

Electronic Supplementary Information

Highly Sensitive, Stable, Scalable Pressure Sensor based on a Facile Baking-Inspired Foaming Process for Human-Computer Interface

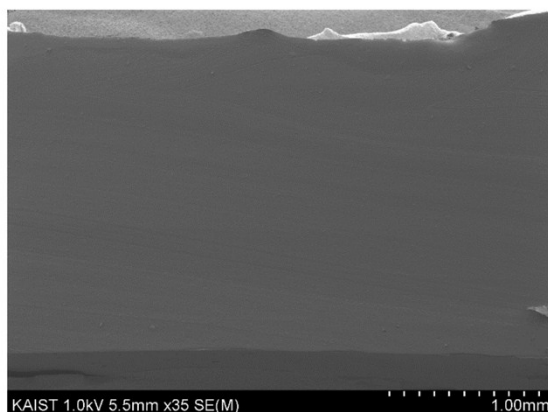
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(a)



(b)

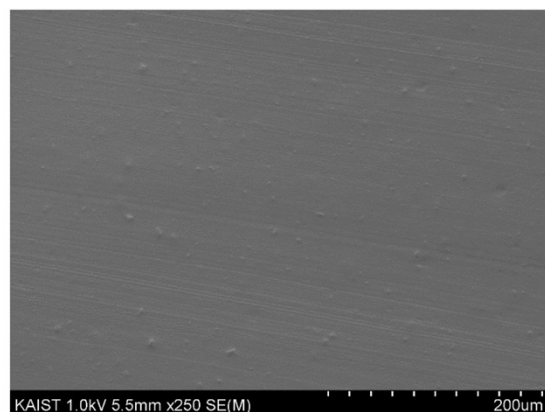


Fig. S1 Cross-section SEM (a) $\times 35$ and (b) $\times 250$ images of PDMS/Ecoflex dielectric layer fabricated without NaHCO_3 and CH_3COOH solutions. The pristine PDMS/Ecoflex dielectric layer was cured at $120\text{ }^\circ\text{C}$ immediately after undergoing the same mixing process as the situation when there were NaHCO_3 and CH_3COOH solutions.

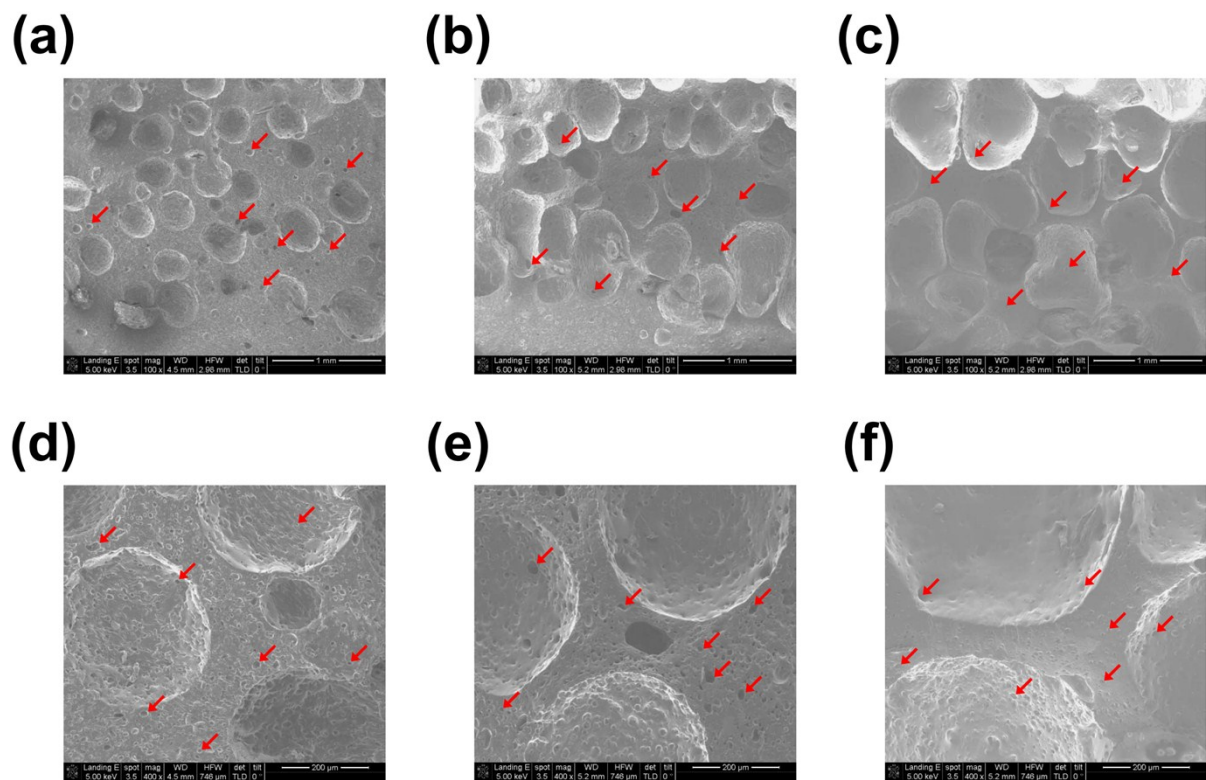


Fig. S2 Cross-sectional SEM images of the microporous PDMS/Ecoflex dielectric layers fabricated under T_c of (a, d) 80 °C, (b, e) 100 °C, and (c, f) 120 °C. Pores with sizes ranging from 4 to 84 μm are indicated by the red arrows.

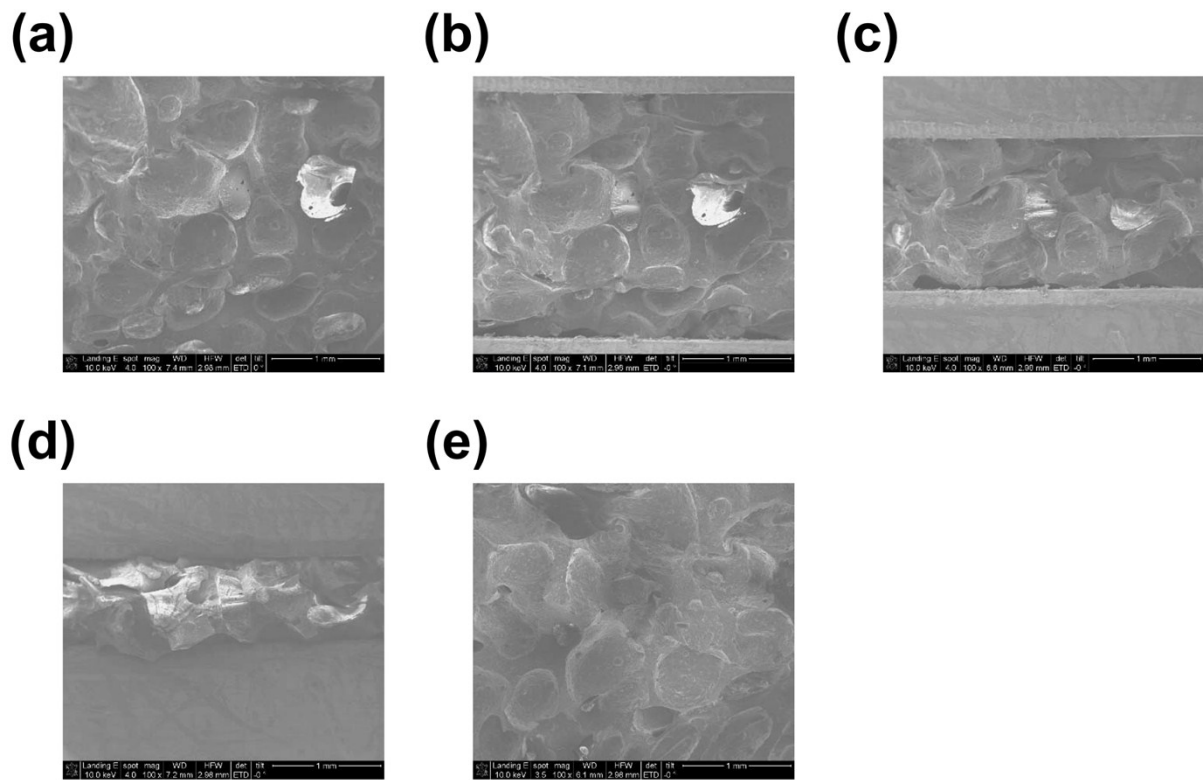


Fig. S3 Cross-sectional SEM images showing the reversibly compressible behavior of the microporous PDMS/Ecoflex dielectric layers fabricated under a T_c of 120 °C and a NC concentration of 38 wt%. The strain increases in order of (a) 0 %, (b) 25 %, (c) 55 %, and (d) 75 %, and then decreases to (e) 0 %.

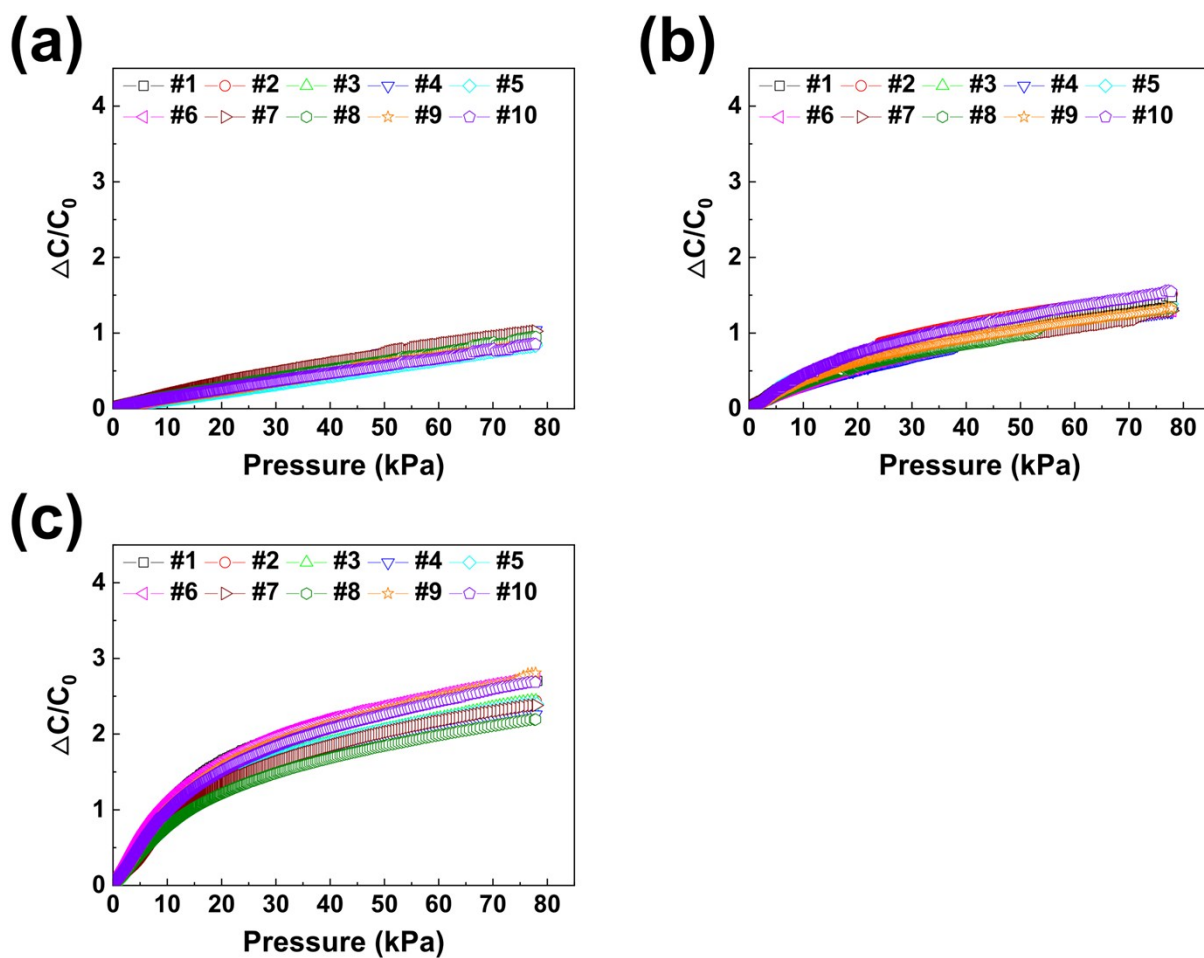


Fig. S4 Uniformity of the piezocapacitive pressure sensors based on 3D macroporous PDMS/Ecoflex elastomer fabricated using a NC concentration of 38 wt% under different T_c . Sensing abilities of 10 pressure sensors fabricated under T_c of (a) 80 °C, (b) 100 °C, and (c) 120 °C.

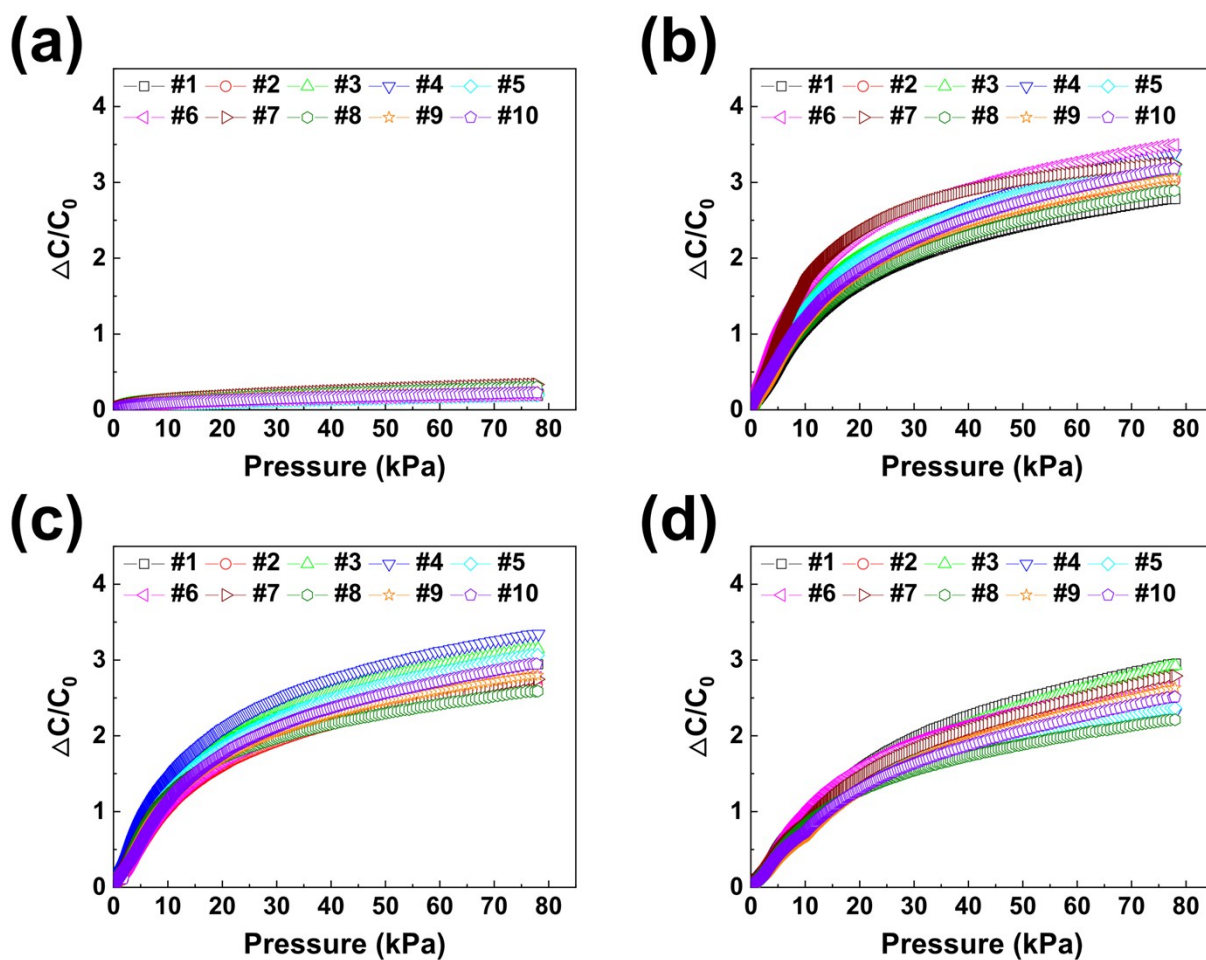


Fig. S5 Uniformity of the piezocapacitive pressure sensor based on the microporous PDMS/Ecoflex film fabricated under a T_c of 120 °C using different NC concentration. Sensing abilities of 10 pressure sensors fabricated using NC concentration of (a) 0, (b) 28, (c) 33, and (d) 38 wt%.

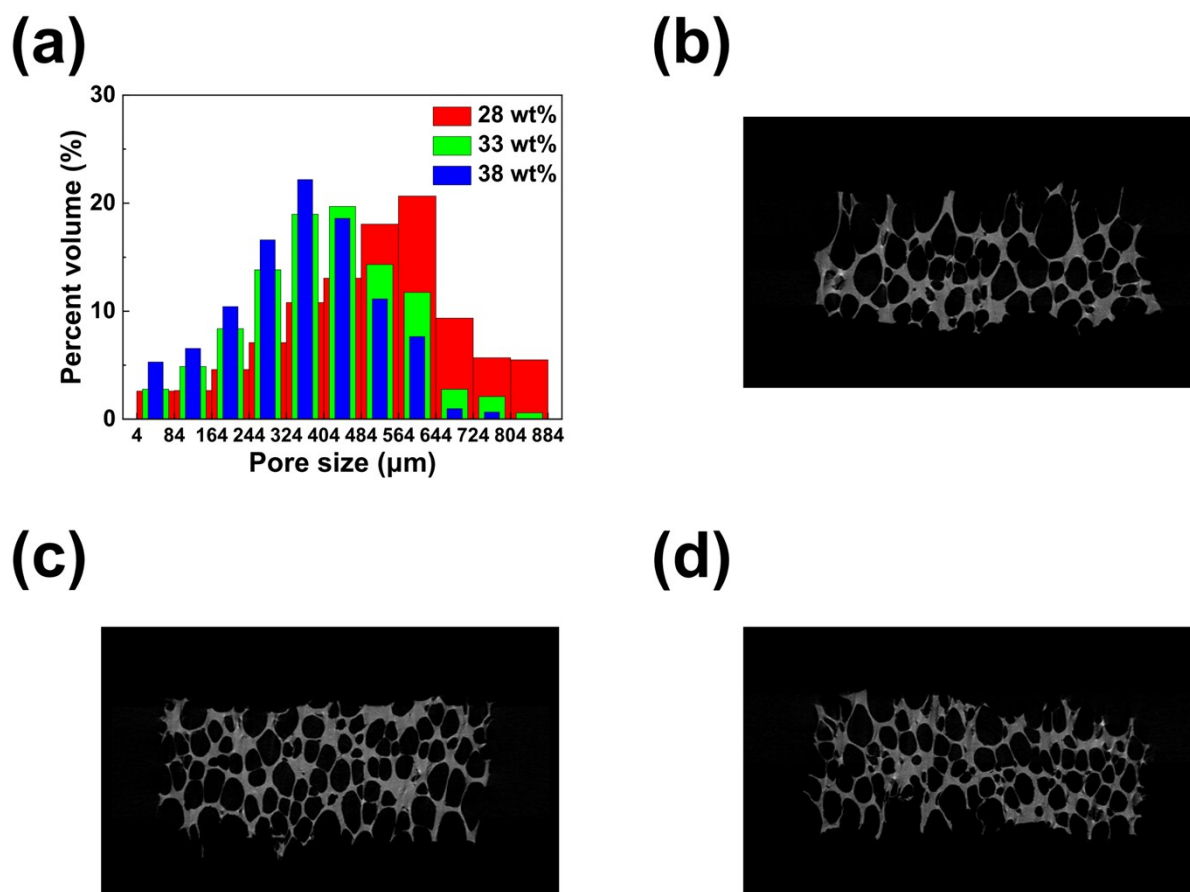


Fig. S6 Micro-CT analysis of the microporous PDMS/Ecoflex film. (a) Pore size distribution of the microporous PDMS/Ecoflex film as a function of the NC concentration used to prepare the film. Cross-sectional images of the films fabricated at NC concentrations of (b) 28, (c) 33, and (d) 38 wt%.

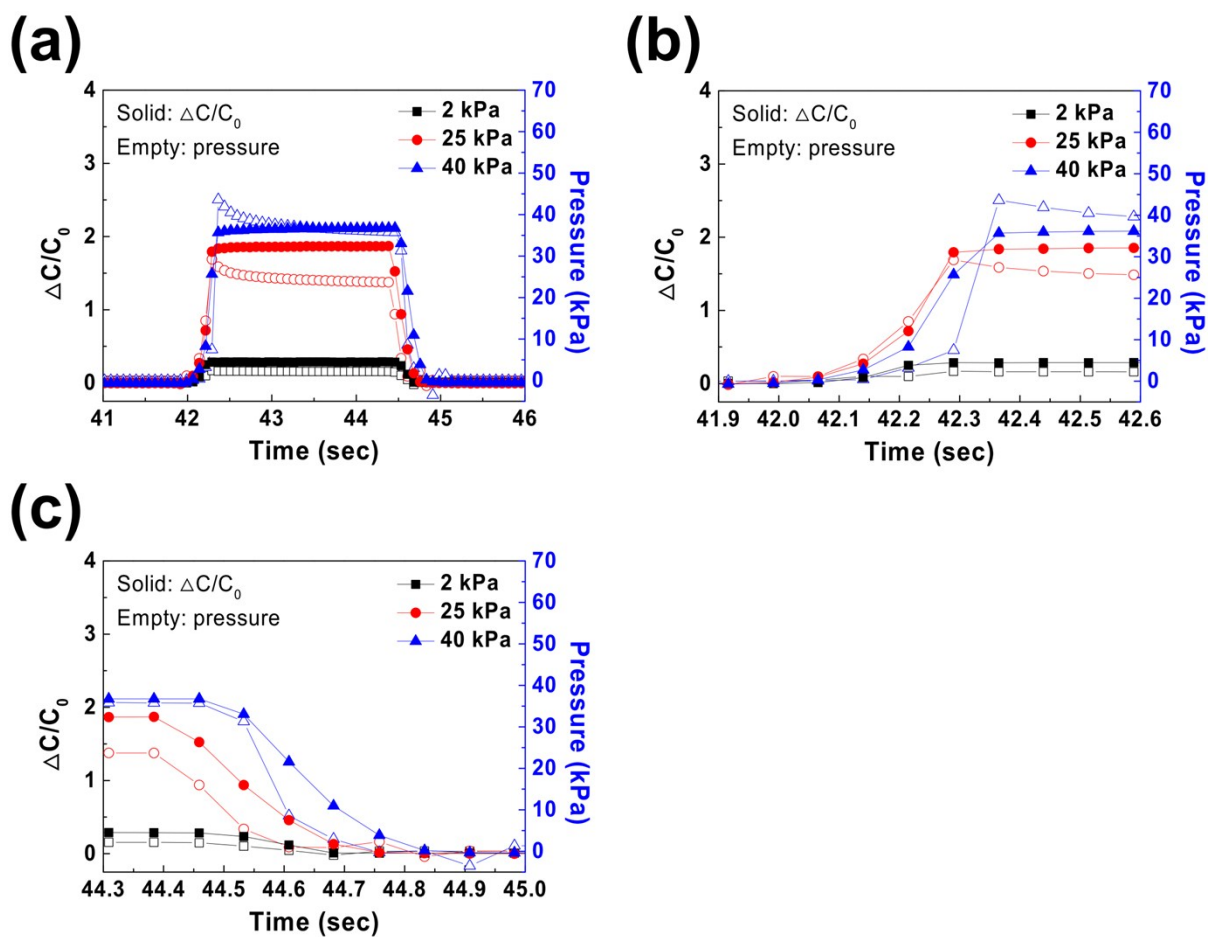


Fig. S7 Pressure-sensitive response at various pressures of 2, 25, and 40 kPa. (a) Relative capacitance change and pressure curves as a function of time. Magnified views of the (b) rising and (c) falling responses.

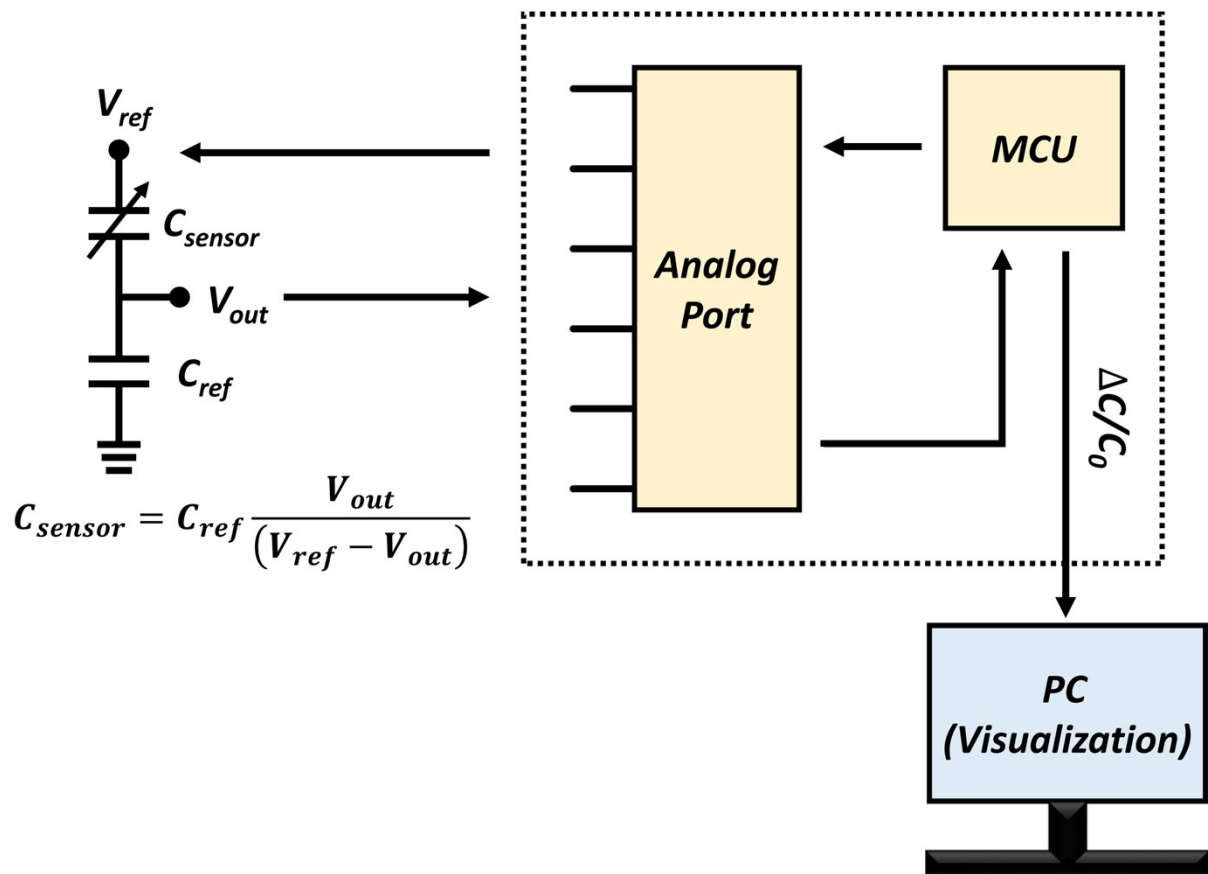
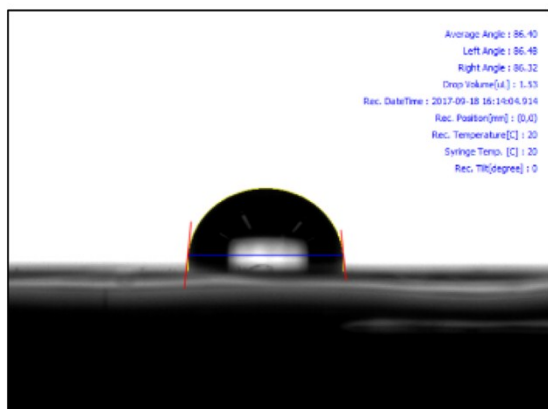
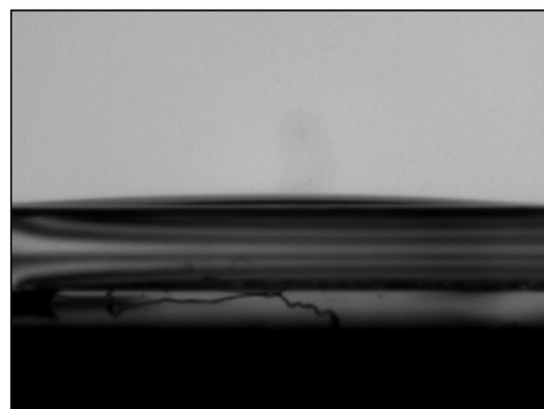


Fig. S8 Schematic illustration of the pressure sensor data acquisition and visualization of finger motion.

(a)



(b)



(c)

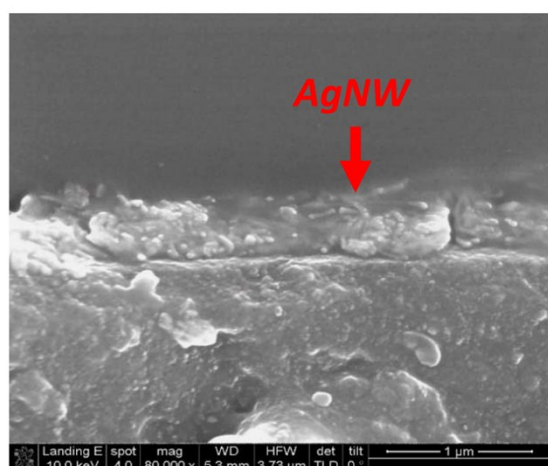


Fig. S9 Surface wettability of the PDMS sheet (a) before and (b) after ultraviolet–ozone (UVO) treatment. (c) Scanning electron microscopy (SEM) image of the silver nanowires (AgNWs) embedded in the PDMS sheet.

Active material	Mechanism	Limit of detection	Maximum sensitivity	Stability (cycle)	Process Time (hour)	References
Sugar-templated foam	Capacitive	0.16 Pa	0.601 kPa ⁻¹ in 5 kPa	1,000	> a few	1
PS-bead-templated foam	Capacitive	2.42 Pa	0.63 kPa ⁻¹ in 1 kPa	10,000	14.5	2
Sugar-templated foam	Capacitive	0.2 Pa	0.51 kPa ⁻¹ in 10 kPa	100	> a few	3
Phase separation foam	Resistive	250 Pa	0.025 kPa ⁻¹ in 100 kPa	—	> a few	4
Phase separation foam	Capacitive	—	1.18 kPa ⁻¹ in 0.02 kPa	—	24	5
Baking-inspired foam	Capacitive	9.8 Pa	0.21 kPa⁻¹ in 1 kPa	10,000	< 1	This work

Table S1 Relative performance of pressure sensors containing a porous dielectric layer.

Molecular weight of NaHCO ₃	84.007	g/mol
Molecular weight of CH ₃ COOH	60.05	g/mol
Density of NaHCO ₃	2.2	g/ml
Density of CH ₃ COOH	1.05	g/ml
Density of water	1	g/ml

Table S2 Molar masses and densities of NaHCO₃, CH₃COOH, and water.

Calculation for mole of NaHCO ₃	Added weight of water	25.016	g
	Volume of water	25.016	ml
	Added weight of NaHCO ₃	0.775	g
	Volume of NaHCO ₃	0.352	ml
	Molar concentration of NaHCO ₃	0.363	mol/L
	Added weight of NaHCO ₃ solution	2.453	g
	Volume of NaHCO ₃ solution	0.766	ml
	Mole of NaHCO ₃	0.278	mmol
Calculation for mole of CH ₃ COOH	Added weight of water	2.142	g
	Volume of water	2.142	ml
	Added weight of CH ₃ COOH	5.006	g
	Volume of CH ₃ COOH	4.767	ml
	Molar concentration of CH ₃ COOH	12.064	mol/L
	Added weight of CH ₃ COOH solution	0.047	g
	Volume of CH ₃ COOH solution	0.022	ml
	Mole of CH ₃ COOH	0.276	mmol

Table S3 Molar ratio calculation of NaHCO₃ and CH₃COOH for the solutions to which NaHCO₃ and CH₃COOH were added.

Movie S1 Movie showing a glass beaker being gripped by a hand wearing a glove equipped with five pressure sensors. The virtual hand on the laptop screen moves according to the output of the sensors. In the first case, the beaker is gripped with the thumb, index finger, and middle finger. In the second case, the thumb and ring finger are used. In the third case, all fingers are used. In the final cases, the beaker is gripped with the thumb and middle finger.

References

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