Electronic Supplementary Material (ESI) for Nanoscale Horizons.

Electronic Supplementary Information

A Location- and Sharpness-Specific Tactile Electronic Skin Based on Staircase-like Nanowire Patches

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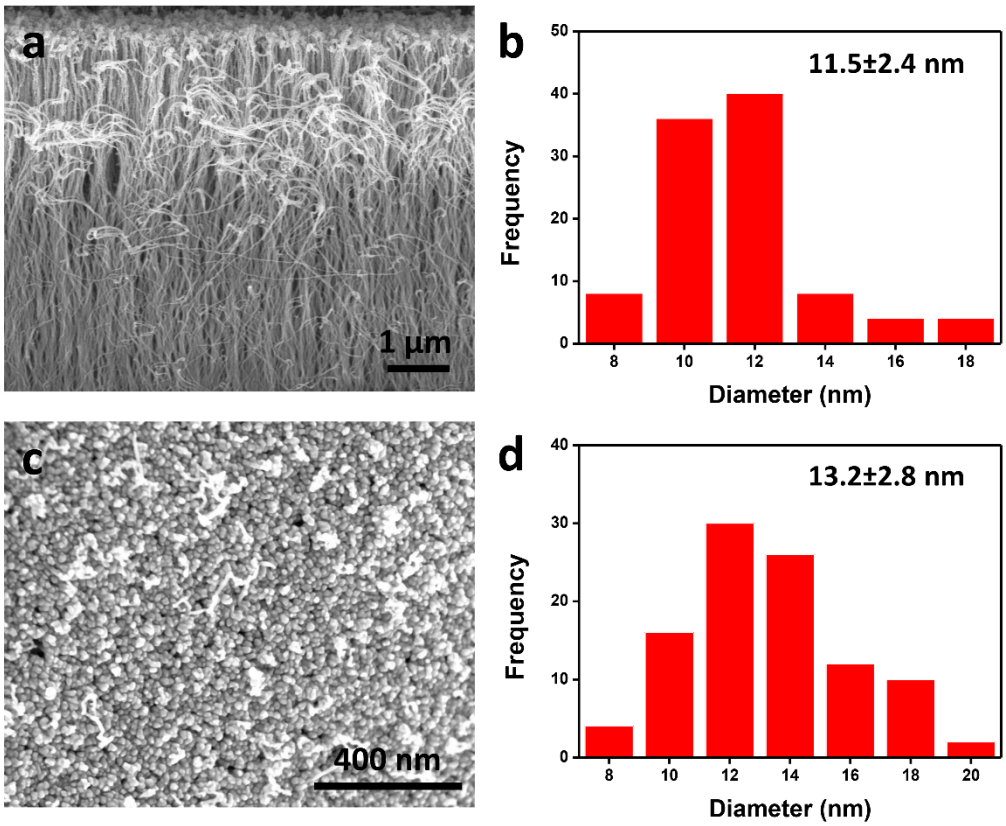

Fig. S1. (a) Cross-sectional Scanning electron microscopy (SEM) image of the enokitake-like standing gold nanowires (V-AuNWs). (b) Histogram of V-AuNWs diameter distribution (10 minutes growth time). (c) Top view SEM image of V-AuNWs. The nanoparticles are closely-packed. (d) Histogram of gold nanoparticle diameter distribution (10 minutes growth time).

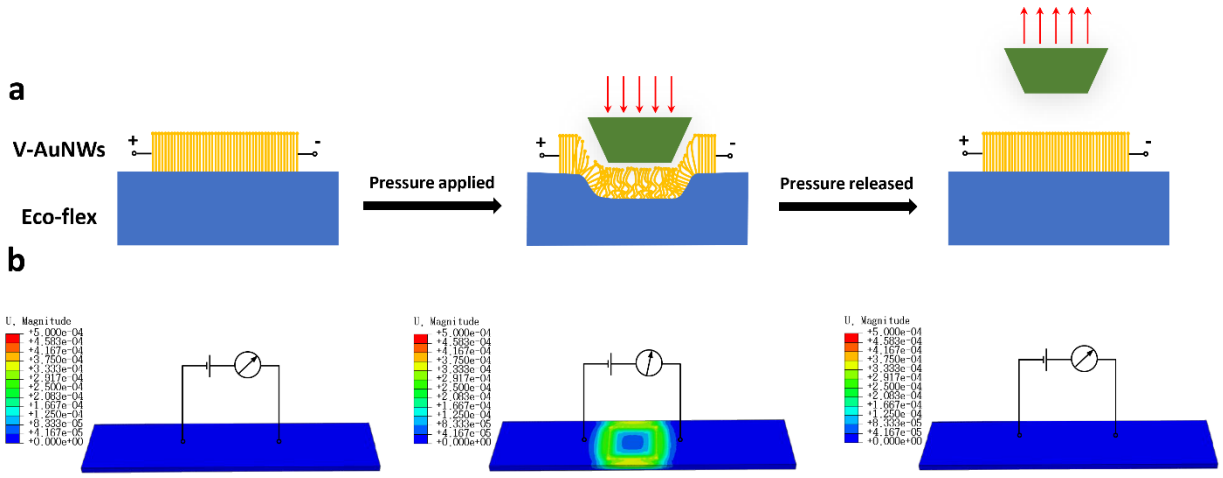

Fig. S2. (a) Schematic illustration of the possible structural changes of V-AuNWs film before (left), during (middle), and after (right) a pressure is applied. When a pressure is applied, cracks will be formed at edges of pressure area, leading to electrical resistance increase of the film. (b) The finite element analysis (FEA) results of the strain distribution of a 25×5×0.5mm^3 V-AuNWs/eco-flex film before (left), during (middle), and after (right) a pressure of 10 kPa is applied with an area of 4×4 mm^2 square. The current between two ends will decrease under a constant voltage when the pressure is applied, indicating resistance increase of the film.

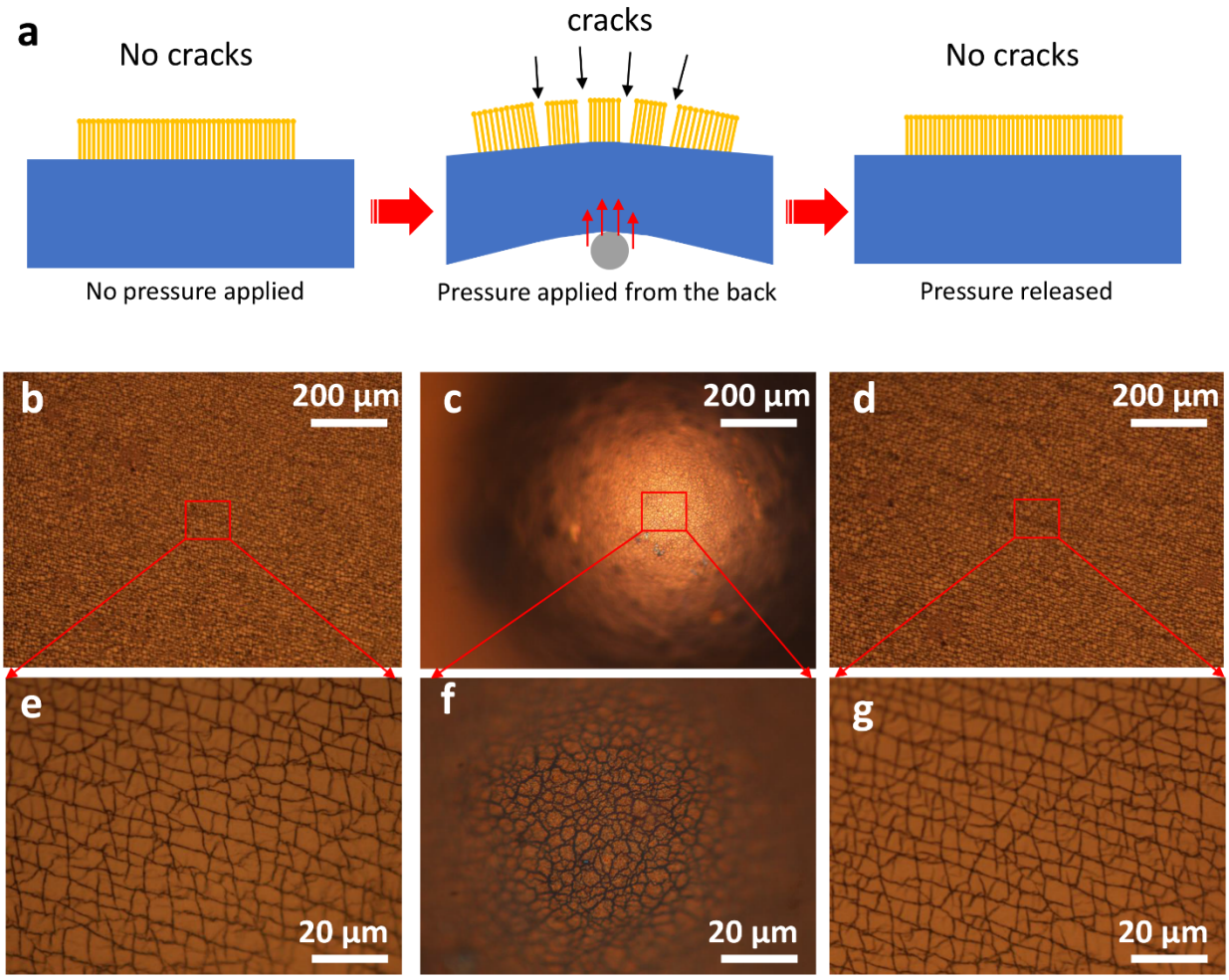

Fig. S3. (a) Schematic illustration of the possible structural changes of V-AuNWs film before (left), during (middle), and after (right) a pressure is applied from the back of the film. (b)-(d) Optical images of a V-AuNWs film before (b), during (c), and after (right) a pressure is applied from the back. (e)-(g) are enlarged view of (b)-(d), respectively.

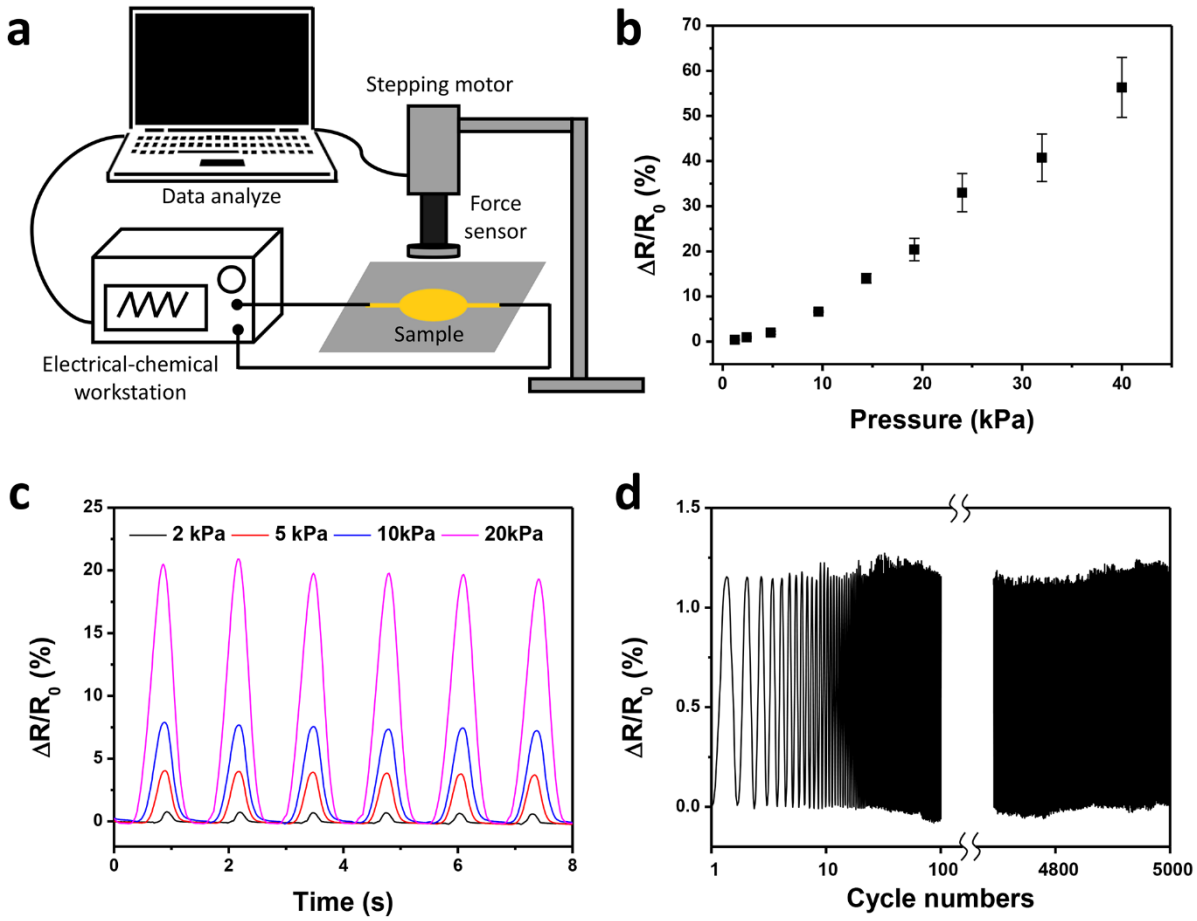

Fig. S4. (a) The schematic of set-up of the pressure test. (b) The resistance changes of a V-AuNWs sample (3 minutes growth time) as a function of static pressure of 0-40 kPa. (c) The resistance changes of a V-AuNWs sample (3 minutes growth time) as a function of dynamic pressure of 2 kPa, 5 kPa, 10 kPa and 20 kPa. (d) The durability test for a V-AuNWs sample (3 minutes growth time) at a dynamic pressure of 2 kPa for 5,000 cycles.

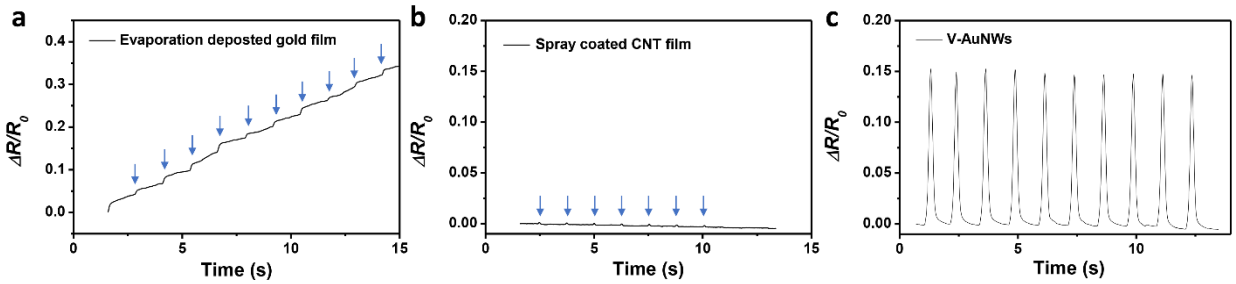

Fig. S5 (a)-(c) The repeating point load-induced resistance changes of an evaporated gold film (a), a spray coated CNT film (b), and a V-AuNWs film (c). The applied point load is 0.1 N.

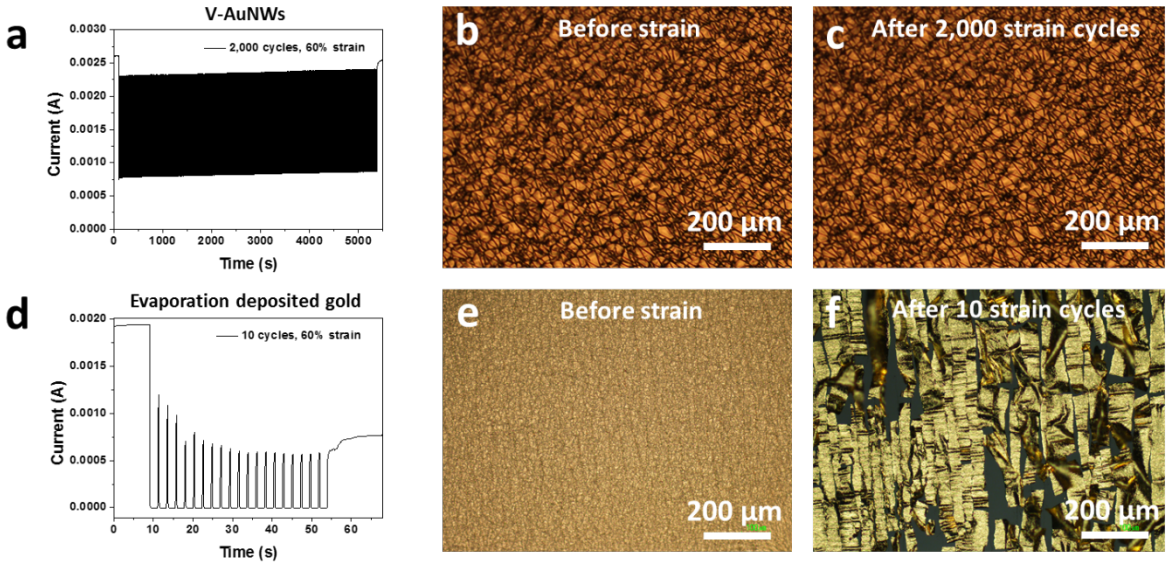

Fig. S6 (a) The current changes of a V-AuNWs film under constant voltage of 0.1V during 2,000 repeated stretch-release cycles at 60% strain. (b)-(c) Optical images of the V-AuNWs film before (a) and after (b) the 2000-cycling test. (d) The current changes of an evaporated gold film under constant voltage of 0.1V during 10 repeated stretch-release cycles at 60% strain. (e)-(f) Optical images of the gold film before (e) and after (f) the 10-cycling test.

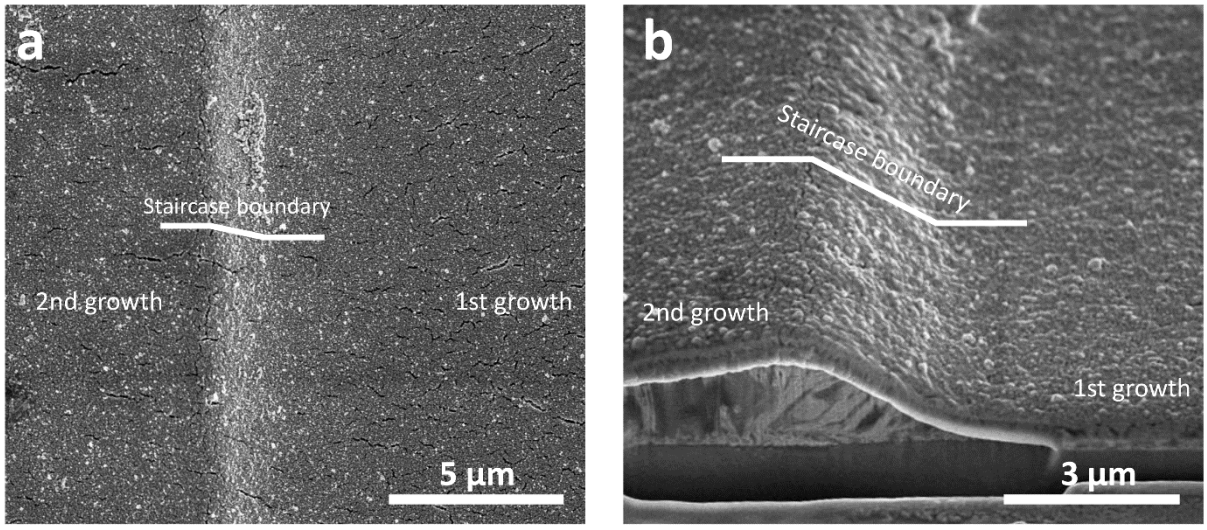

Fig. S7. SEM images of the step boundaries of V-AuNWs film. (a) The top view step boundary; (b) The cross-sectional view of the same area after FIB-milling.

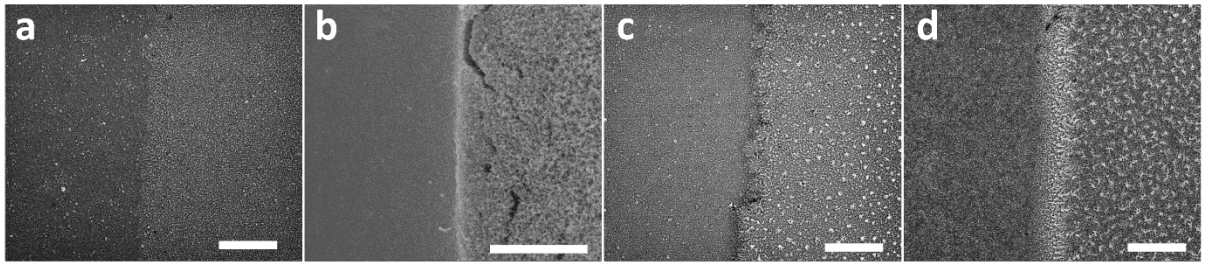

Fig. S8. SEM images of the step boundaries of V-AuNWs film. Step boundaries with nanowires growing time between 1 minute to 2 minutes (a), 2 minutes to 3 minutes (b) 3 minutes to 4 minutes (c) and 4 minutes to 5 minutes (d). Scale bar: 5 μm.

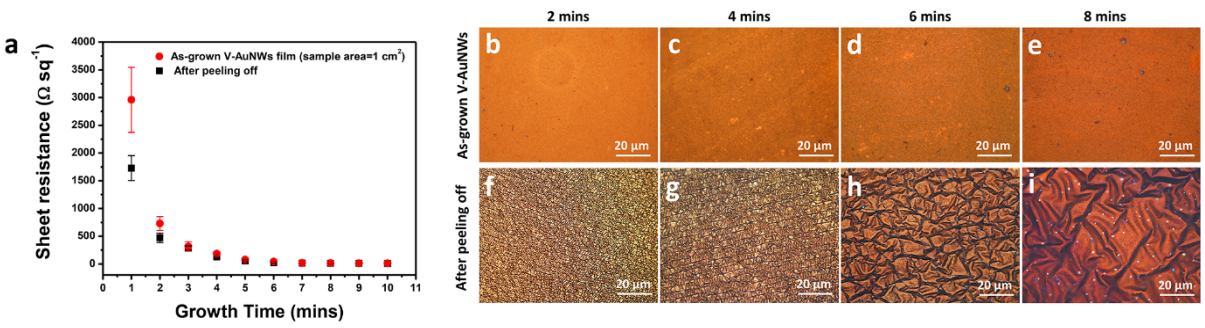

Fig. S9. (a) The sheet resistance of as-grown V-AuNWs film on Ecoflex (red) and V-AuNWs film after peeling off (black) as a function of nanowires growth time. (b)-(e) The optical images of the as-grown V-AuNWs film with nanowires growth time at 2 minutes (b), 4 minutes (c), 6 minutes (d), and 8 minutes (e). (f)-(i) The optical images of the V-AuNWs film after peeling off with nanowires growth time at 2 minutes (f), 4 minutes (g), 6 minutes (h), and 8 minutes (i).

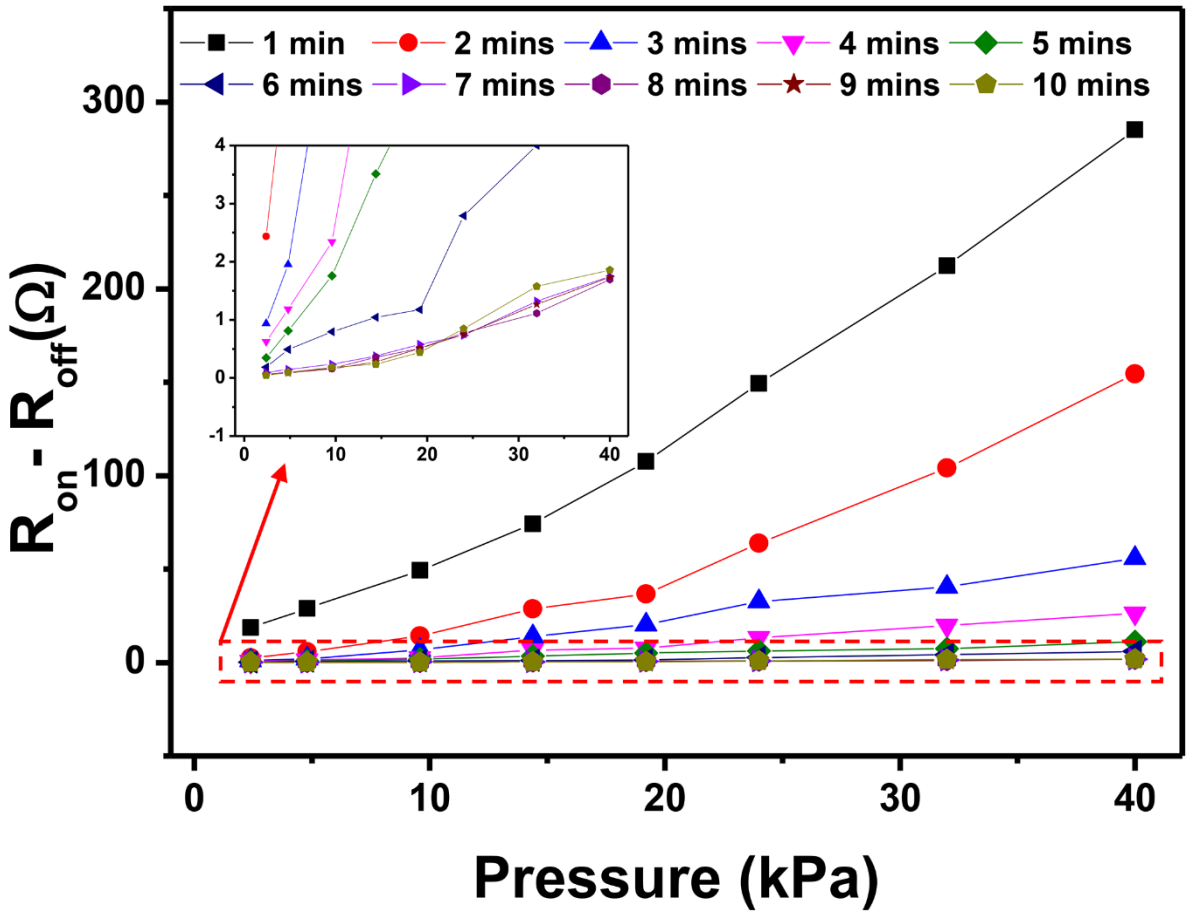

Fig. S10. The resistance changes of V-AuNWs films as a function of growth time with pressure ranging from 4 to 40 kPa. Inset is the enlarged figure of the dashed box.

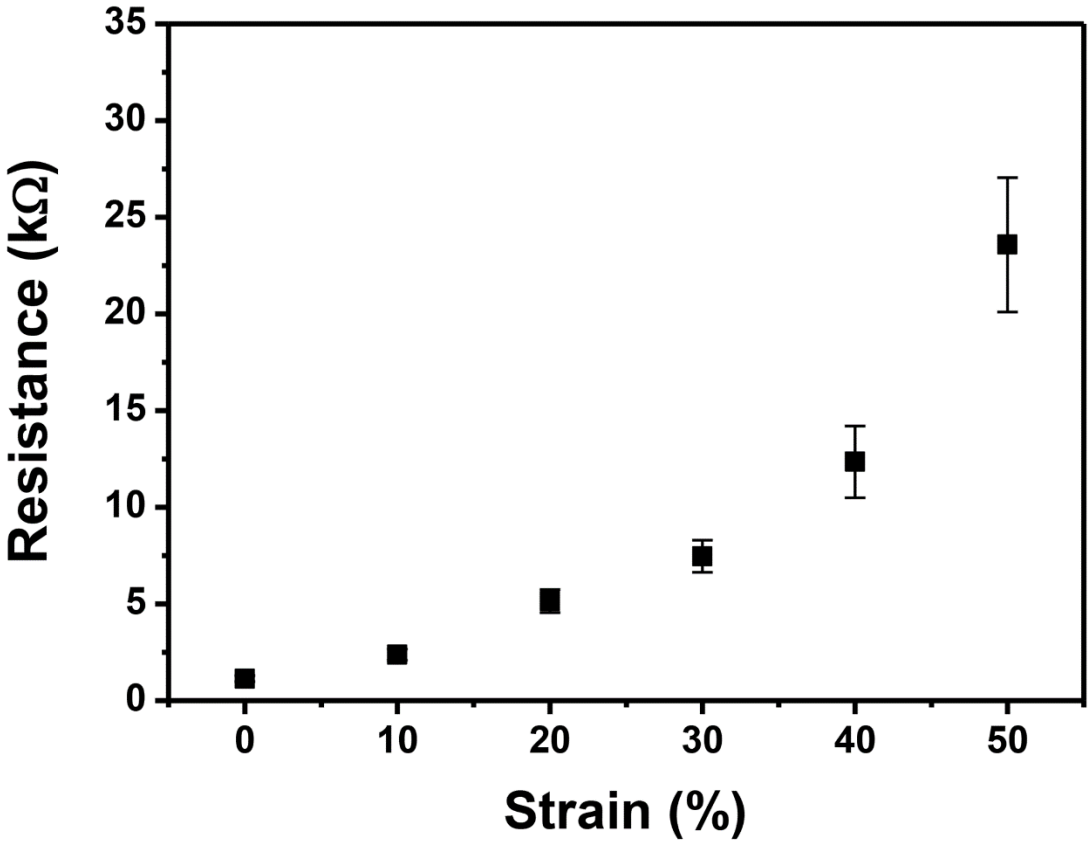

Fig. S11. The electrical resistance of a 6-step staircase sensor as a function of uniaxial strains in the length direction.

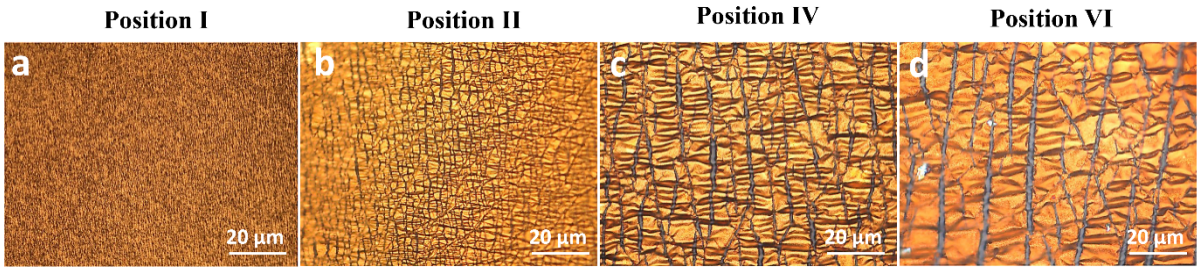

Fig. S12. The optical images of the surface morphology of a 6-step staircase V-AuNWs film with 50% uniaxial strain along the longitudinal direction at position *I* (a), position *II* (b), position *IV* (c) and position *VI* (d).

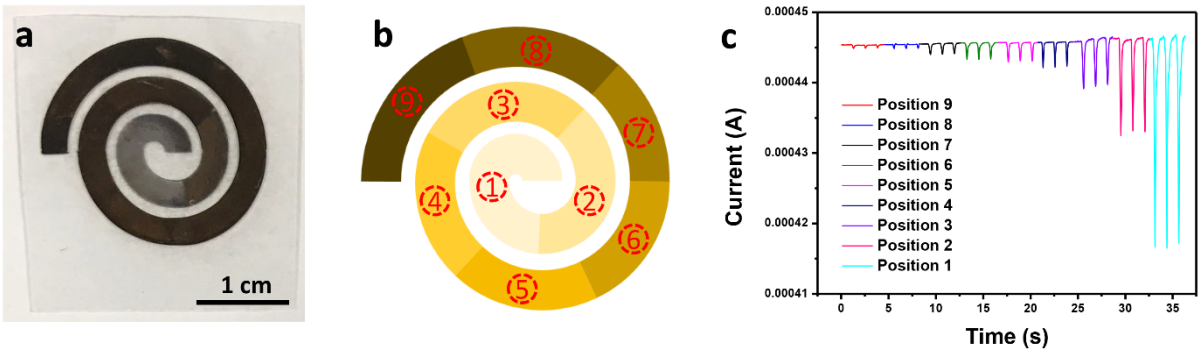

Fig. S13. (a) The photograph of a 9-steps staircase spiral V-AuNWs pattern. The nanowires growth time from inside to outside are 1 minute to 9 minutes at 1 minute' interval. (b) The schematic design of the pattern and the positions where pressures are applied. (c) The current changes of the spiral electrode at a constant voltage of 0.1V with applied pressure of 20 kPa from position 9 to position 1.

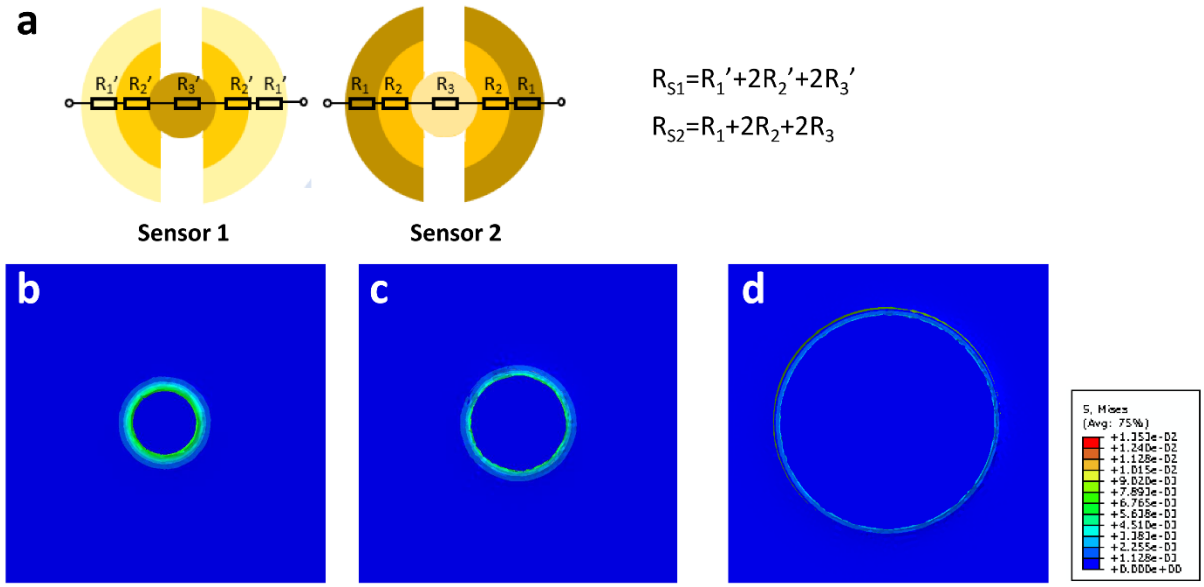

Fig. S14. (a) The schematic design of the concentric circle patterns and the corresponding simplified circuit diagram. (b)-(d) The finite element analysis (FEA) results of the stress distribution of a 500 μm eco-flex film when a normal force of 0.15 N by a cylinder with radius of 0.6 mm (b), 1.3 mm (c) and 2 mm (d) is applied.

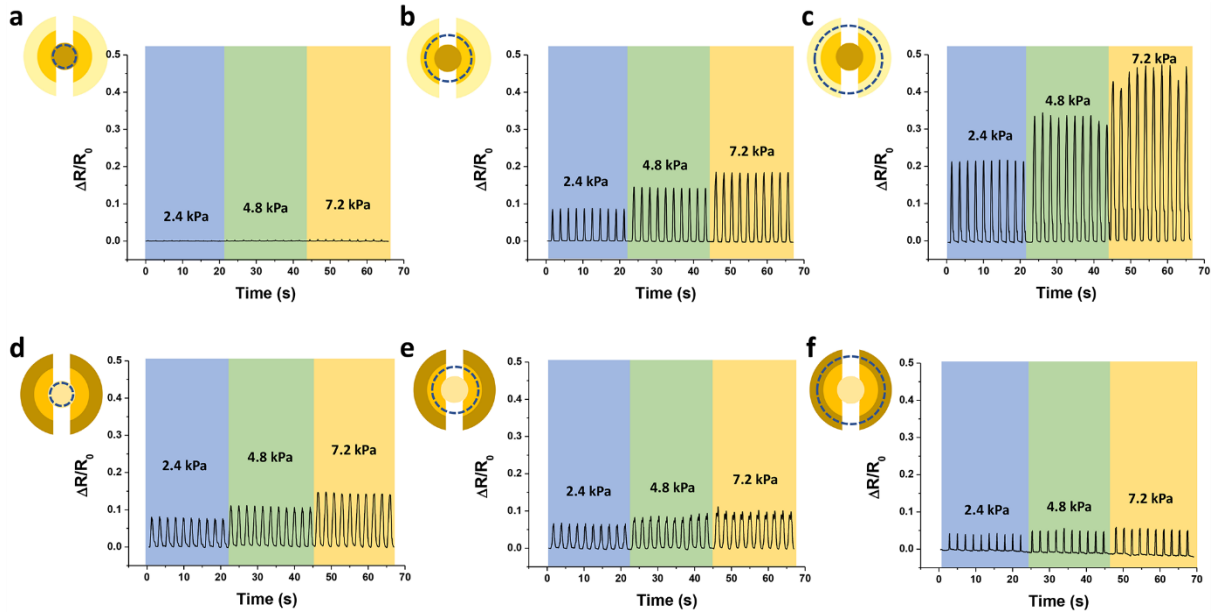

Fig. S15. (a-c) Resistive responses of sensors 1 to cylinders with radius of 0.6mm (a), 1.3 mm (b) and 2 mm (c) under pressures of 2.4 kPa, 4.8 kPa and 7.2 kPa. (d-e) Resistive responses of sensors 2 to cylinders with radius of 0.6mm (a), 1.3 mm (b) and 2 mm (c) under pressures of 2.4 kPa, 4.8 kPa and 7.2 kPa.

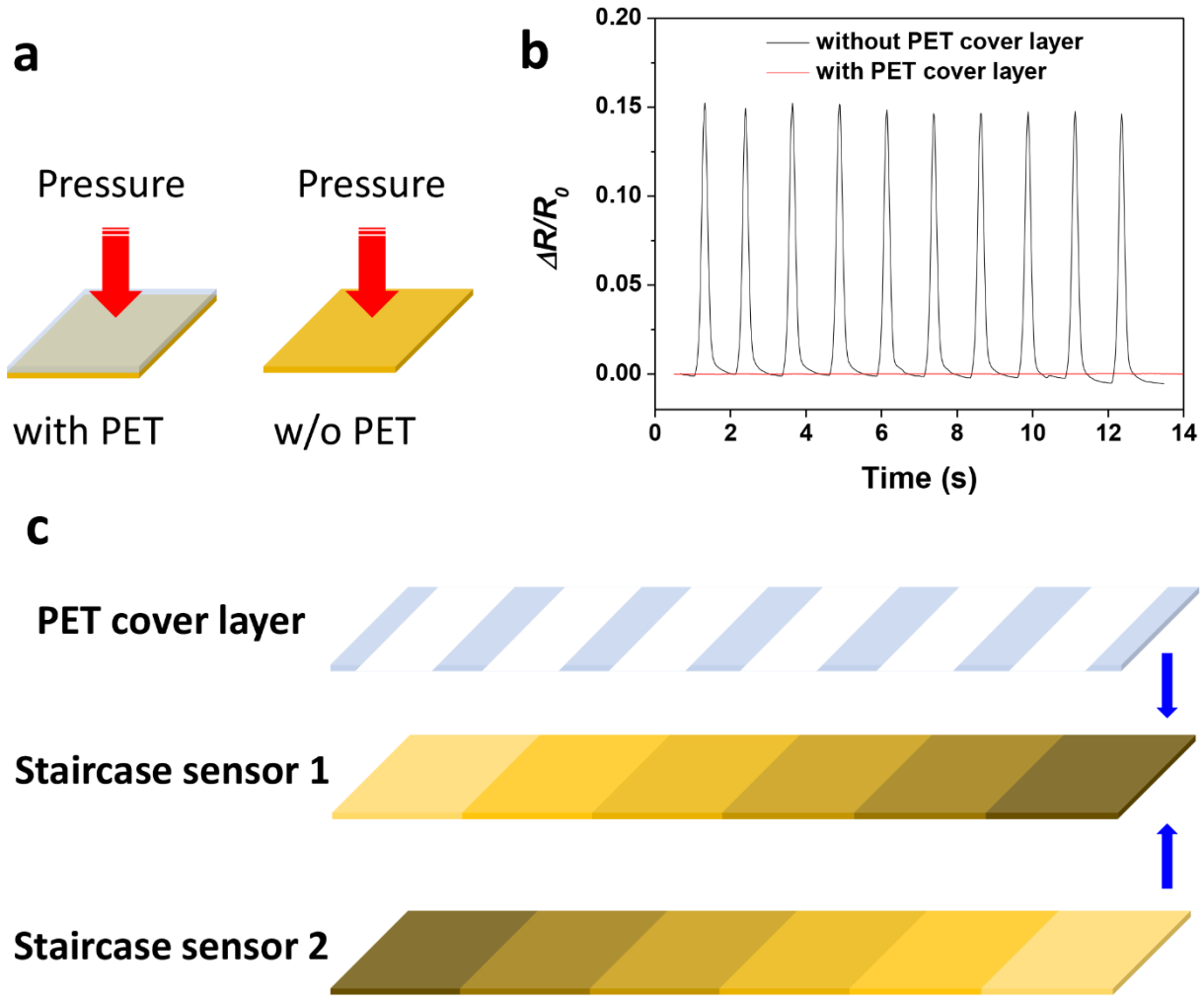

Fig. S16. (a) schematic of a V-AuNWs film under point load with and without PET cover layer. (b) The resistance changes of a V-AuNWs film under repeated point load of 0.1N with (black) and without (red) PET cover layer. (c) a rational design to avoid inaccuracy pressure/location detection at the boundary of staircases.