Supporting information

Surfactant-free synthesis of ultralong silver nanowires for endurable transparent conducting electrodes

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Experimental methods

Synthesis of AgNWs

According to the galvanic replacement reaction, $AgNO_3$ can be reduced by V in subsequent equation:

$$V_{(s)} + 2Ag^{+}_{(aq)} \rightarrow 2Ag_{(s)} + V^{2+}_{(aq)} \quad E^0 = 1.9746\ V \quad \text{Eq.(s1)}$$

In the present study, 1.70 mg of $AgNO_3$ powder and 10 mL of DI water were mixed for 1.0 mM $AgNO_3$ aqueous solution. Subsequently, an appropriately sized (0.5 cm x 0.5 cm x 0.0127 cm) vanadium foil was immersed in the $AgNO_3$ aqueous solution and kept for 4 hours at different temperatures, a large number of AgNWs were produced in the solution subsequently.

Growth of MoS_2 Films

A large-area MoS_2 film was grown using pyrolysis. A 3.0 wt% precursor solution contains 0.29 g of $(NH_4)_2MoS_4$ powder and 10 mL of dimethylformamide (DMF) were

mixed. The precursor solution was ultrasonicated for several hours to dissolve the powder. Spin-coating was then adopted to deposit the precursor onto the SiO_2 substrate. The deposited film was placed in a vacuum furnace for pyrolysis. During the heating, the pressure was maintained at 1.8 Torr, and 100 sccm of forming gas was purged into the furnace. The deposited film was heated to 450°C with a rate of 15°C/min, and kept at 450°C for 30 min.

Fabrication of Transparent flexible device Arrays

The MoS_2 film on SiO_2 was spin-coated with PMMA. After baking at 120 ^oC for 15 min, the sample was then immersed in 2 M NaOH solution for few min, the PMMA/MoS_2 film was peeled off from the SiO_2. The delaminated PMMA/MoS_2 film was washed few times in DI water to remove the residual chemicals, and then picked up by PET substrate. After drying, the PMMA was removed with acetone.

Then, photolithography was used to define the pattern and positions of the electrodes. Subsequently, the AgNWs were dripped onto the pattern area. After the lift-off process, transparent flexible device arrays with AgNW electrodes were fabricated.

Analysis and measurements

The present study employed a scanning electron microscope (Hitachi SU-8010) to check the morphologies of Ag nanostructures under different synthesis conditions. The structure and atomic arrangement of AgNWs were examined by using a spherical-aberration-corrected field emission TEM (JEOL JEM-ARM200FTH) at 200 kV. Furthermore, an ultraviolet-visible spectroscopy (AvaSpec-ULS2048) and a high-resolution semiconductor characterization system (Agilent B1500A) were used to assess material transmittance and electrical measurements, respectively.

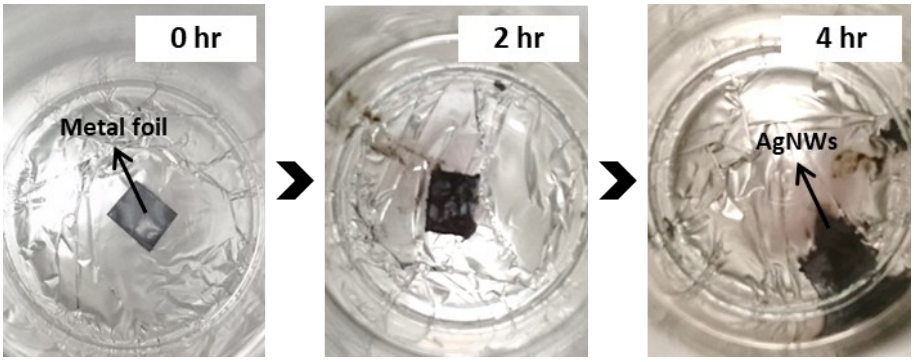

Figure S1 Growth of silver nanowires (AgNWs) at different reaction times.

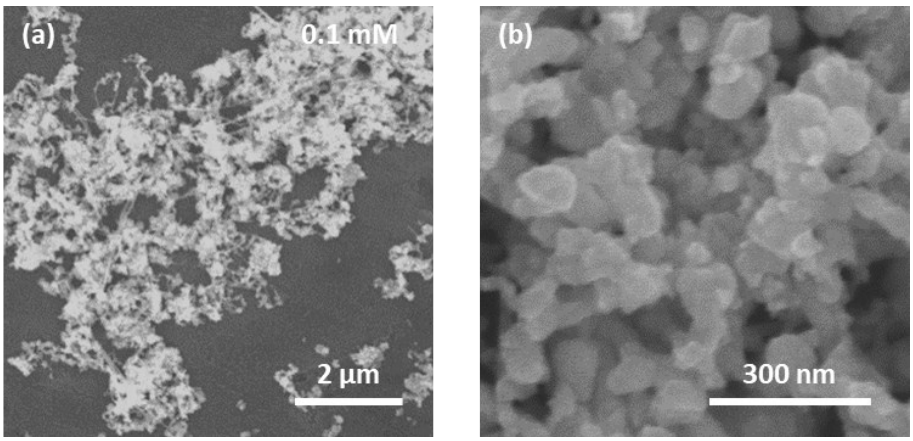

Figure S2 (a) SEM image of the Ag nanostructures synthesized with a Ag ion concentration of 0.1 mM. (b) High-magnification image of (a).

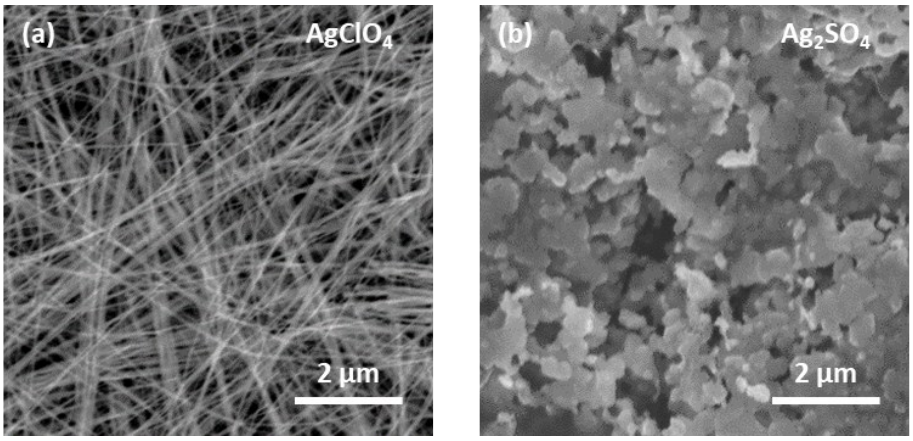

Figure S3 SEM images of the Ag nanostructures synthesized using (a) $AgClO_4$ and (b) Ag_2SO_4 as the source.

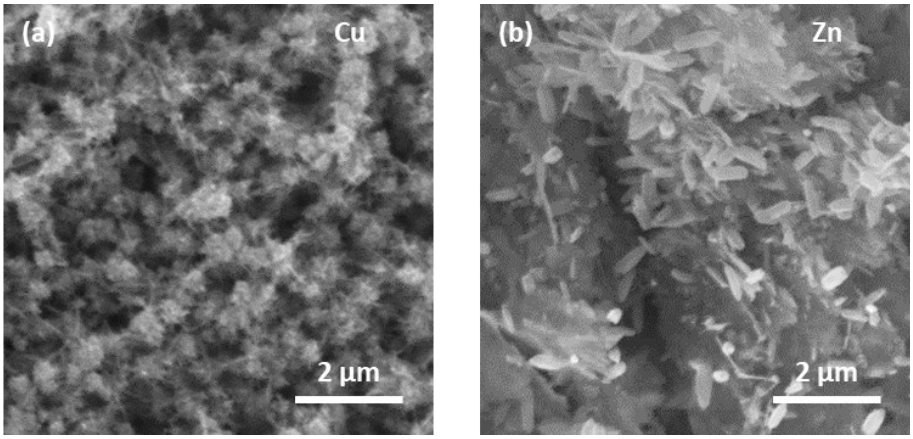

Figure S4 SEM images of the Ag nanostructures synthesized by using (a) Cu and (b) Zn as reactive metals.

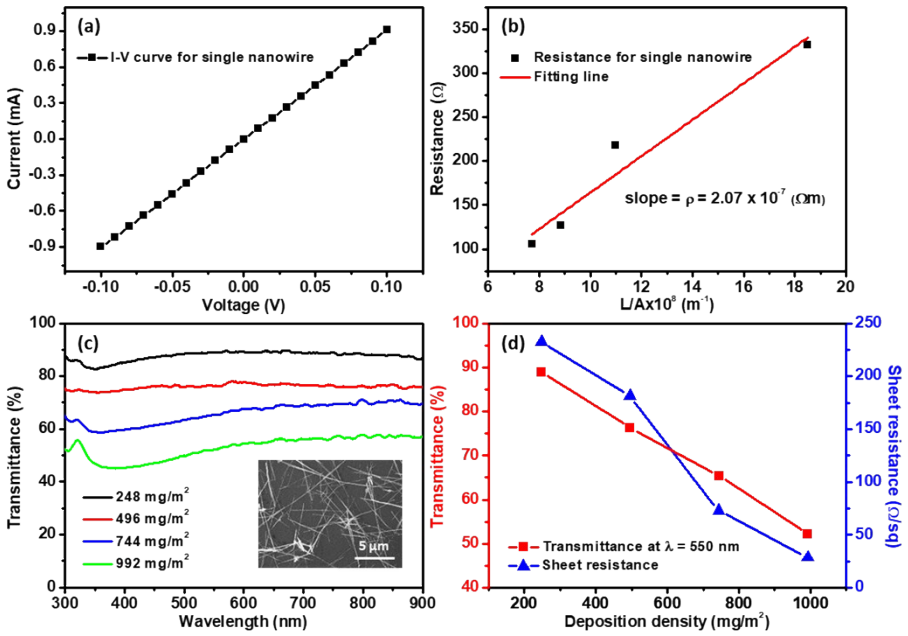

Figure S5 (a) Current–voltage characteristic (I–V) curve of a single Ag nanowire. (b) Correlation between the resistance and the geometric parameters (L/A) of different nanowires. (c) The transmittance for samples with different deposition densities. The insert is the SEM image of the AgNWs electrodes fabricated by the drop casting. (d) The variations of sheet resistance and transmittance for different AgNWs deposition densities.

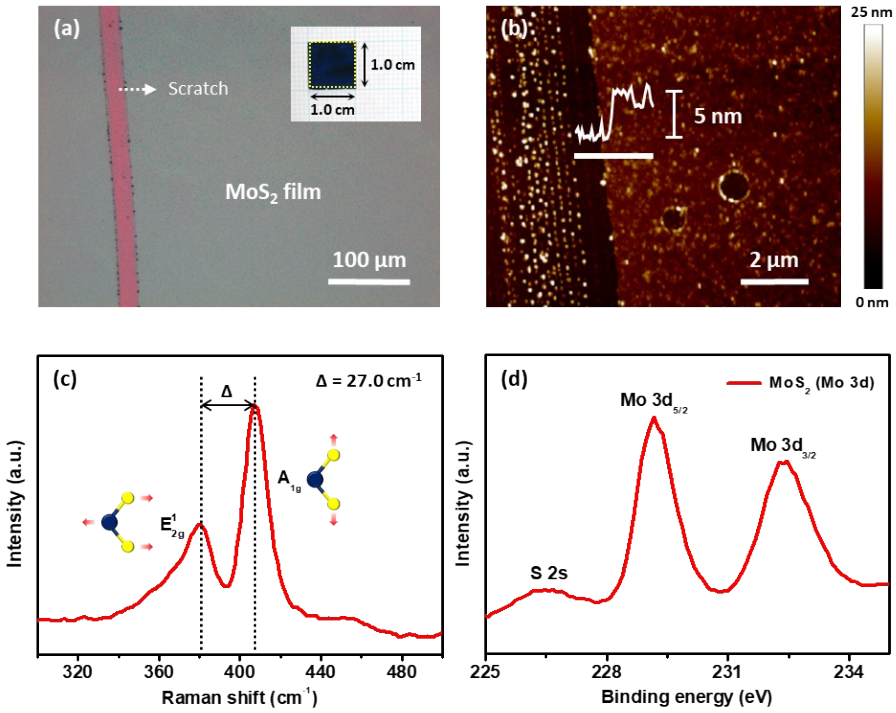

Figure S6 (a) OM image (The insert is the photograph of the sample), (b) AFM image, (c) Raman spectrum, and (d) X-ray photoelectron spectroscopy spectrum of MoS_2.

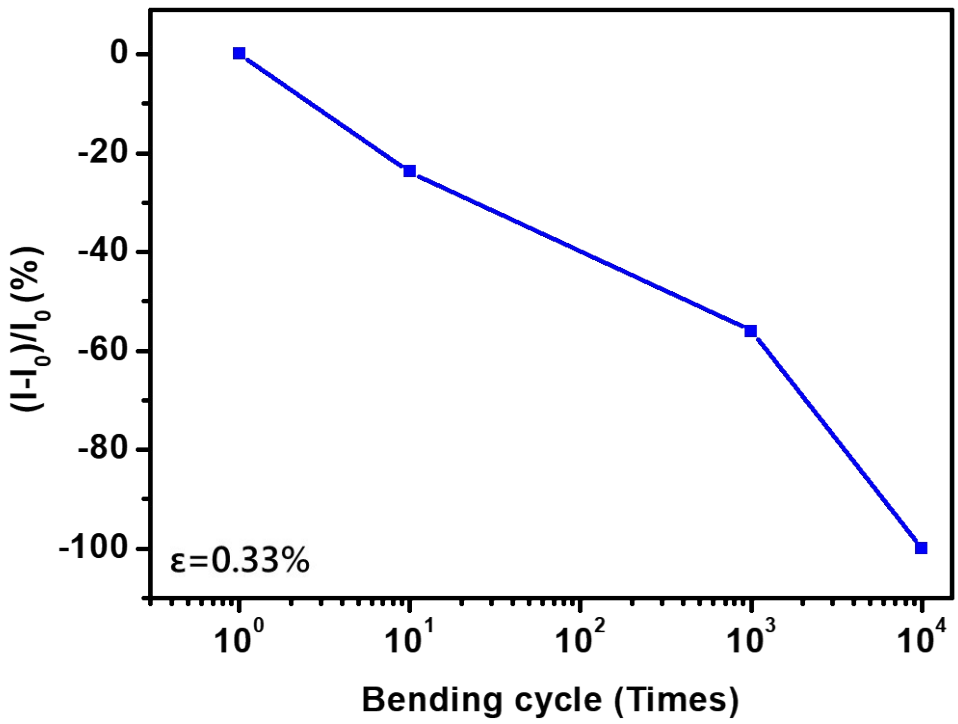

Figure S7 The changes of electrical property of 1.7 nm MoS_2 device arrays as the function of bending cycles. I_0 and I represent the current of device before and after bending test, respectively.