Electronic Supplementary Information

Self-assembled Gold Nanorime Mesh Conductor for Invisible Stretchable Supercapacitor

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This PDF file includes:

Fig. S1-19
Caption for Movie S1

Other Supporting Information for this manuscript includes the following:

Movie S1

Fig. S1-19:

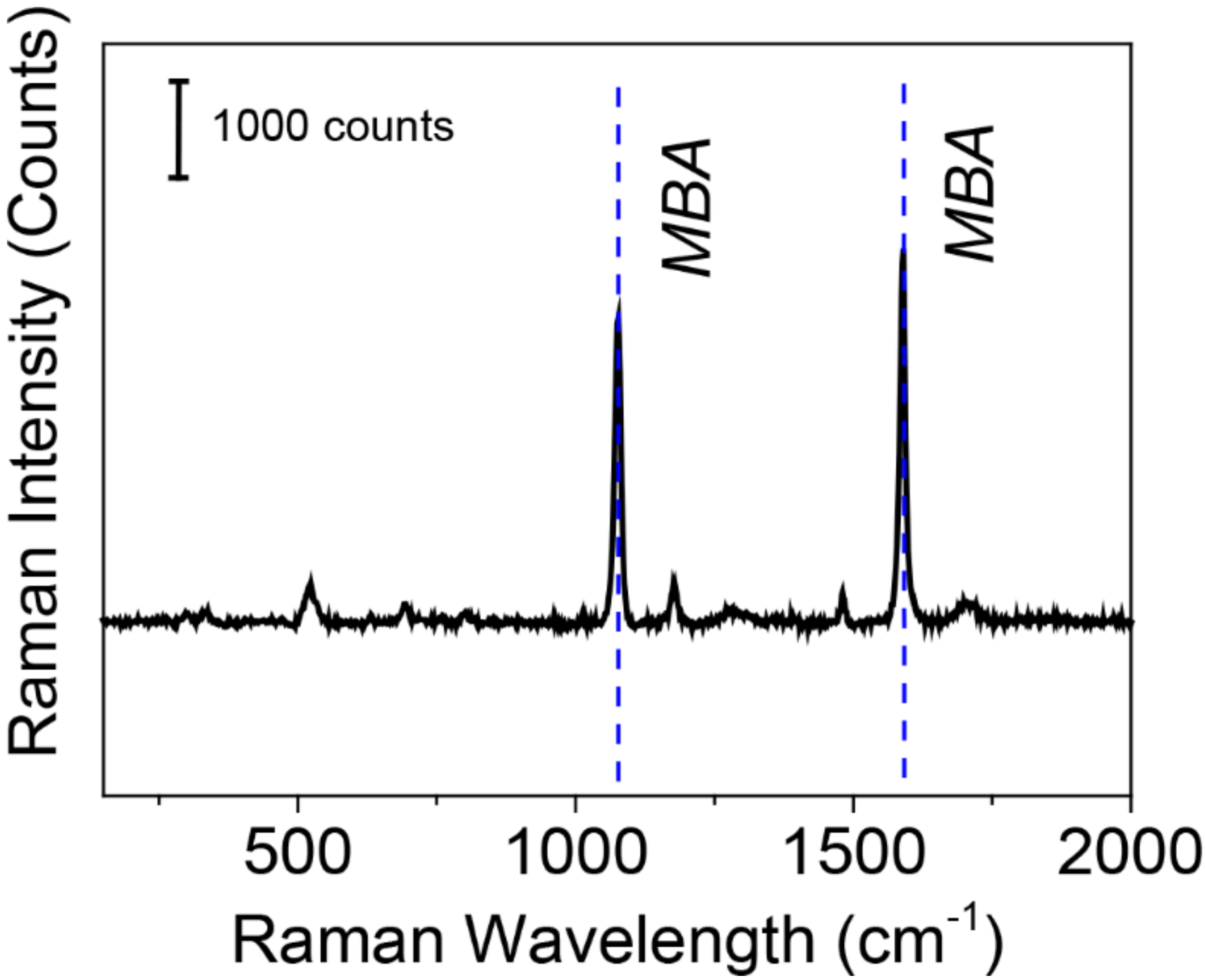

Fig. S1. Raman spectra of blank nanorime-based film, demonstrating the presence of MBA bands at 1078 and 1856.

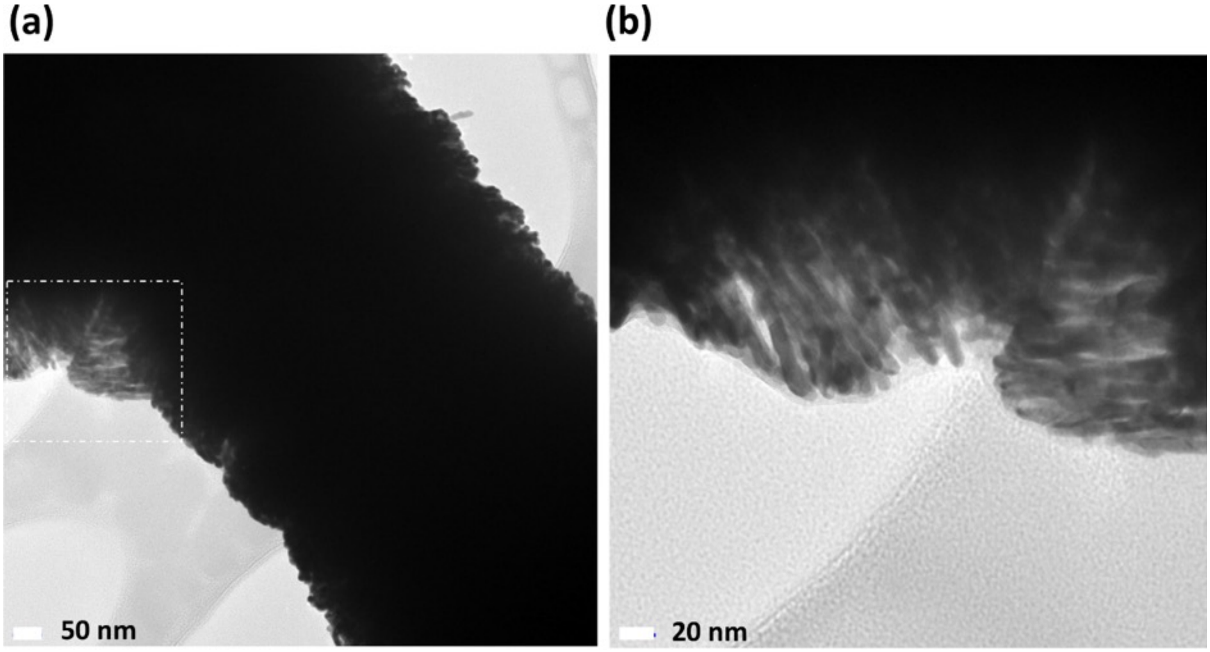

Fig. S2.TEM images of nanorime structure. t_P=20 mins; t_A=9 hrs; t_G=6 mins.

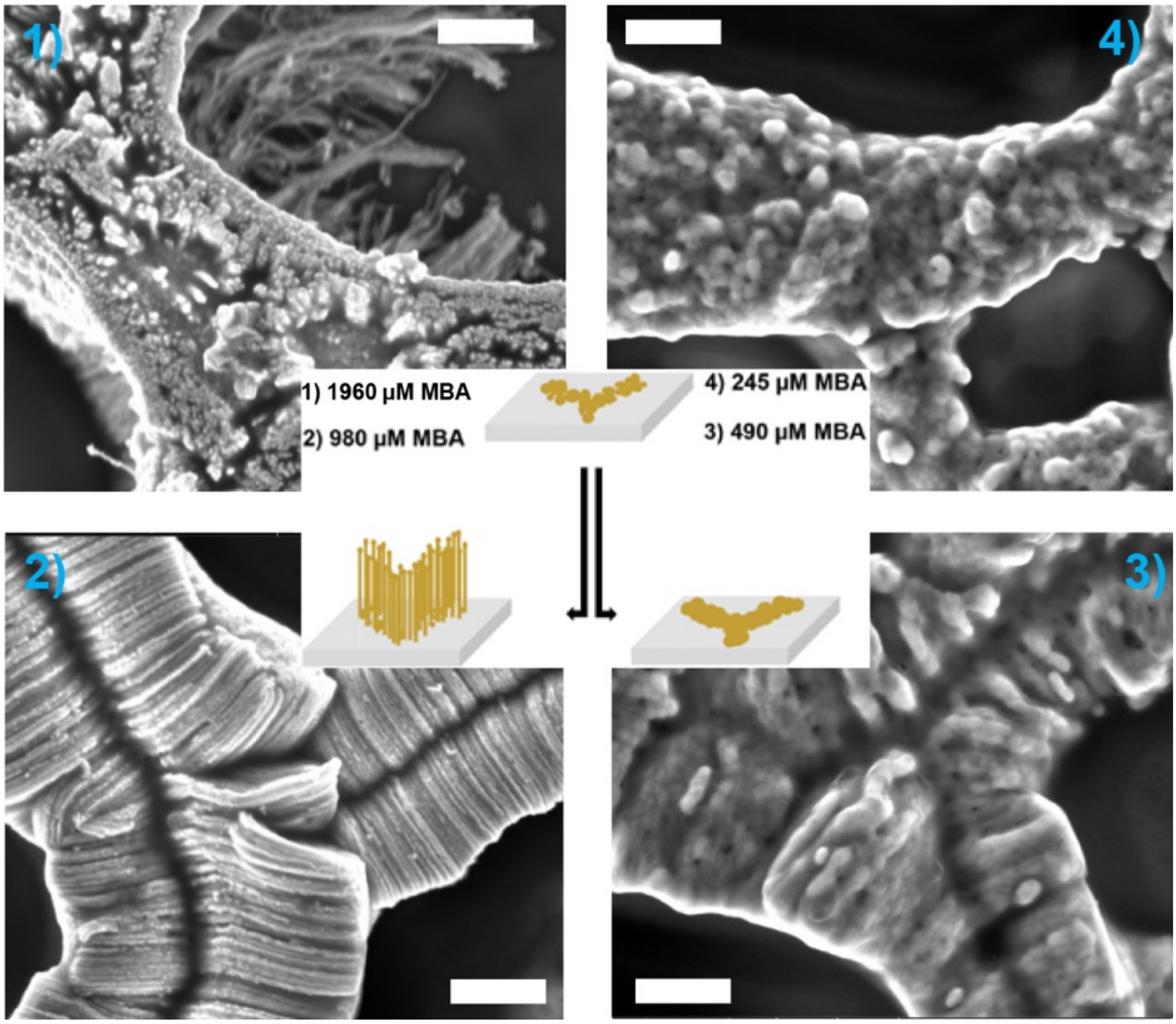

Fig. S3. SEM images of the aligned nanowires grown on templated mesh structures at different MBA concentrations: (1) 1960 µM, (2) 980 µM, (3) 490 Mm and (4) 245 µM MBA. Scale bar: 200 nm. The samples were prepared with ultrathin gold nanowires solution ageing time t_A=6 hrs; plasma treatment time t_P= 20 mins, and nanomesh-templated nanowire growth time t_G= 9 mins.

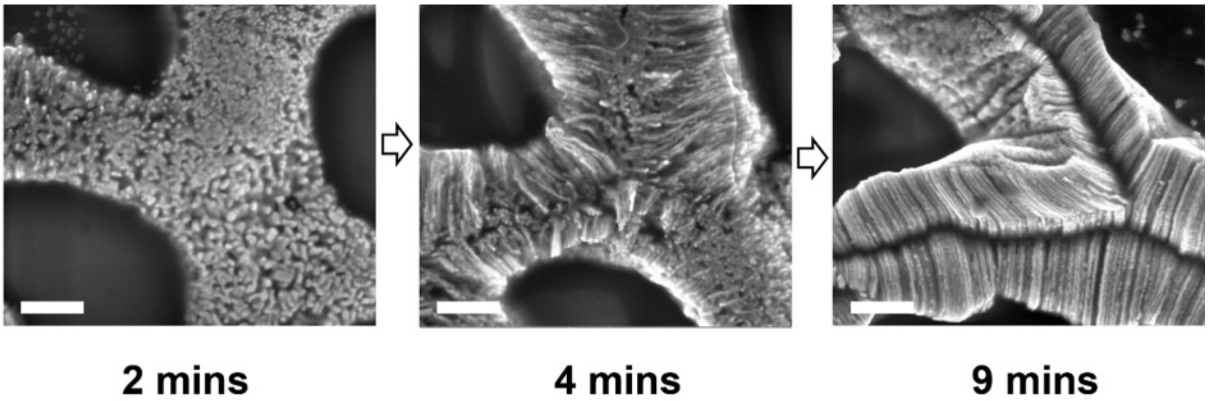

Fig. S4. SEM images of the gold nanorime growth under different period of time: 2 mins, 4 mins and 9 mins. Scale bar: 200 nm. The samples were prepared with ultrathin gold nanowires solution ageing time t_A=6 hrs, plasma treatment time t_P= 20 mins.

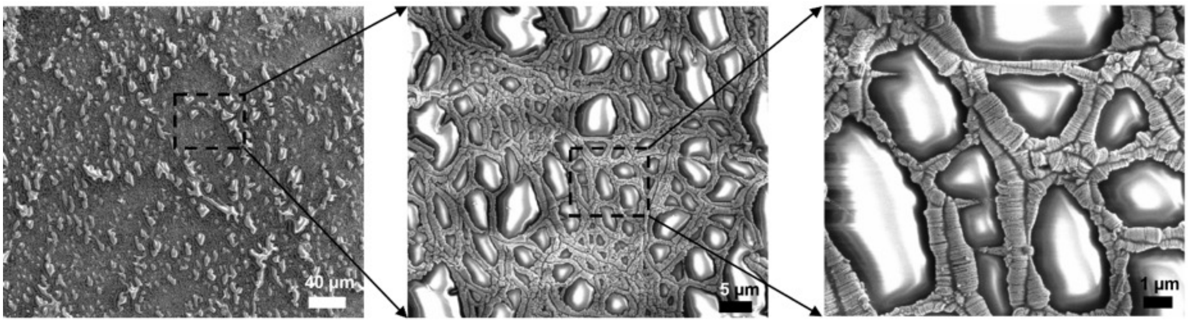

Fig. S5. SEM images (low to high resolution) of gold nanorimes grown on templated mesh structures. The samples were prepared with ultrathin gold nanowires solution ageing time t_A= 6 hrs; plasma treatment time t_P= 20 mins, and gold nanorime mesh growth time t_G= 9 mins.

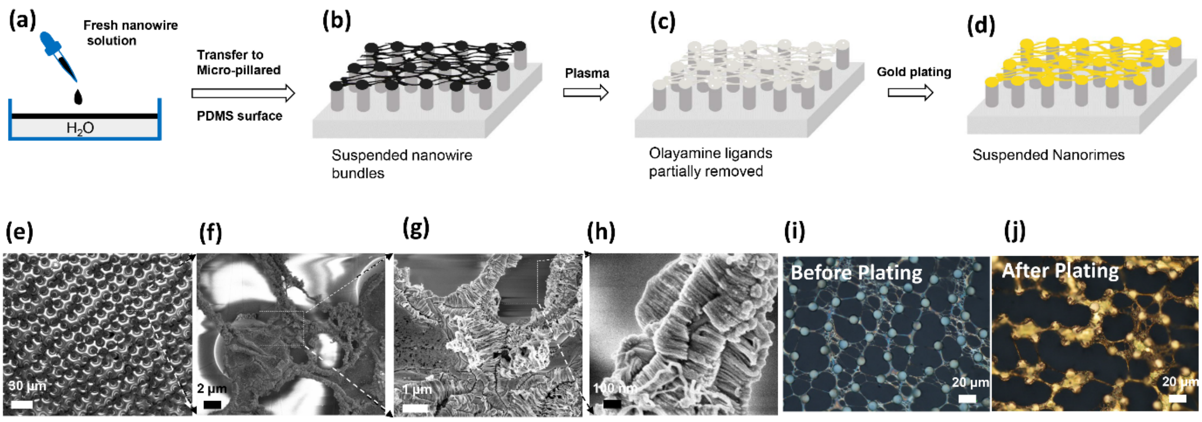

Fig. S6. Fabrication and characterization of suspended nanorime web on micro-pillared PDMS substrate. (a) Drop-casting of oleylamine-capped 2-nm-thin gold nanowire solution onto the air-water interface, leading to the formation of self-assembled nanomesh; (b) Bundled nanowire mesh transferred onto micro-pillared PDMS substrate; (c) Removal of oleylamine by O_2 plasma treatment, leading to fused and fragmented nanowires; (d) Formation of nanowire nanorimes on bundled nanowires. (e-h) SEM images of suspended nanorime web from low to high resolution (i-j) Optical micrographs of suspended nanorime web before and after gold plating. t_P= 20 mins, t_A= 0 hr and t_G= 6 mins.

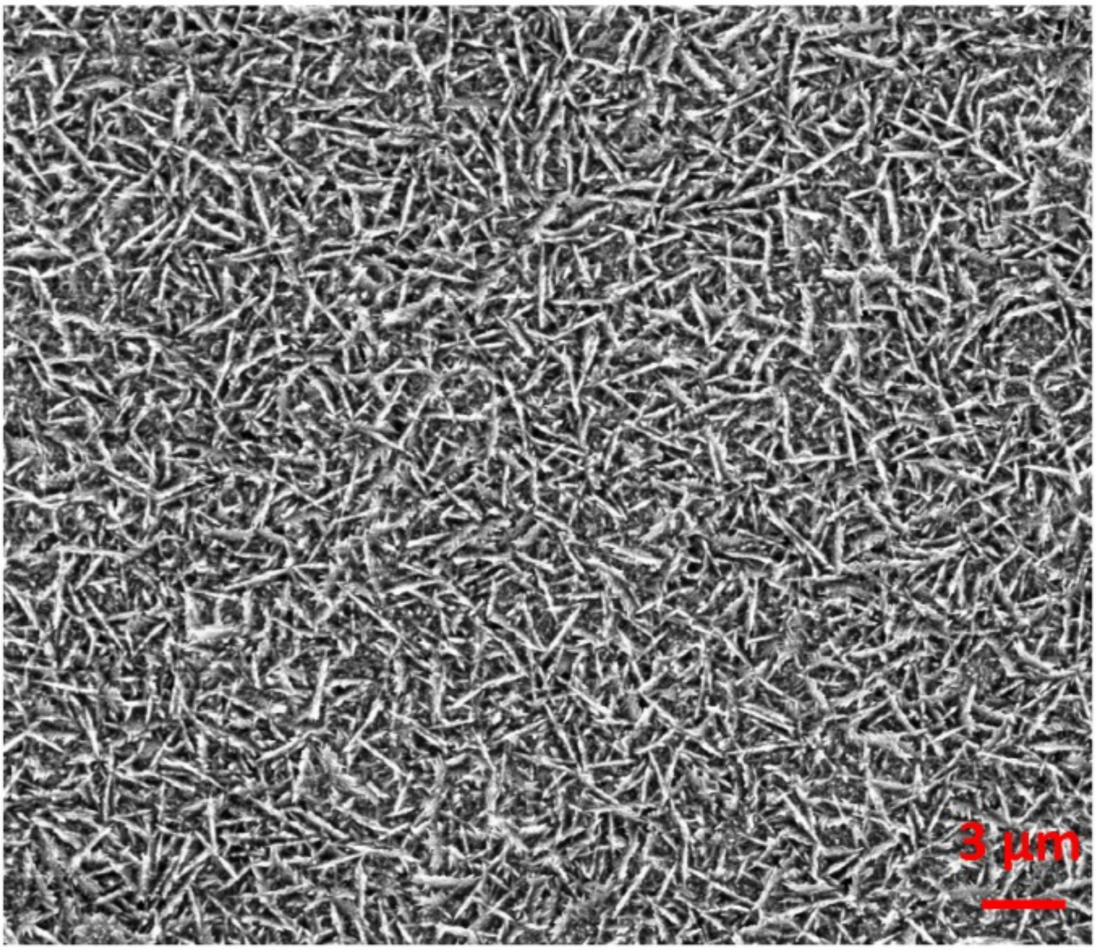

Fig. S7. SEM images of gold nanomaterials grown on evaporated Au particle film.

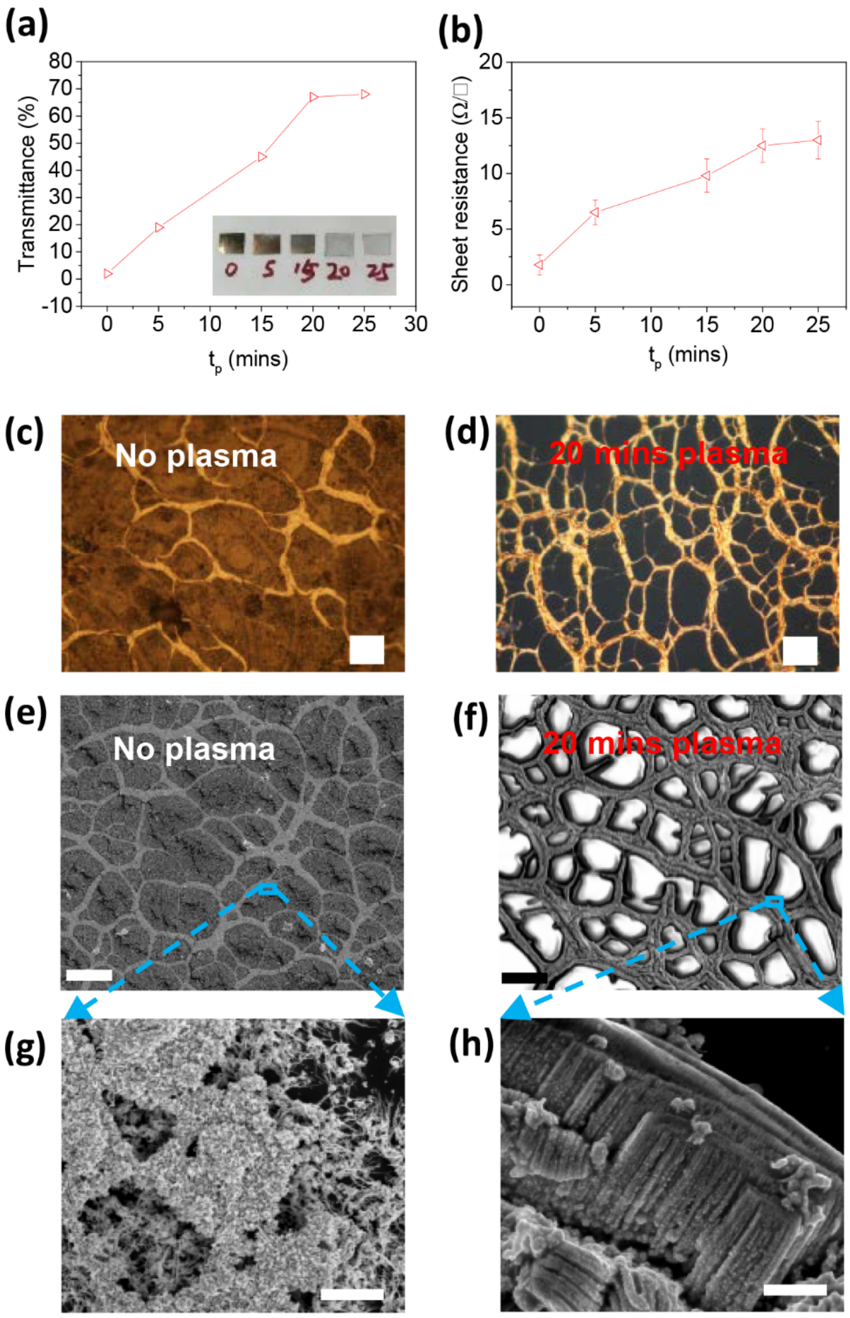

Fig. S8. (a) Effects of plasma treatment time (t_P) on the optical transmittance. The insets are photographs of film with different plasma treatment time; (b) Effects of plasma treatment time on sheet resistance. Optical micrographs of nanowire film without (c) and with (d) with 20 mins O_2 plasma treatment. Scale bar: 10 µm. (e, g) SEM images of nanowire films without plasma treatment. (f, h) SEM images of nanorime films with 20 minutes plasma treatment. Scale bar for (e-f): 20 µm; Scale bar for (g-h): 100 nm. The samples were prepared with ultrathin gold nanowires solution ageing time t_A=9 hrs; and gold nanorime mesh conductor growth time t_G= 6 mins.

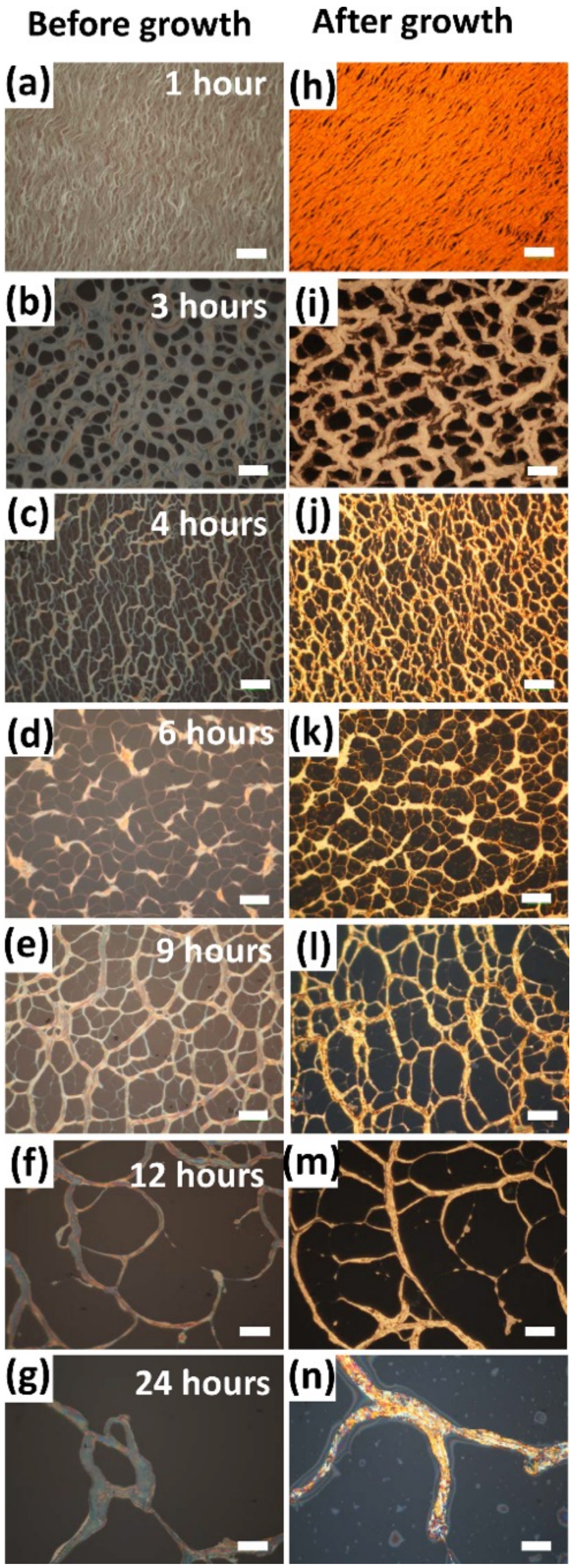

Fig. S9. Optical micrographs of mesh films with the ageing time t_A from 1 hr to 24 hrs before (a-g) and after (h-n) nanorime growth. Scale bar: 10 μm. t_G=6 mins. t_P=20 mins.

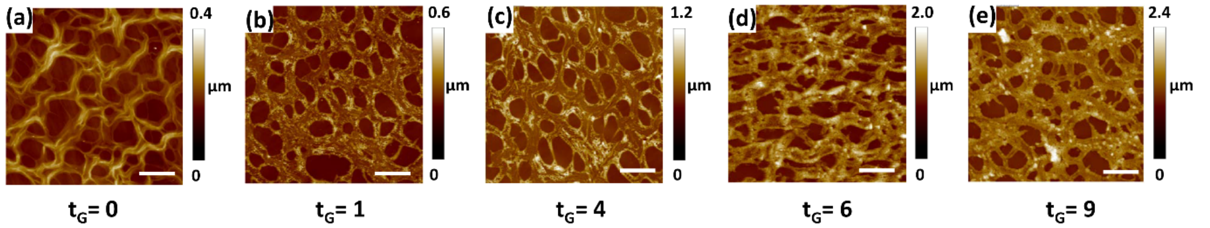

Fig. S10. (a-e) AFM characterizations of gold naorime mesh conductors with different growth time (t_G=1, 4, 6 and 9 mins). All the sample were made from gold nanowire solution with t_A=3 hrs ageing time. Scale bar: 10 μm. t_P=20 mins.

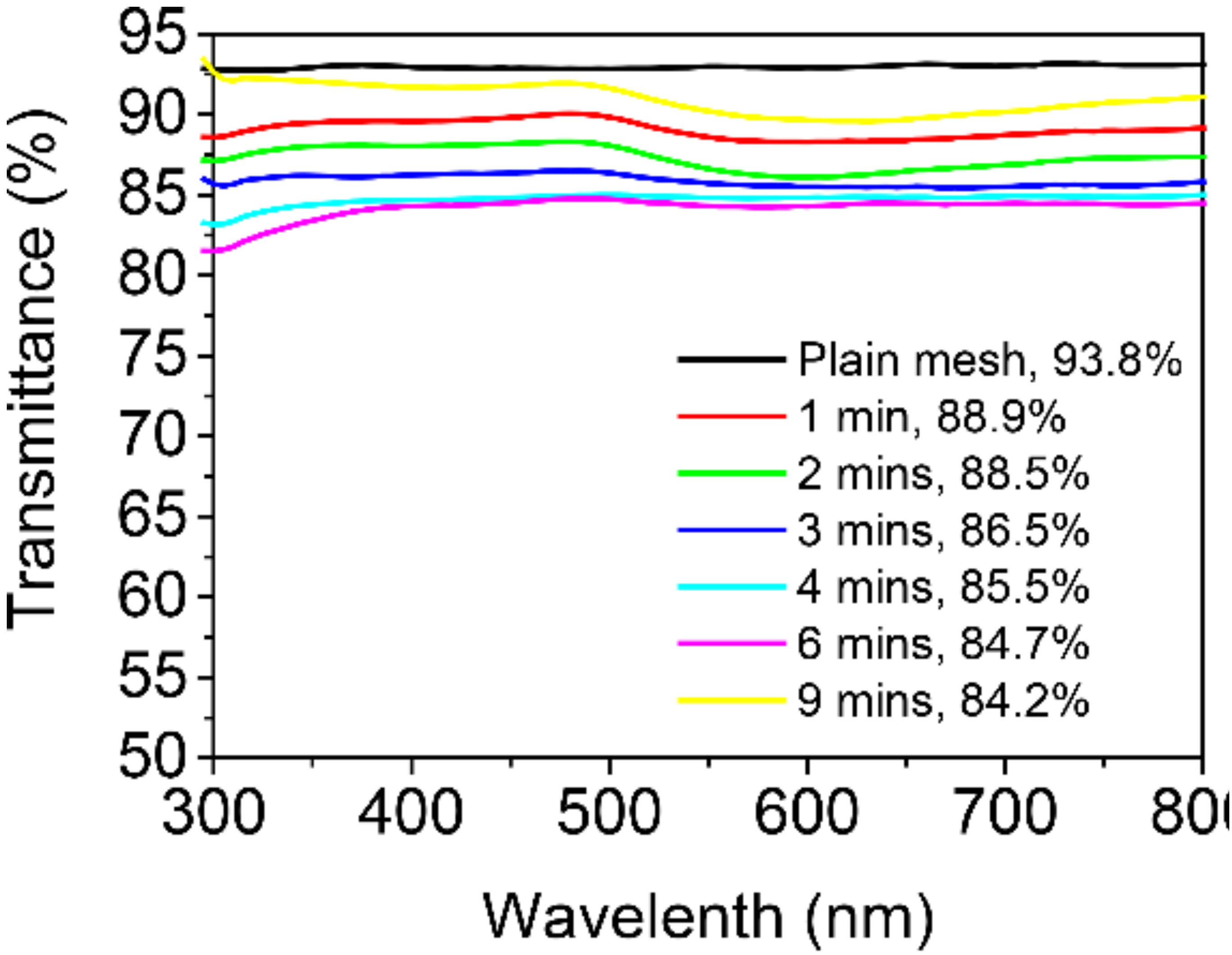

Fig. S11. Optical transmittance of the as-prepared gold nanorime mesh conductors (t_A=24 hrs) with different growth time, t_G. t_P=20 mins.

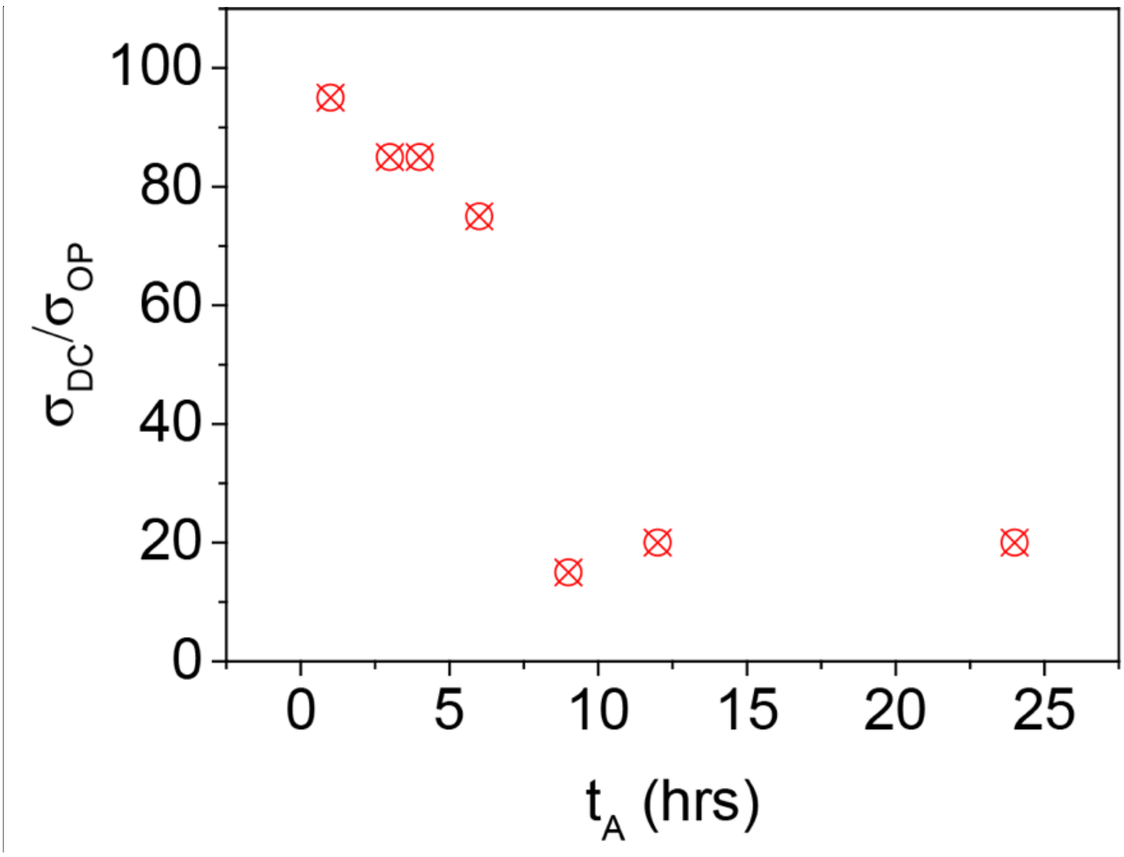

Fig. S12. Figure of merit of transparent electrodes as a function of ageing time, t_A = 1, 3, 4, 6, 9, 12 and 24 hrs. t_P=20 mins; t_G=9 mins.

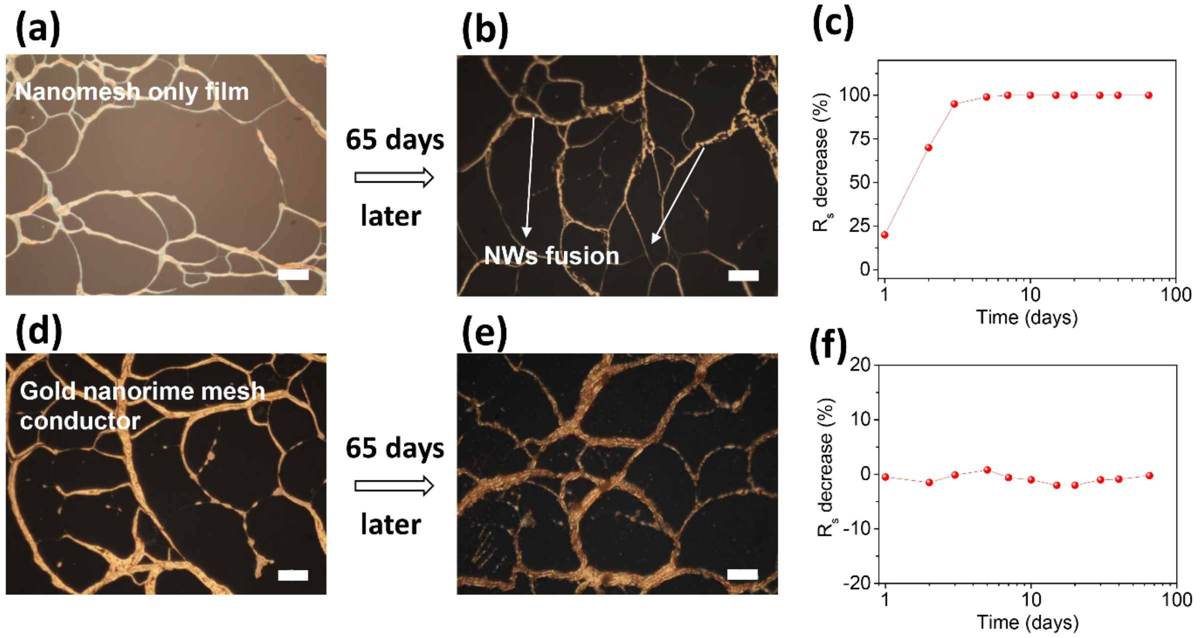

Fig. S13. Temporal stability of gold nanorime mesh conductor. Optical micrographs of self-assembled gold nanowire bundle mesh film (a-b) and gold nanorime mesh conductor (d-e) before and after 65 days storage under room temperature. Scale bar: 10 µm. (c, f) Sheet resistance change as a function of ageing time. t_P=20 mins; t_A=12 hrs; t_G=9 mins.

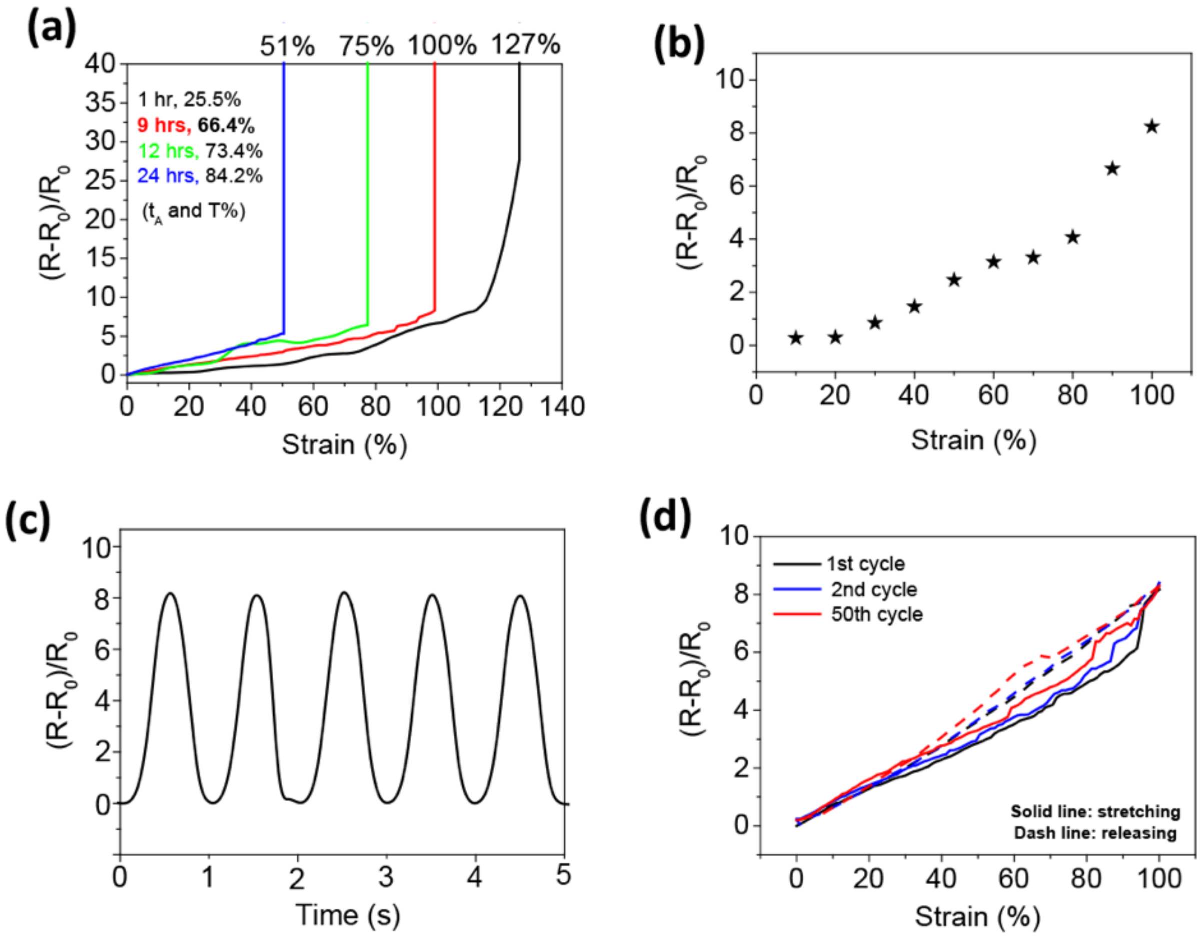

Fig. S14. Electromechanical properties gold nanorime mesh conductor. (a) Stretchabilities of nanowire electrodes prepared from variour ageing time t_A=1, 9, 12 and 24 hrs. (b) Resistance change and (c) Dynamic conductivity change as a function of strain (0-100%). (d) Cycling test of gold nanowire mesh conductor under 100% strain. t_P=20 mins; t_A=9 hrs; t_G=9 mins.

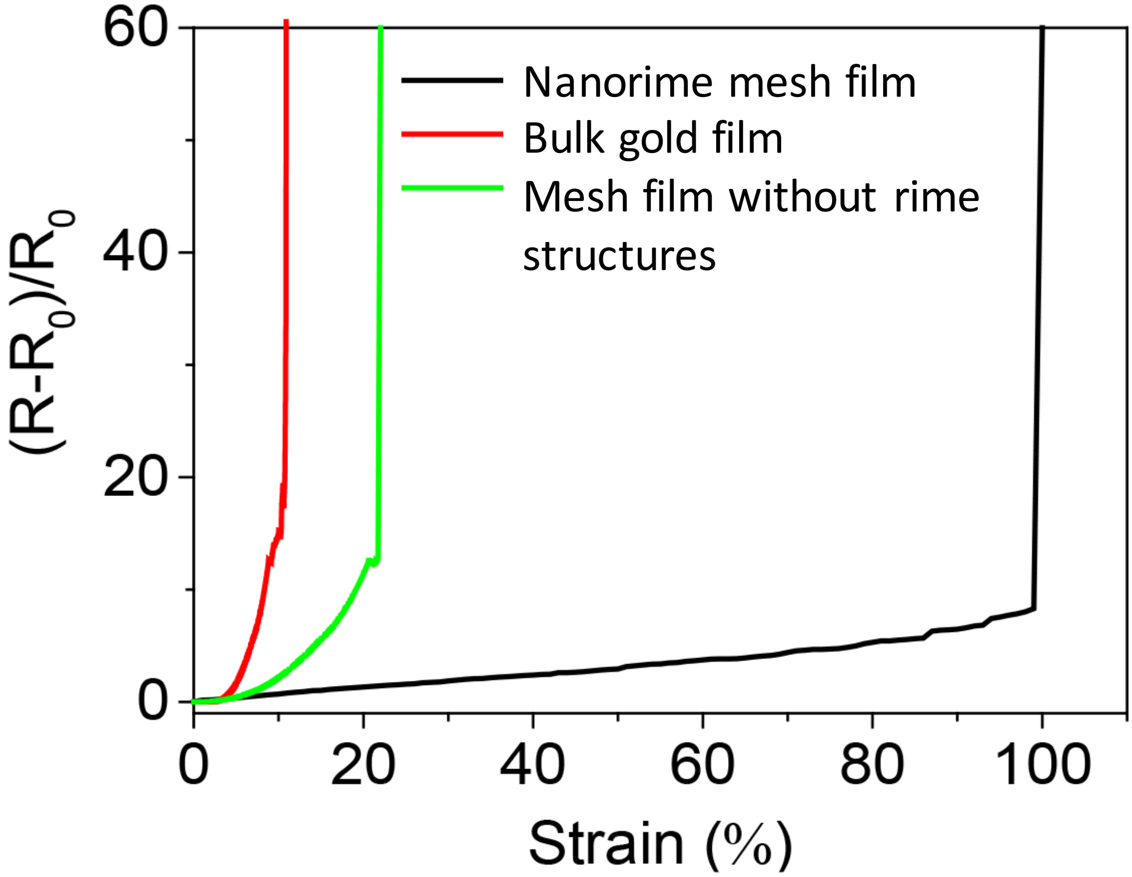

Fig. S15. Stretchability comparison of bulk-gold electrode, mesh electrode without nanorime structures, and nanorime-based electrode (t_P=20 mins; t_A=9 hrs; t_G=9 mins).

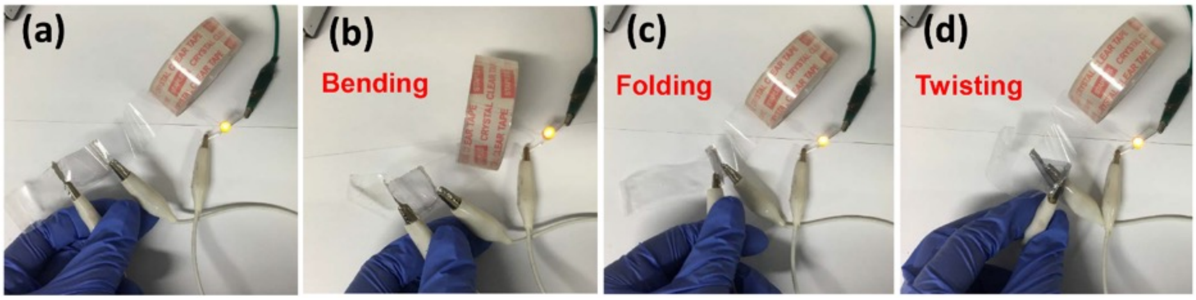

Fig. S16. Growth of nanorime mesh conductor on transparent scotch tape. The sample was prepared by transferring self-assembled nanowire mesh onto crystal tape followed by templated nanowire growth. LED lights remain on in nature state (a), bending (b), folding (c) and twisting (d). t_P=20 mins; t_A=9 hrs; t_G=3 mins.

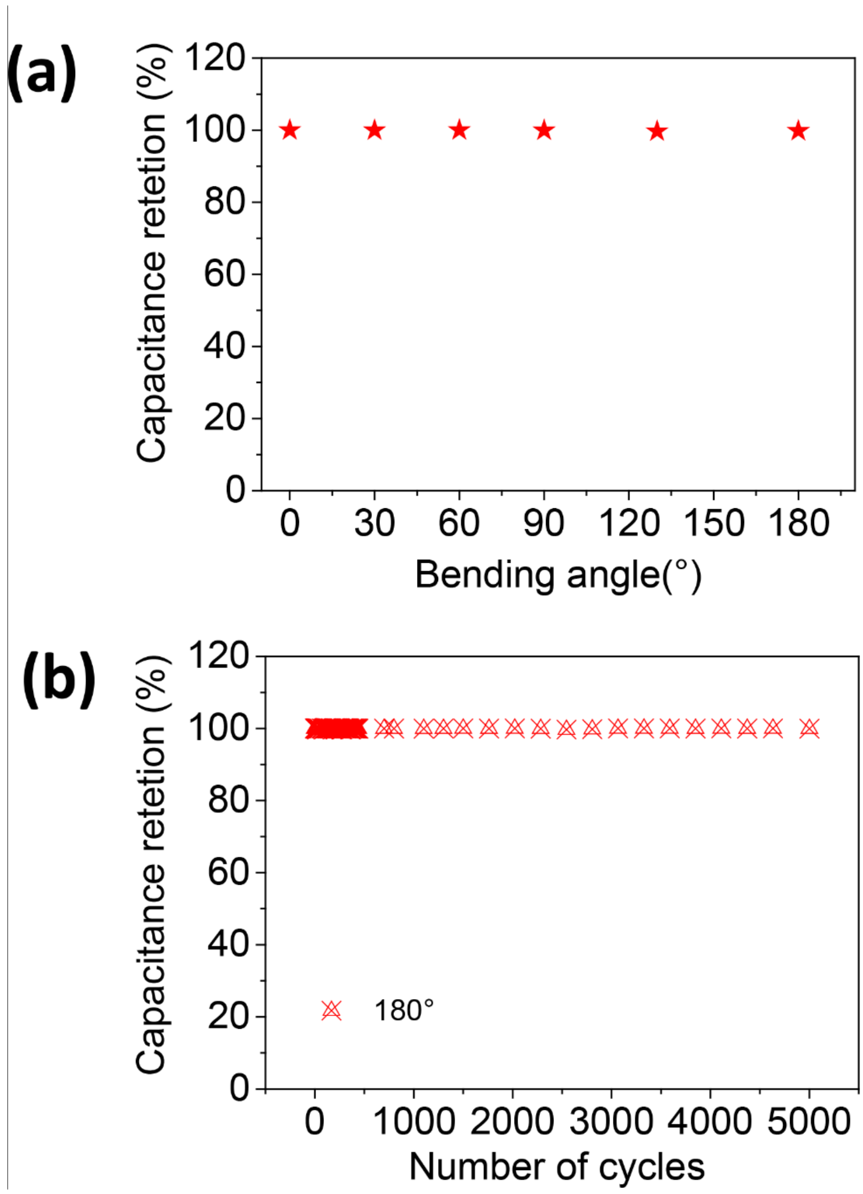

Fig. S17. (a) Capacitance retention during bending from 0 to 180 degrees. (b) Capacitance retention at the bending angle of 180 degree for 5,000 cycles.

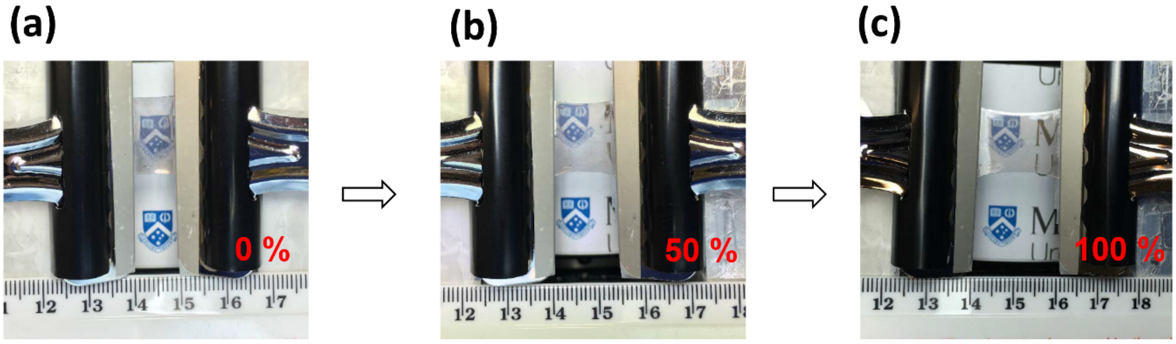

Fig. S18. Photographs showing nanorime mesh-based transparent stretchable supercapacitor under 0% -50% -100% strains.

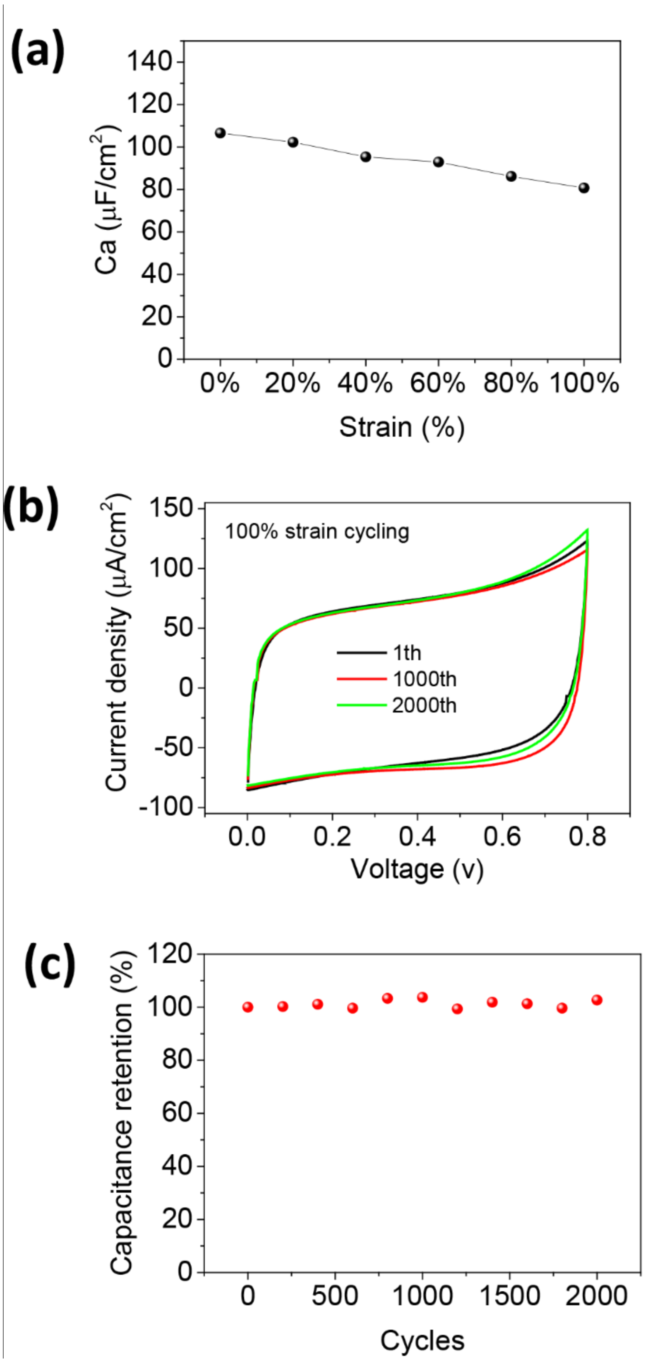

Fig. S19. (a) The calculated areal capacitances as a function of strain (0-100%). (b) CV curves of the supercapacitor after different stretching cycles under strain of 100%. The scan rate is 500 mV/s. (c) Capacitance retention during 2,000 cycles of stretching/ releasing under 100% strain.

Captions

Movie S1 Invisible conductive tape with self-assembled gold nanorime mesh coating. The conductive tape can light up LED lights bending, folding and twisting.