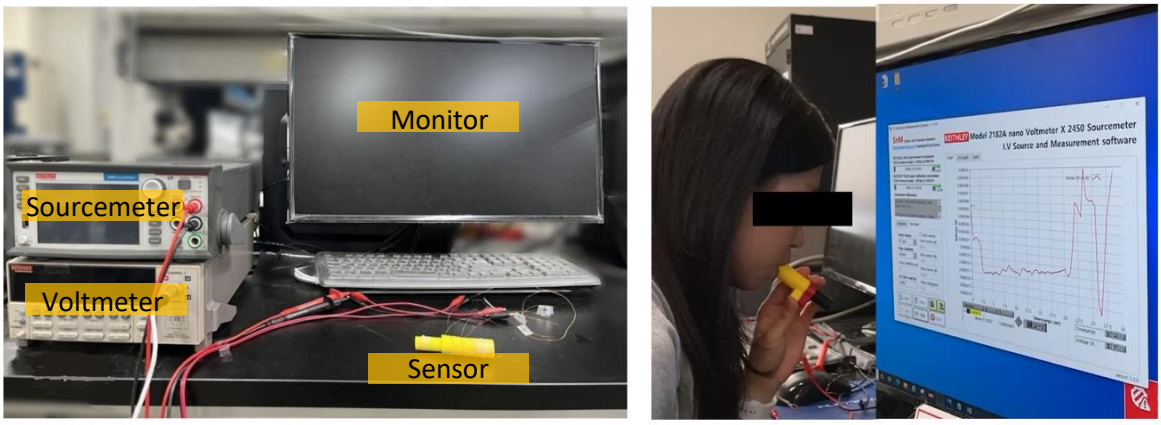
PDMS (10:1) characterization. (Left) Tensile stress-strain plot for PDMS membrane characterization. (Right) Characterization was carried out by uniaxially stretching a dogbone-shaped PDMS using a Universal Testing Machine (Shimadzu EZ-LX) at a rate of 20 mm/min.

Supplementary Information 4



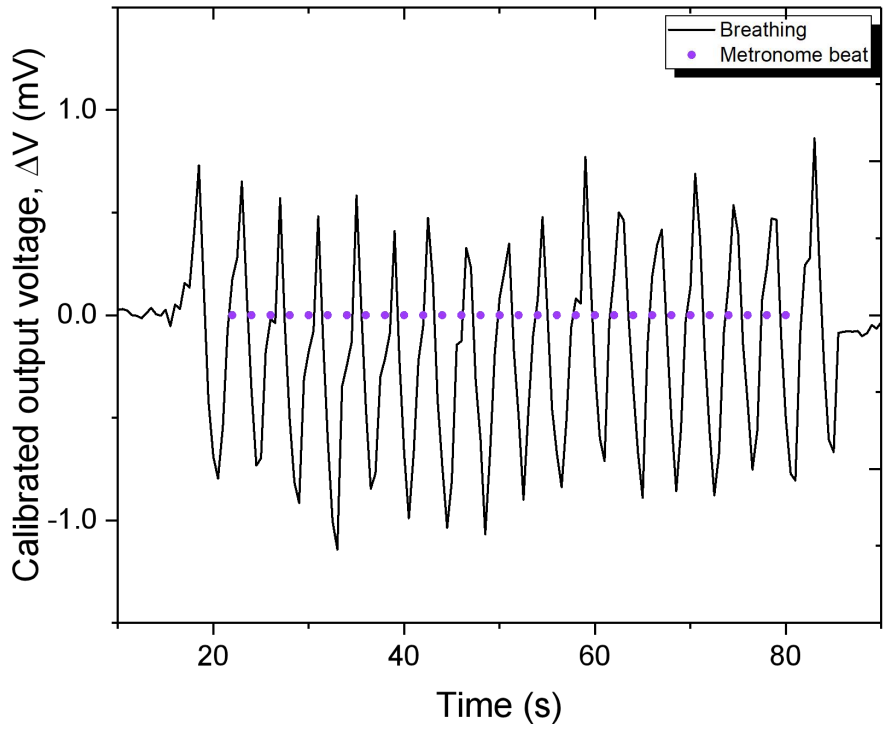
Polynomial regression curves (quadratic) were fitted using OriginPro software against datasets obtained from inhalation and exhalation pressure characterization experiment. Both curves show excellent fits based on their R^2 values.

Supplementary Information 5



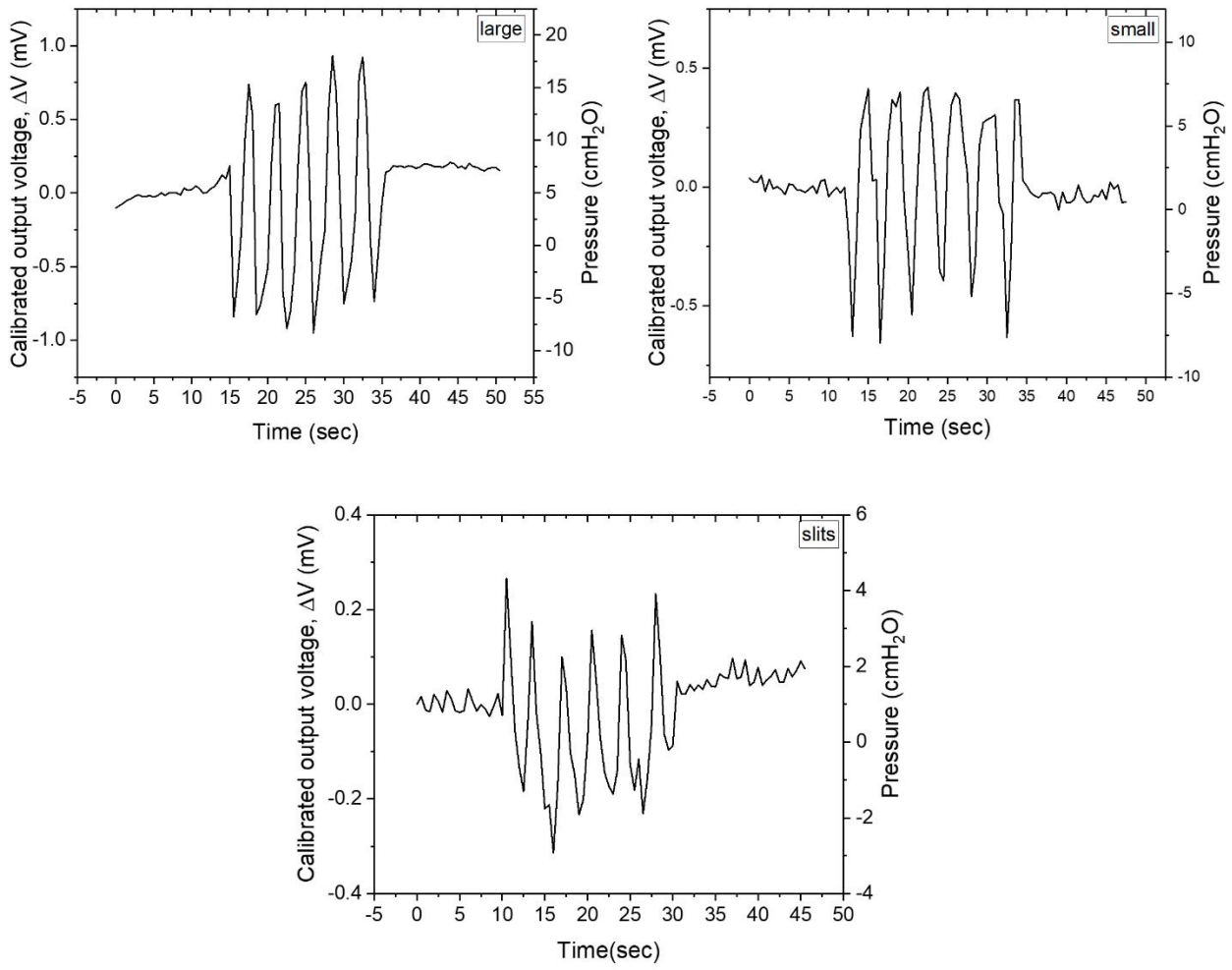
Experimental setup for the measurement of the respiration sensor. (Left) The PHR sensor requires a constant current supply of around 1 mA, provided by the sourcemeter. Its resulting output voltage was measured by a nanovoltmeter. (Right) A volunteer demonstrates the usage of the respiration sensor. The visual breathing profile was depicted on a monitor using a custom-made LabView software.

Supplementary Information 6



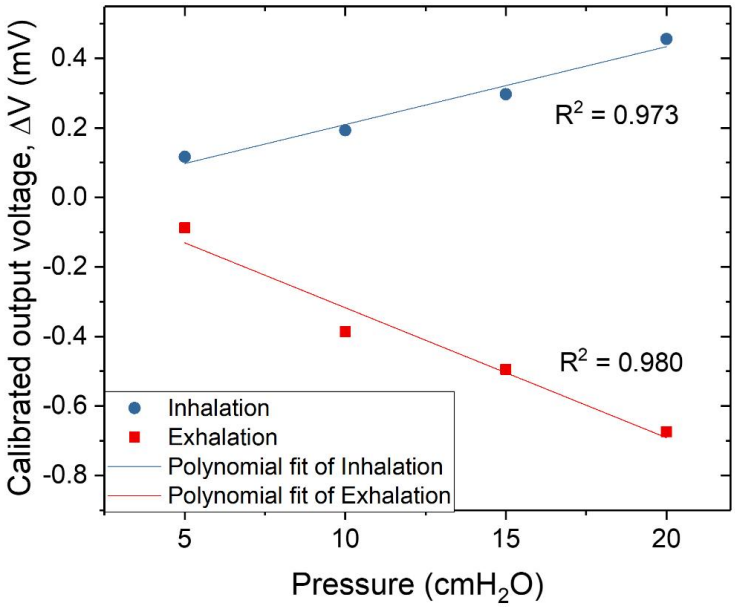
A metronome with frequency of 30 beats/min were used to time the breathing of a volunteer in a fixed, orderly manner. When the first beat sounds, the volunteer has to naturally start their inhalation and regulate the pace of their breathing so that when the next beat sounds, their exhalation matches perfectly to it. This fixed breathing cycle continues for one minute (30 metronome beats). Volunteer had to ensure that the breathing stays as natural and in tidal state (normal breathing, rather than deep breathing) as possible throughout the experiment.

Supplementary Information 7



The respiration sensor was modified to function as an IMT (inspiratory muscle training) device. Three air holes with distinctly different hole shapes and sizes were introduced and the calibrated output voltages and calculated air pressures were plotted. Only one volunteer performed this experiment in one session, using the same respiration sensor (same magnet and PHR sensor).

Supplementary Information 8



A linear regression curve was fitted against output voltage data measured for different PDMS membrane thicknesses. The resulting plots are shown in the figure. Both fits illustrate high values of R^2 and can be represented with the following equations;

Inhalation (positive pressure):

$\Delta V = -0.0144 + 0.02242P$

Exhalation (negative pressure):

$\Delta V = 0.05655 - 0.03738P$