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# Micro/nanofiber-coupled Superhydrophobic and Conductive Textile for Wearable Strain Sensors Underwater with Full-scale Human Motion Detection Ability

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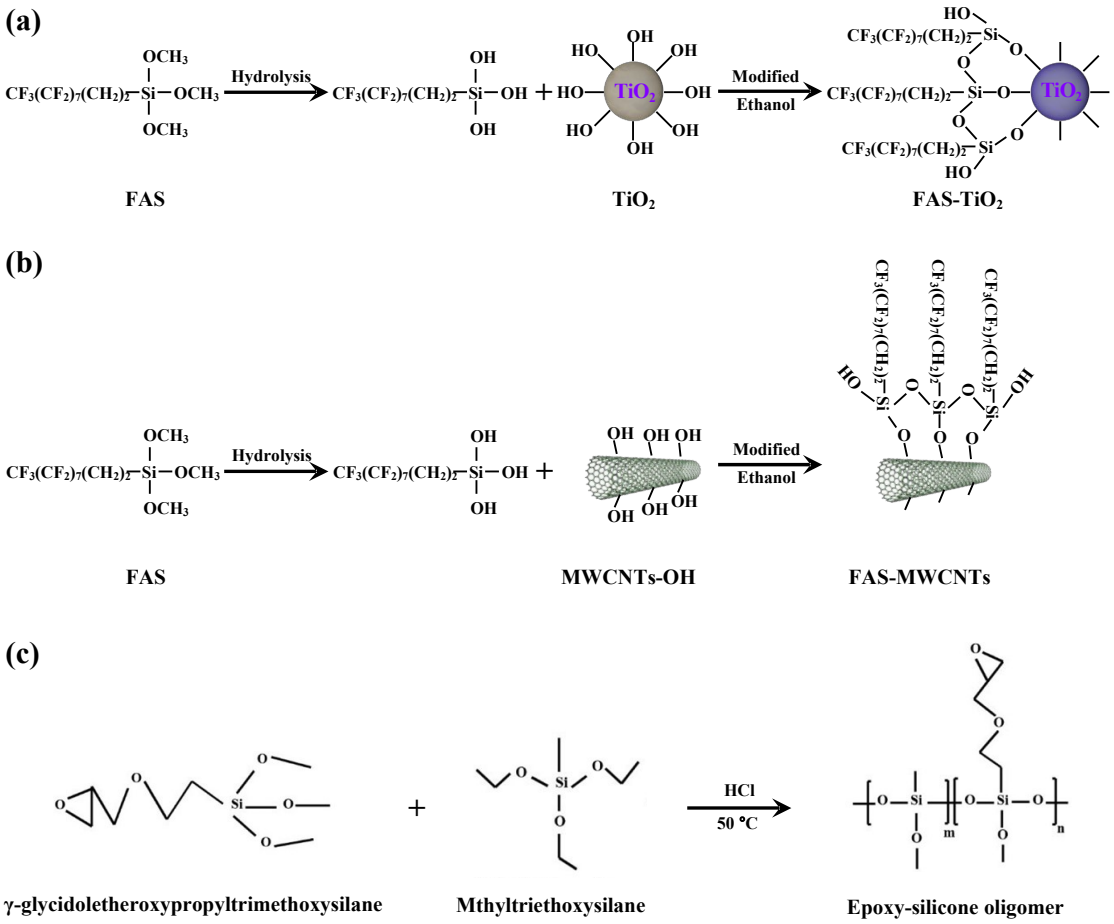


**Figure S1.** (a) 1H,1H,2H,2H-Perfluorodecyltrimethoxysilane (FAS)-grafted $TiO_2$ to obtain

hydrophobic $TiO_2$ (FAS-$TiO_2$). (b) FAS-grafted MWCNT-OH to obtain hydrophobic MWCNT (FAS-MWCNT). (c) Methyltriethoxysilane and γ-glycidoxypropyltrimethoxysilane react to obtain epoxy-silicone oligomer under the action of an acid catalyst.

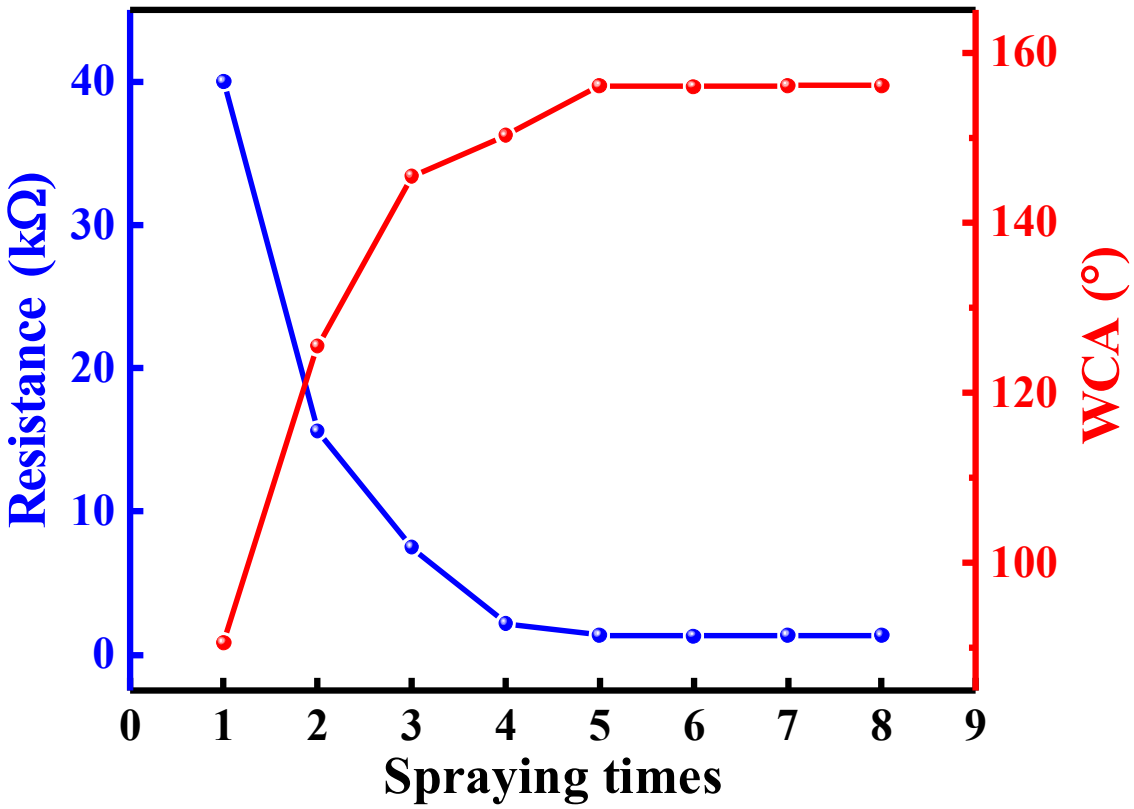


**Figure S2.** Resistance and WCA of the SNWTC as a function of spraying times.

The resistance of the SNWTC declined dramatically from 40 kΩ to 1.35 kΩ, spary-coated from 1 to 5 times, then, the resistance tended to be stable at approximately 1.35 kΩ (Figure S2, Supporting Information). Meanwhile, the WCA improved to 156.1°, realizing the superhydrophobicity of the surface. These results proved that composite had been completely coated on the surface of the nylon fibers by spraying 5 times.

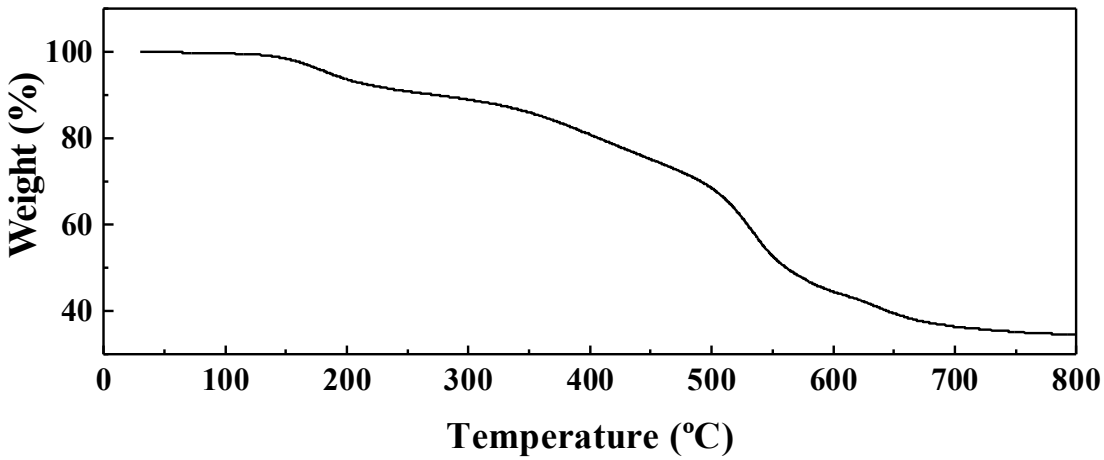


**Figure S3.** TGA curve of the superhydrophobic and conductive nano coating.

Since the physical and chemical properties of substances change at different temperatures,[1, 2] TGA measurements of the nano coating were carried out (Figure S3). The sample was heated from 25 to 800 °C at a linear heating rate of 20 °C /min by Simultaneous Thermal Analyzer (NETZSCH STA 449 F3, Germany) with the atmosphere of air. As shown in Figure S3, the weight-loss (30%) was at 100–500 °C, arising from the decomposition of epoxy-silicone oligomer and PDMS.[3, 4] Another noticeable sharp weight-loss (36.5%) appeared 500–700 °C, which was attributed to the gradual decomposition of FAS-MWCNTs.[5, 6] Finally, the thermal decomposition products and the thermally stable FAS-$TiO_2$ were left.[7] The result of TGA could simply evaluate the content of each component. The content of the epoxy-silicone oligomer and PDMS was nearly 30 wt%, FAS-MWCNTs was 36.5 wt%. In addition， the result showed that the nano-coating was very stable at room temperature, it began to decompose at 150 °C. It can be safely used as the sensing material of wearable strain sensor.

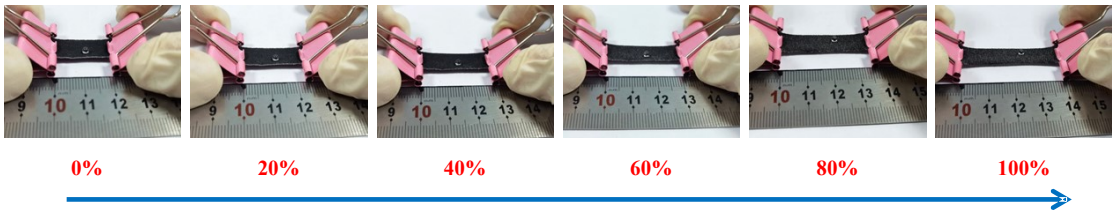


**Figure S4.** Photograph of water droplets under different strain.

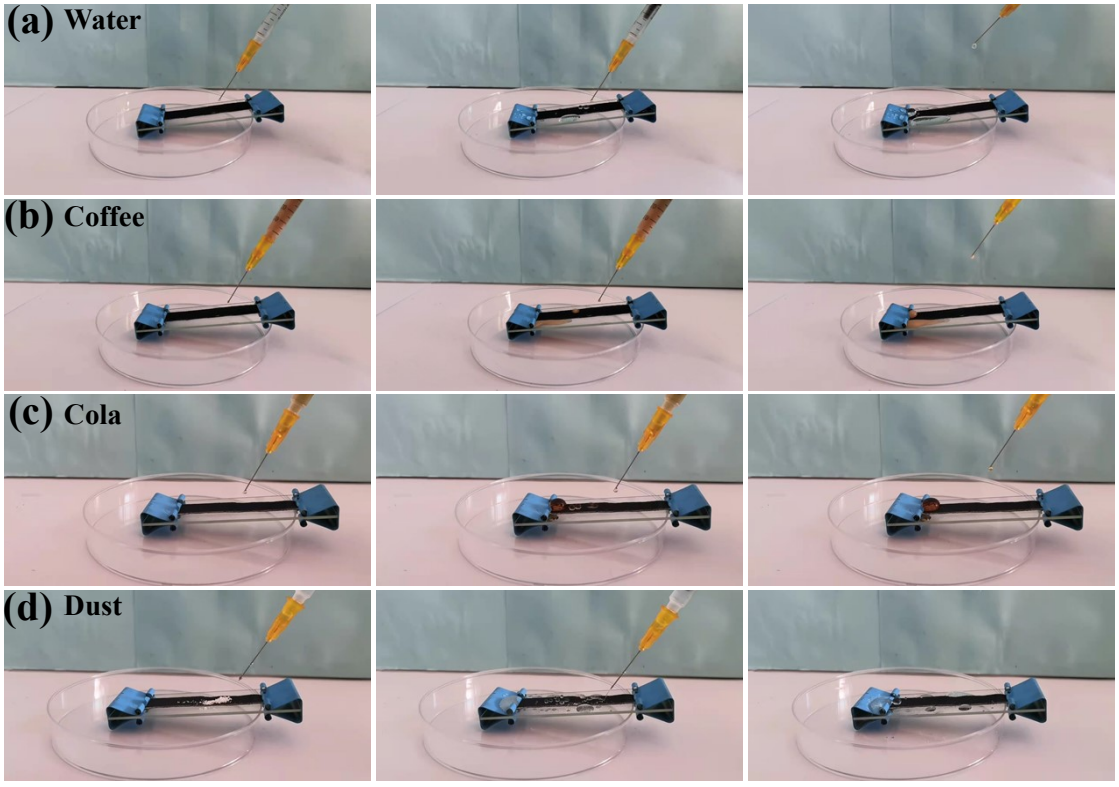


**Figure S5.** Self-cleaning process of the SNCWC surface with a small inclination angle (<10°): (a) Water, (b) Coffee, (c) Cola, and (d) Dust.

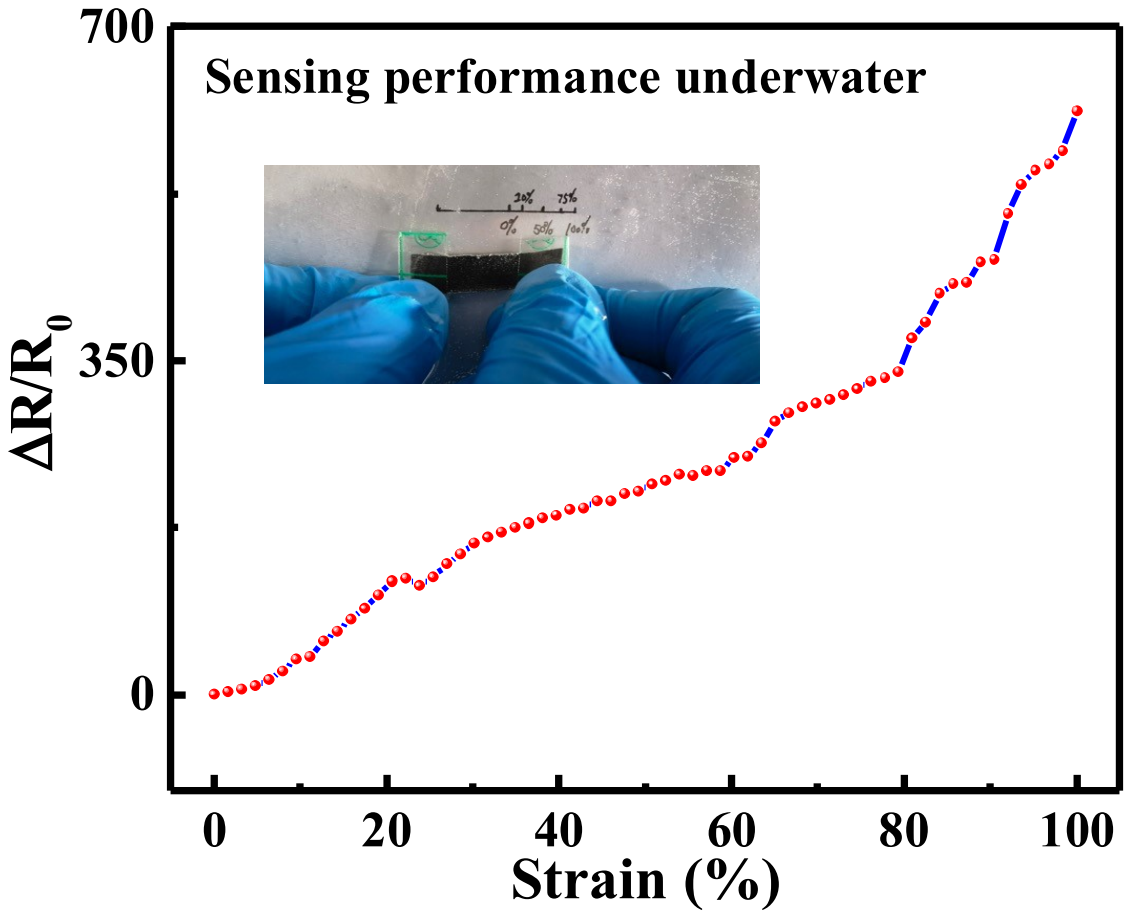


**Figure S6.** Relative resistance changes of the sensor as a function of strain underwater.

**Table. 1.** Comparative analysis of the GF values and maximum working ranges of the superhydrophobic sensor reported in previous publications.

| Reference | Materials of sensor | Sensing range | Gauge factor |
|---|---|---|---|
| 2 | TPU/Graphene | 100% | 21 |
| 17 | PU/Graphene/$SiO_2$ | 100% | 5.9 |
| 18 | TPU/ACNTs/AgNPs/PDMS | 70% | $1.04 \times 10^5$ |
| 51 | Carbon black/PDMS | 100% | 67.2 |
| 52 | MXene based composite | 700% | 2.9 |
| 53 | Natural rubber (NR)/NR-CNTs/NR | 500% | 2280 |
| 39 | Polypropylene textile/MXene/PDMS | 50% | 18 |
| 54 | PDMS/CNTs | 100% | 3.1 |
| 55 | TPU/CNTs/PDMS | 100% | 0.339 |
| 56 | TPE/CNTs | 76% | 1 |
| 57 | PDMS/CNTs | 200% | 22.64 |
| 58 | PU/rGO/PDA/PFDT | 590% | 221 |
| This work | Nylon textile/MWCNTs/$TiO_2$/PDMS | 100% | 949.5 |

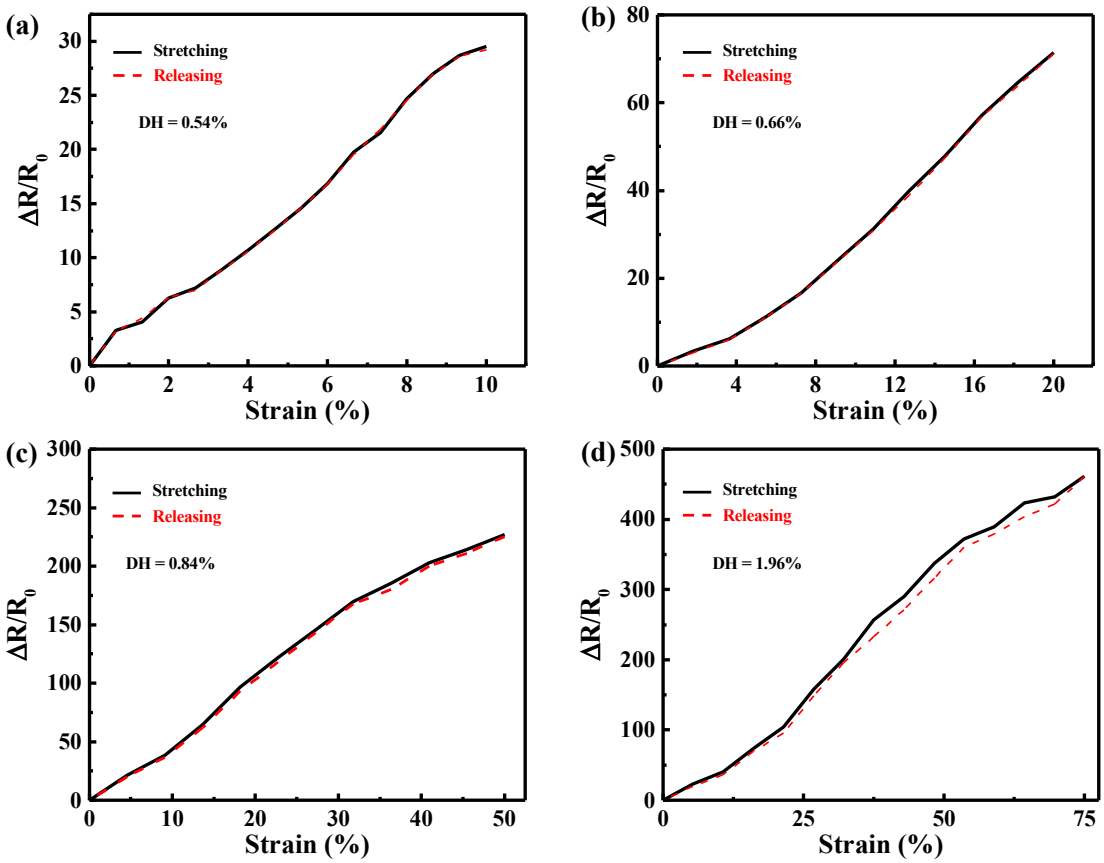


**Figure S7.** The hysteresis performance of the SNWTC strain sensors for different strain stretching/releasing: (a) 10%, (b) 20%, (c) 50%, and (d) 75%.

## Supplementary Videos

**Movie S1:** Direct antifouling test of the SNWTC surface.

**Movie S2:** Indirect antifouling test of the SNWTC surface.

## Reference

[1] L. Liu, M. Zhu, Z. Ma, X. Xu, J. Dai, Y. Yu, S. M. Seraji, H. Wang, P. Song, *Chem. Eng. J.* **2022**, 440, 135645.

[2] L. Liu, Z. Ma, M. Zhu, L. Liu, J. Dai, Y. Shi, J. Gao, T. Dinh, T. Nguyen L. C. Tang, P. Song, J. Mater. Sci. Technol. **2023**, 132, 59.

[3] I. Bustero, I. Gaztelumendi, I. Obieta, M. A. Mendizabal, A. Zurutuza, A. Ortega, B. Alonso, *Adv. Compos. Hybrid Mater.* **2020**, 3, 31.

[4] M. Zhu, L. Liu, Z. Wang, *Compos. Part B-Eng.* **2020**, 199, 108283.

[5] S. Gao, H. Li, H. Guan, L. Zheng, X. Lai, W. Chen, X. Zeng, *Cellulose* **2022**, 29, 605.

[6] L. Xu, G. Xiao, C. Chen, R. Li, Y. Mai, G. Sun, D. Yan, *J. Mater. Chem. A* **2015**, 3, 7498.

[7] C. Lin, B. Liu, L. Pu, Y. Sun, Y. Xue, M. Chang, X. Li, X. Lu, R. Chen, J. Zhang, *Adv. Compos. Hybrid Mater.* **2021**, 4, 339.