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Supporting Information

Nano-Toughening of Transparent Wearable Sensors with High Sensitivity and Wide Linear Sensing Range

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1. **Resistance changes as a function of applied strain for strain sensors with different conductive nanofillers**

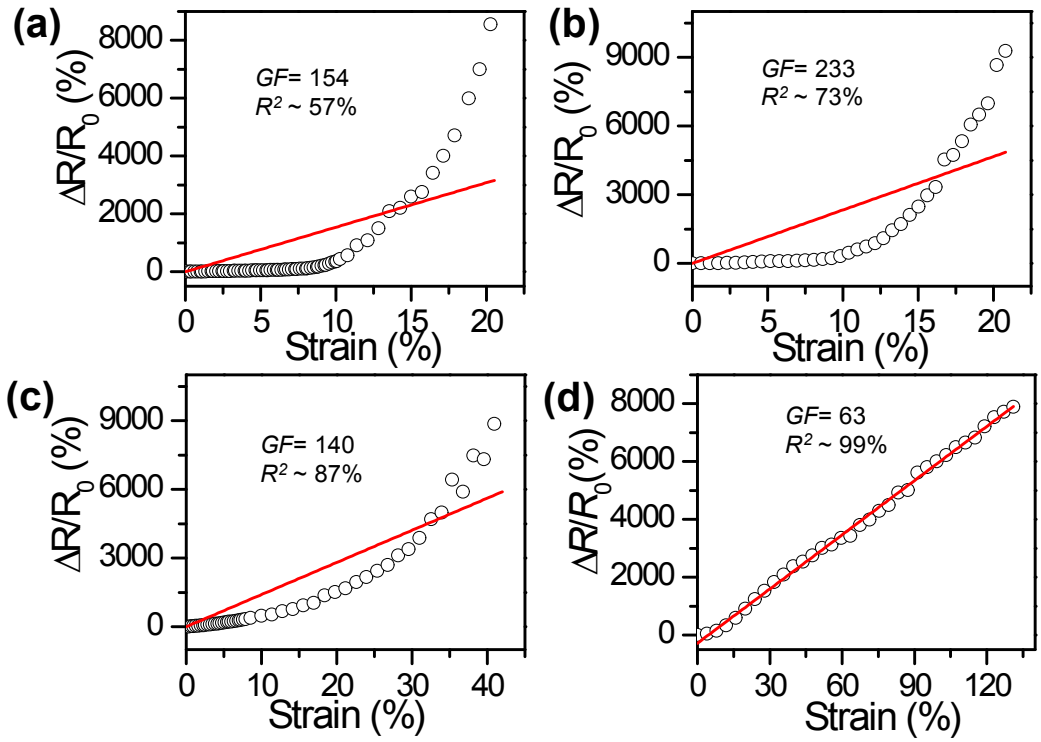

Fig. S1 Resistance changes as a function of applied strain for strain sensors with different conductive nanofillers: (a) pure PEDOT; (b) PEDOT/AgNWs; (c) PEDOT/GNPs; (d) PEDOT/CNFs. The linear fitting (solid lines) was carried out for all the data points within the range of failure strain.

2. **Image analysis of cracking pattern**

A multi-step image processing was performed in view of extracting the cracked area from the optical images, as shown in Fig. S2. Firstly, the colour image was converted into a greyscale image, where the intensity of the image was adjusted to improve the contrast between the cracks and the background, as shown in Fig. S2(a). Second, the crack-like structures were enhanced using multi-scale Hessian filtering techniques developed for angiographic images processing [1,2], as shown in Fig. S2(b). The resulting image was then converted into a binary image, as shown in Fig. S2(c), where blobs having an aspect ratio lower than 5 were excluded, i.e. only the elongated, crack-like structures were retained. The crack information, such as the crack length, width, and crack number (N) can be extracted. The N is the average number of cracks at each line in the direction vertical to the crack orientation. The crack density (D) is defined as the average gaps between two cracks in the direction vertical to the crack propagation path. In order

to estimate how the cracks pattern affect the electrical properties, the voltage distribution though the thin film samples was simulated directly from the images obtained in Fig. S2(c), by applying a potential difference between the left and right sides of the images, following the method proposed in [3].

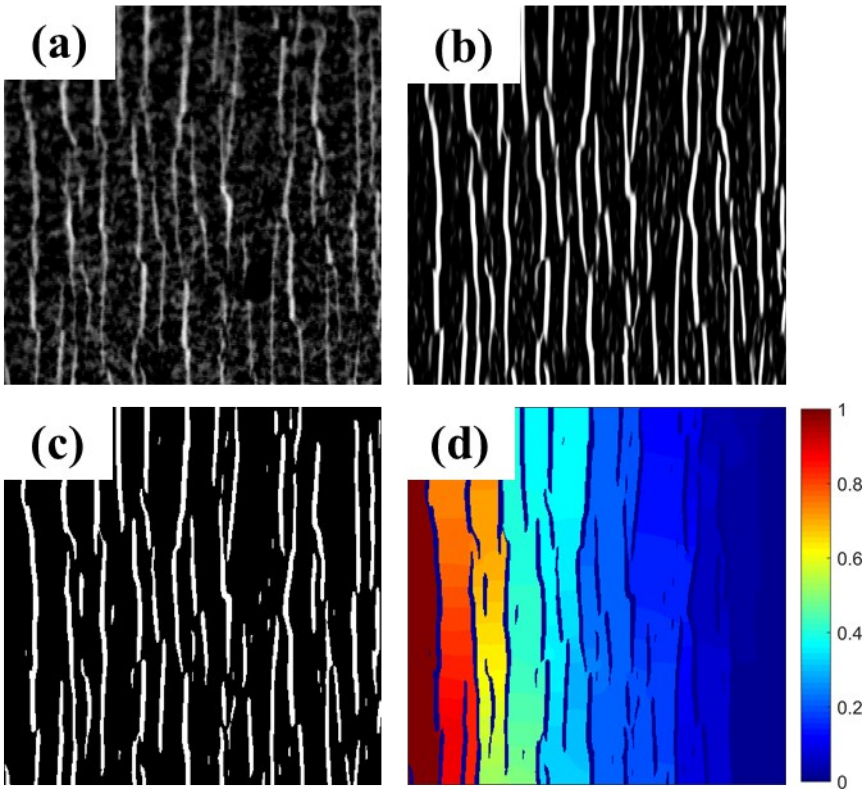

Fig. S2 Image processing steps applied onto a 400-by-400 pixel area of an image obtained under 20% strain for the PEDOT/CNF_1 sample: (a) greyscale conversion and scale adjustment; (b) crack-like structure enhancement using multi-scale Hessian filtering based on literatures [1,2]; (c) binary image conversion and aspect ratio filtering; (d) Voltage distribution simulations based on reference [3].

3. Videos for the strain sensors with propagating cracks under in-situ optical microscope.

Strain sensors with PEDOT/CNF1 (Video S1), PEDOT/CNF2 (Video S2), and PEDOT/CNF3 (Video S3) with loading and unloading of a maximum strain of 50%.

References

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[3] W. Cao, P. Görrn, S. Wagner, Modeling the electrical resistance of gold film conductors on uniaxially stretched elastomeric substrates, Appl. Phys. Lett. 98 (2011) 2009–2012. doi:10.1063/1.3594240.