Highly sensitive, durable and stretchable plastic strain sensors using sandwich structures of PEDOT:PSS and elastomer

Xi Fan,[a] Naixiang Wang,[a] Jinzhao Wang,[b] Bingang Xu,[c] Feng Yan*[a]

[a] Department of Applied Physics, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

[b] Department of Material Science and Engineering, Hubei University, Wuhan 430062, China

[c] Nanotechnology Center, Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong, China

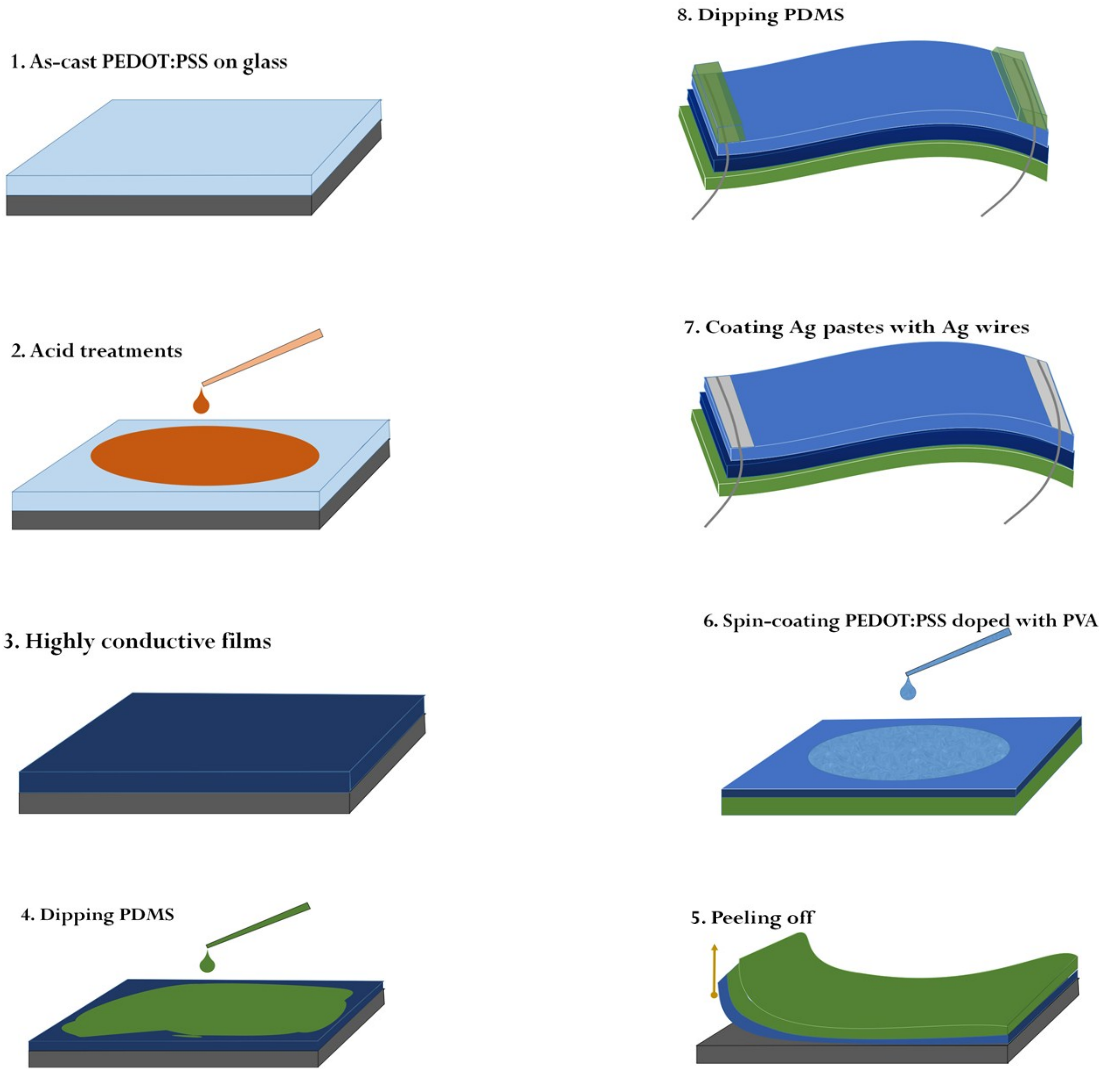

Figure S1 Integration processes of strain sensors with the sandwiched stretchable conductors.

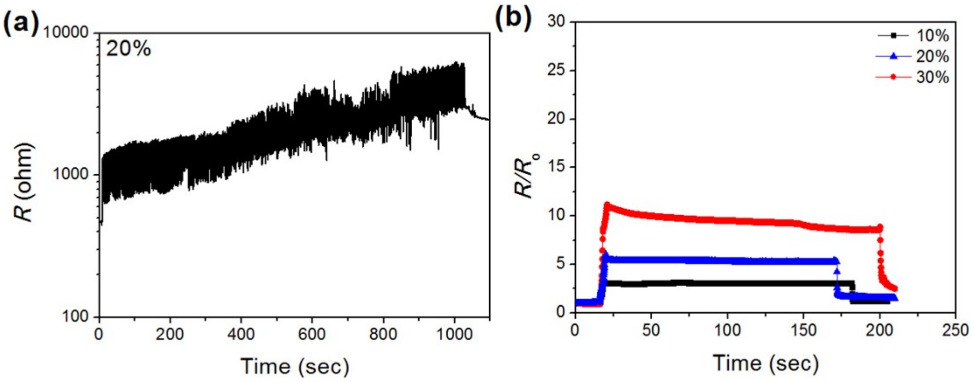

Figure S2 (a) Resistance changes of the reference films with the simple structure of PEDOT:PSS/PDMS in a 400-cycle stretching-relaxing test at 20% strain. (b) Long-time (over 120 sec) loading test of reference films at the strains of 10%-30%.

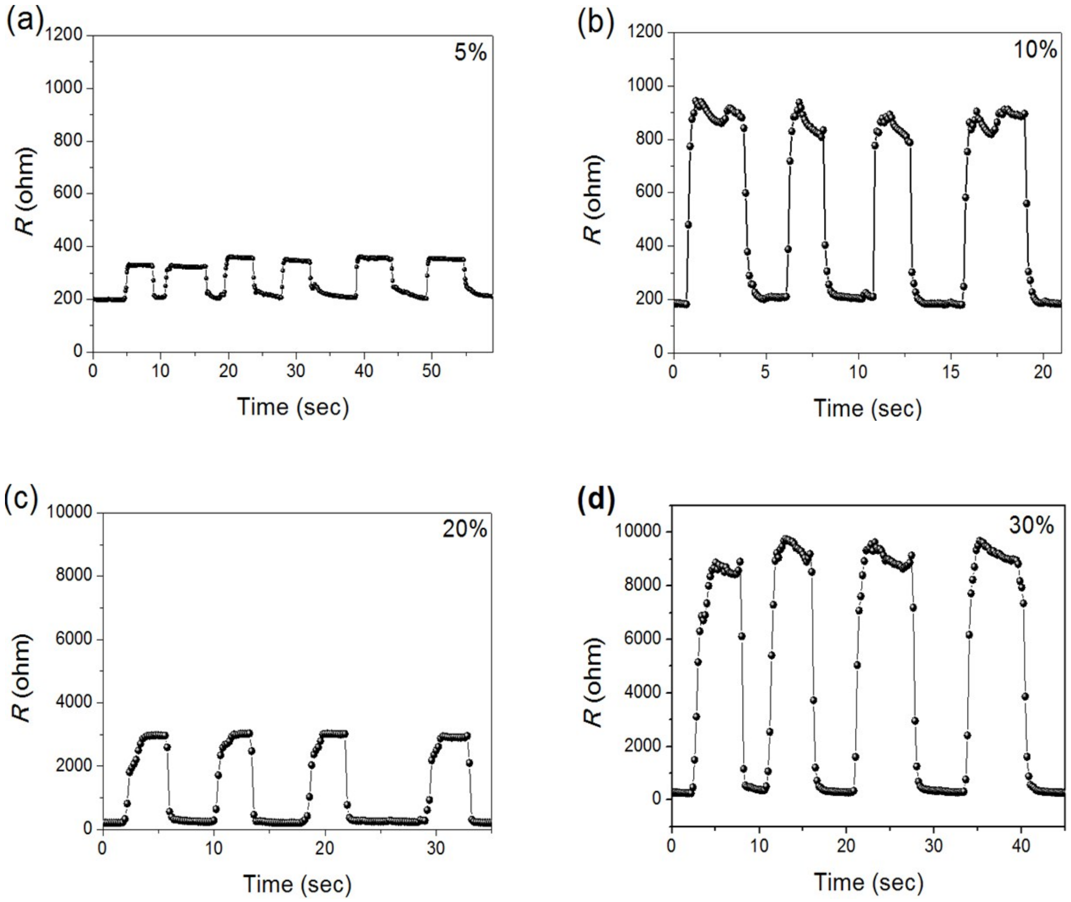

Figure S3 Changes of resistance in the stretching-relaxing tests at 5% (a), 10% (b), 20% (c) and 30% (d) strain, respectively.

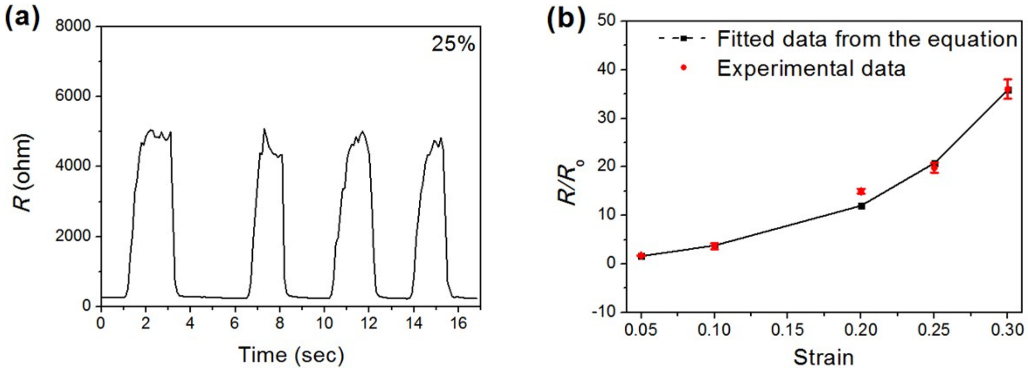

Figure S4 (a) Response of resistance of the sandwiched films in the stretching-relaxing tests at 25% strain. (b) Relative variation in R/R_o of the sandwiched films versus strain calculated from the following model and the experimental data, respectively.

The increased resistance (ΔR) is mainly determined by a tunneling mechanism, which demonstrates that ΔR increases exponentially with the values of $(L - L_o)$.[1,2] Here, The L is the length of the films under strain states, and L_o is the initial length of the films. The ΔR is induced by the geometric distortion and the cracks of the films, which can be defined as as $\Delta R = r[e^{(\alpha(L-Lo))}-1]$, increasing exponentially with the increase of $L-L_o$. Here, r is the constant factor that shows the proportionality between ΔR and the exponential factor (α). The total resistance of the strain sensor is shown by

$$R = R_o + \Delta R = R_o + r(e^{\alpha(L-L_o)} - 1),$$

$$\frac{R}{R_o} = 1 + \beta(e^{\alpha(L-L_o)} - 1), \beta = \frac{r}{R_o}.$$

Here, on the basis of the typical experimental data of Figure S3b (ε=10%) and S3d (ε=30%), we obtained that

$$\alpha = 536,$$
$$\beta = 1.46.$$

Therefore, $\frac{R}{R_o} = 1 + 1.46(e^{536(L-L_o)} - 1).$ (1)

The fitted curves (R/R_o *versus* strain) from the equation can match well with our experiment data, as shown in **Figure S** 4b.

Reference

1 T. Yamada, Y. Hayamizu, Y. Yamamoto, Y. Yomogida, A. IzadiNajafabadi, D. N. Futaba, K. Hata, Nat. Nanotechnol. 2011, 6 (5), 296.

2 C. Z. Luo, J. J. Jia, Y. N. Gong, Z. C.Wang, Q. Fu, C. X. Pan, ACS Appl. Mater. Interfaces 2017, 9, 19955.