Supporting Information for

Strain Effect on the Field-Effect Sensing Property of Si Wires

Yuan Lin, [†] *Bingchang Zhang,* [*, ‡] *Yihao Shi,* [†] *Yongchao Zheng,* [§] *Jia Yu,* [†] *Jiansheng Jie,* [*, †] *and Xiaohong Zhang* [*, †, ǁ]

[†]Institute of Functional Nano & Soft Materials (FUNSOM), Jiangsu Key Laboratory of Advanced Negative Carbon Technologies, Soochow University, Suzhou, 215123, Jiangsu, People's Republic of China.

[‡]School of Optoelectronic Science and Engineering, Key Lab of Advanced Optical Manufacturing Technologies of Jiangsu Province, Key Lab of Modern Optical Technologies of Education Ministry of China, Soochow University, Suzhou, 215123, Jiangsu, People's Republic of China.

[§]State Key Laboratory of NBC Protection for Civilian, Research Institute of Chemical Defense, Beijing 102205, People's Republic of China.

[ǁ]Jiangsu Key Laboratory of Advanced Negative Carbon Technologies, Soochow University, Suzhou, 215123, Jiangsu, P.R. China.

Email: xiaohong_zhang@suda.edu.cn; zhangbingchang@suda.edu.cn; jsjie@suda.edu.cn

Supporting Discussion

Discussion S1. Derivation of the relationship between the relative change in electrical current ($\Delta I/I_0$) and the relative change in electron concentration ($\Delta n/n_0$) under a given strain.

According to Ohm's law, the electrical current can be expressed as

$$I = \frac{\sigma A U}{l} \tag{1}$$

where *I* is the current, *σ* is the material conductivity, *A* is the cross-sectional area of the silicon wire (SiW), *l* is the effective length of the SiW, and *U* is the applied fixed bias. Due to the large piezoresistive effect of Si, the impact of the shape effect under a strain on *I* is negligible compared with the impact of conductivity change. Thus, the relative change in electrical current ($\Delta I/I_0$) under a strain can be expressed as

$$\frac{\Delta I}{I_0} = \frac{\Delta\sigma}{\sigma_0} \tag{2}$$

where I_0 is the electrical current without applying strain. The conductivity of a material depends on the carrier mobility and carrier concentration.

$$\sigma = ne\mu \tag{3}$$

where e is the elementary charge and μ is the carrier mobility. The SiWs used in this work are n-type, and the majority carriers are electrons. Thus, n is the electron concentration. The carrier mobility μ is mainly affected by the applied strain. Based on Equations 2 and 3, $\Delta I/I_0$ under a strain can be further expressed as:

$$\frac{\Delta I}{I_0} = \frac{\Delta n}{n_0} \qquad (4)$$

where n_0 is the initial electron concentration and $\Delta n/n_0$ is the relative change in electron concentration.

Discussion S2. The effect of q_0 change under strain on humidity sensitivity is negligible.

The volume (V) and lateral area (S_1) of the SiWs can be calculated with Equations 12 and 13, respectively:

$$V = \pi r_0^2 l \tag{5}$$

$$S_1 = 2\pi r_0 l \tag{6}$$

where r_0 and l are the radius and effective length of the SiW, respectively.

When strain was applied on the SiW, the effective length of the SiW (l) and the radius of SiW were changed to l' and r_0', which can be calculated with Equations 14 and 15, respectively:

$$l' = l(1 + \varepsilon) \tag{7}$$

$$r_0' = \sqrt{\frac{V}{\pi l'}} = \frac{r_0}{\sqrt{1 + \varepsilon}} \tag{8}$$

Then, the lateral area (S_1) of the SiW was changed to S_1':

$$S_1' = 2\pi r_0' l' = 2\pi r_0 l\sqrt{1 + \varepsilon} = S_1\sqrt{1 + \varepsilon} \tag{9}$$

Furthermore, the saturated adsorption amount of water molecules (q_0) was changed to q_0':

$$q_0' = q_0\sqrt{1 + \varepsilon} \tag{10}$$

In the experiments, under 0.3% tensile strain, the change ratio of q_0 is 0.15%, while the change in humidity sensitivity is over 20%. In other words, the impact of q_0 on humidity sensitivity under strain is less than 1% of the total strain effect. Thus, the effect of q_0 change under strain on humidity sensitivity is negligible.

Supporting Figures

Figure S1. Schematic diagram of the experimental setups for silicon wire-based field-effect sensor (SiW-FET sensor) humidity detection.

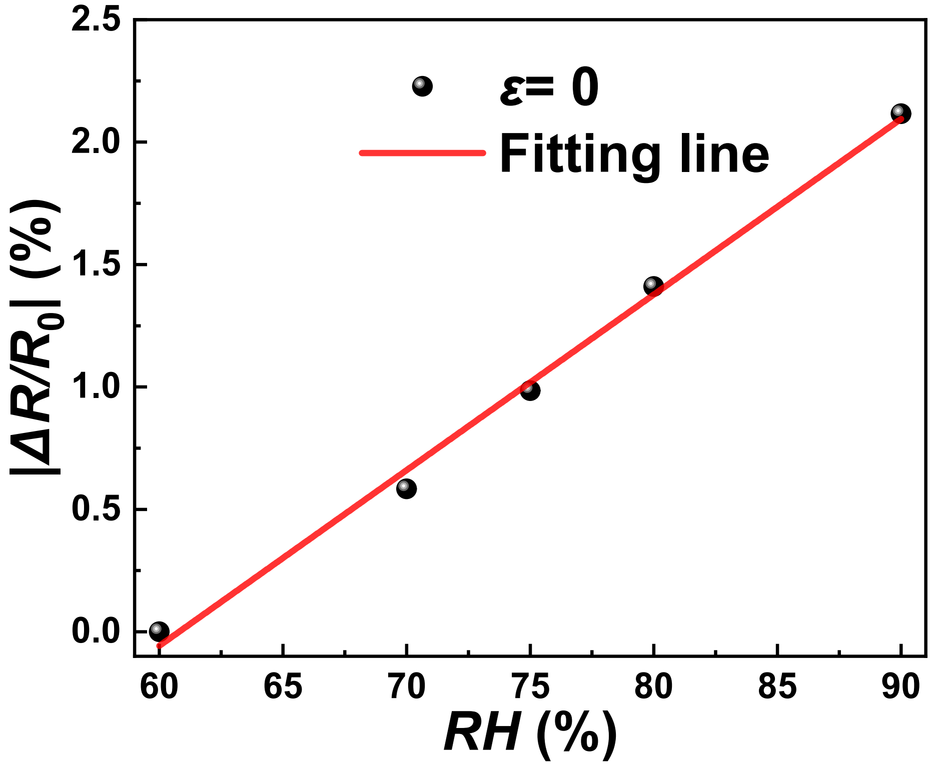

Figure S2. The plots of the relative change in electrical resistance ($\Delta R/R_0$) of the device versus the relative humidity under 0 strain.