Electronic Supplementary Material (ESI) for Nanoscale

Supplementary information

Template-free and Filamentary Growth of Silver Nanowires: Application to Anisotropic Conductive Transparent Flexible Electrodes

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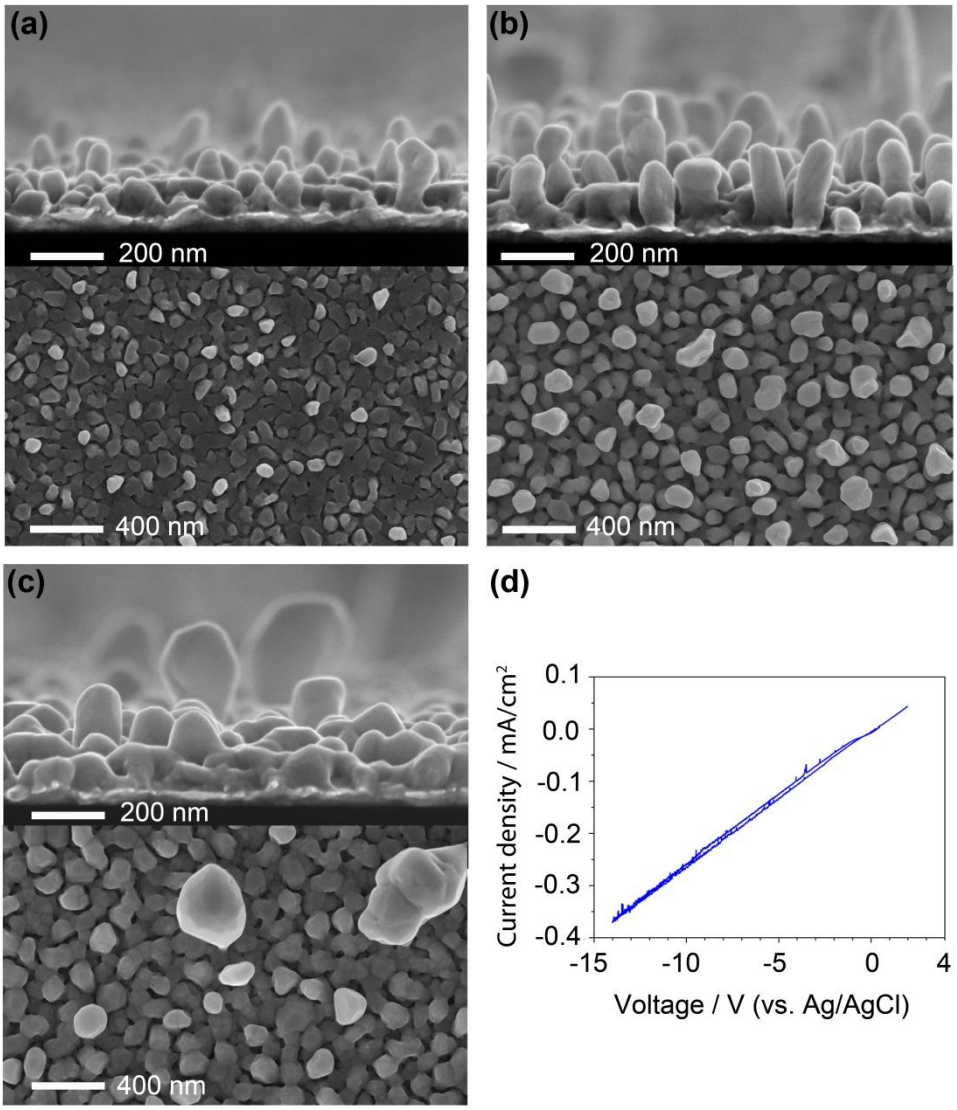

Figure S1. Cross-sectional and plan-view SEM images of 1-D silver nanocrystals deposited in the potentiostatic mode for one hour at various reduction potentials. (a) 7 V, (b) 10 V, and (c) 14 V. (d) Typical cyclic voltammogram with a scan rate of 50 $mV \cdot s^{-1}$ in a 0.02 mM $AgNO_3$ electrolyte.

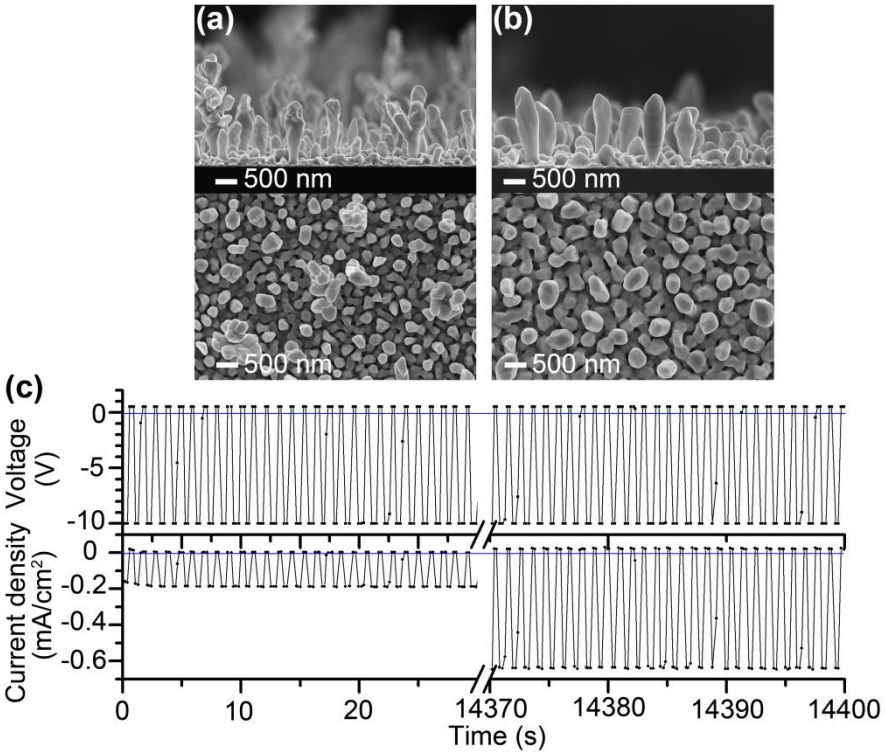

Figure S2. Cross-sectional and plan-view SEM images of 1-D silver nanocrystals electrochemically deposited in (a) potentiostatic (V_R = 10 V) and (b) reverse-pulse potentiodynamic modes (1 Hz, V_R = 10 V and V_O = 0 V) for four hours. (c) Variation of the current density corresponding to the reverse-pulse potential with time (s) at the deposition frequency of 1 Hz.

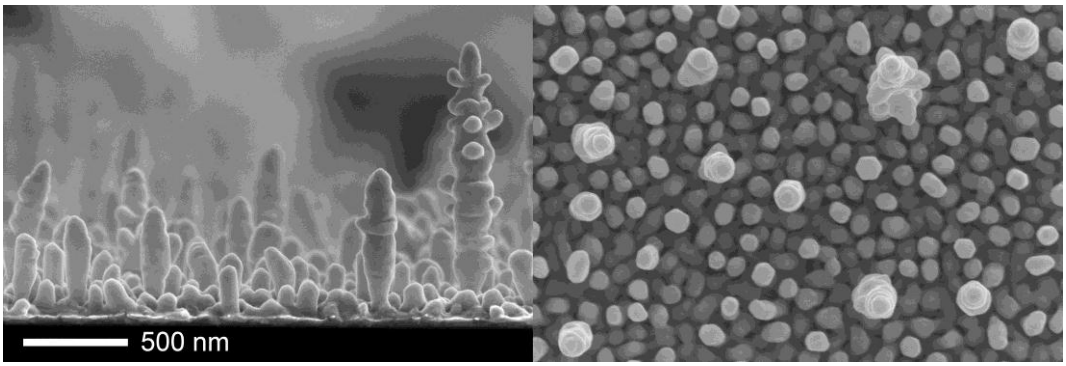

Figure S3. Cross-sectional and plan-view SEM images of silver NWs deposited for 45 min in a potentiostatic mode at V_R = 7 V in a 0.1 mM Na_2SO_4-supporting electrolyte.

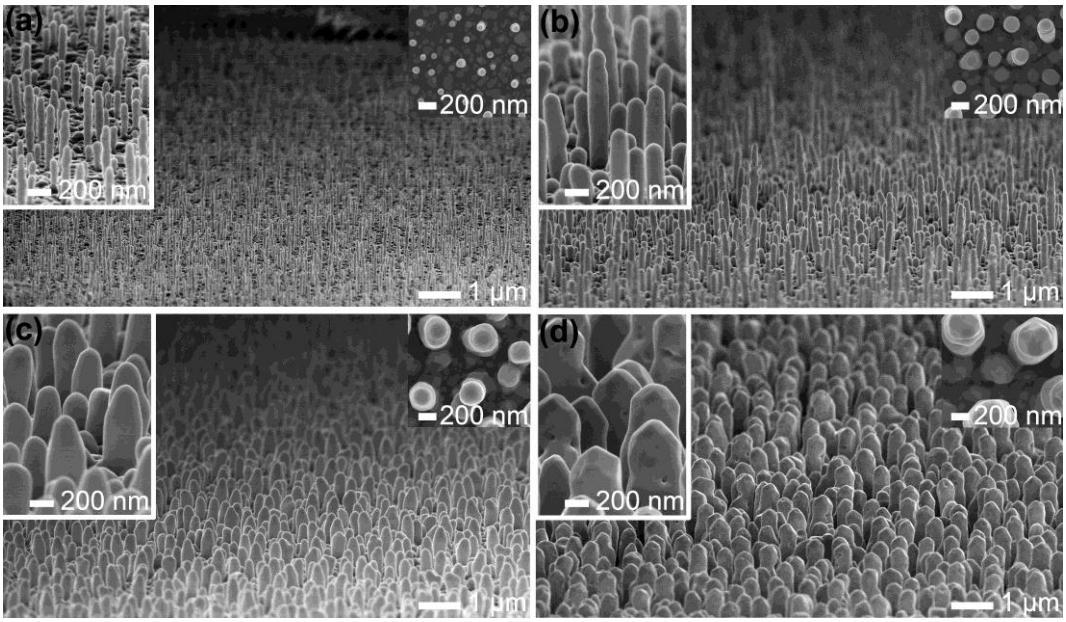

Figure S4. SEM images of silver NWs deposited in a 2.11 mM NH_4OH-supporting electrolyte at various deposition frequencies, (a) f = 5 Hz, t = 20 min, (b) f = 1 Hz, t = 65 min, (c) f = 500 mHz, t = 2 hr, and (d) f = 250 mHz, t = 12 hr under a reverse-pulse potentiodynamic mode (V_R = 14 V, V_O = 0.5 V). The left and right insets in each figure denote the enlarged tilt (13º-tilted from the surface plane) and the plan-view SEM images, respectively.

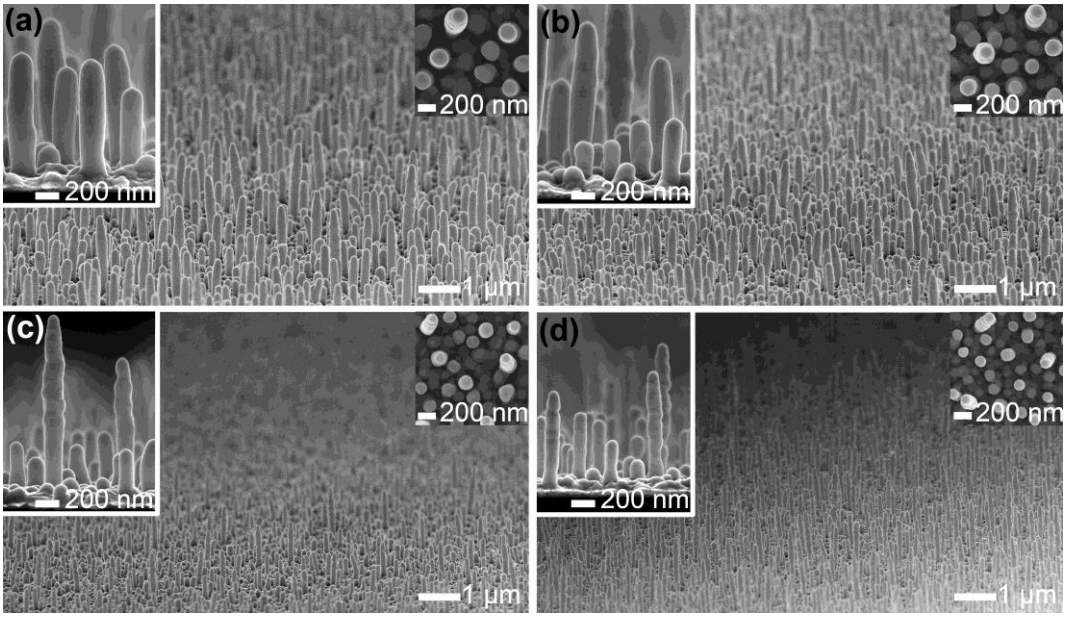

Figure S5. SEM images of silver NWs deposited in 1.32 mM NH_4OH-supporting electrolyte at various reduction potentials, (a) V_R = 7 V, *t* = 2 hr, (b) V_R = 10 V, *t* = 1 hr 40 min, (c) V_R = 14 V, *t* = 1 hr, and (d) V_R = 20 V, *t* = 1 hr under a reverse-pulse potentiodynamic mode (1 Hz, V_O = 0.5 V). The left and right insets in each figure denote the enlarged cross-sectional and plan-view SEM images, respectively.

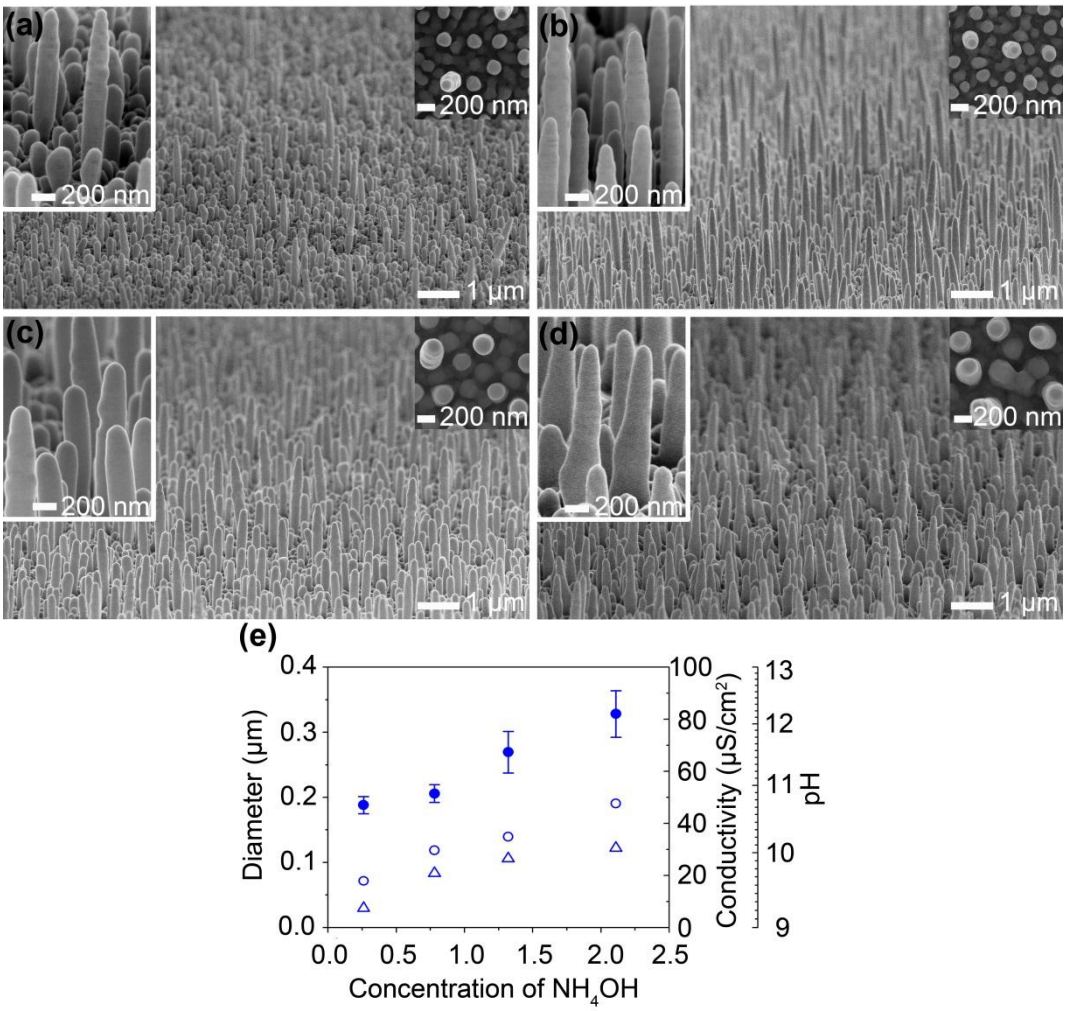

Figure S6. 13º-tilted SEM images of silver NWs deposited at various NH_4OH concentration, (a) 0.26 mM, t = 1 hr, (b) 0.79 mM, t = 1 hr, (c) 1.32 mM, t = 2 hr, and (d) 2.11 mM, t = 2 hr under a potentiodynamic mode (V_R = 14 V, V_O = 0.5 V). The left and right insets in each figure denote the enlarged tilt and plan-view SEM images, respectively. (e) Variations in the diameter, conductivity, and pH with the concentration of NH_4OH. Solid circles: NW diameter, open circles: electrolyte conductivity, and open triangles: pH of the electrolyte.

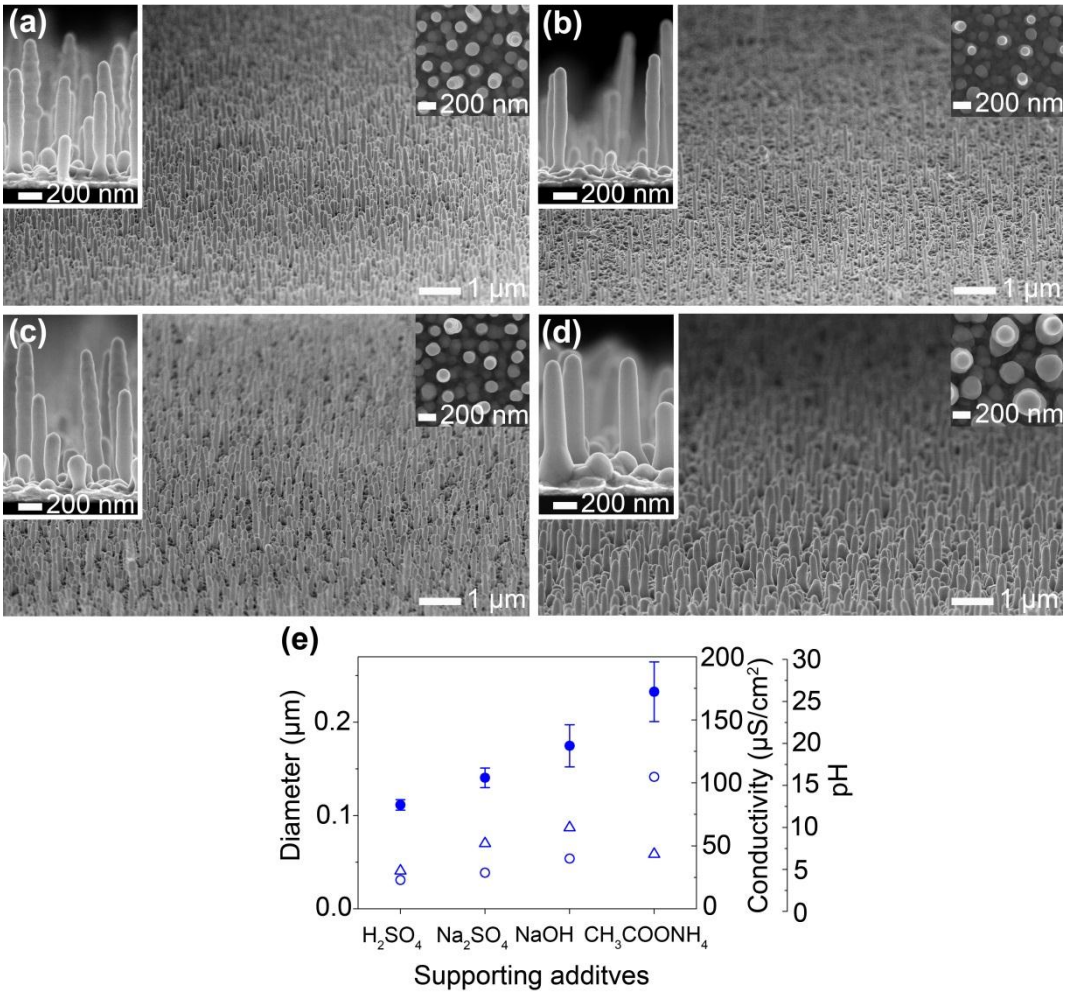

Figure S7. SEM images of silver NWs deposited using various supporting ions, (a) Na_2SO_4 (0.1 mM), *t* = 40 min, (b) H_2SO_4 (0.026 mM), *t* = 15 min, (c) NaOH (0.1 mM), *t* = 1 hr, and (d) CH_3COONH_4 (1 mM), *t* = 2 hr 30 min under a potentiodynamic mode (V_R = 14 V for (a, b, c), and V_R = 7 V for (d)). The left and right insets in each figure denote the enlarged cross-sectional and plan-view SEM images, respectively. (e) Variations in the NW diameter, σ, and pH with the different supporting ions. Solid circles: diameter, open circles: electrolyte conductivity, and open triangles: pH of the electrolyte.

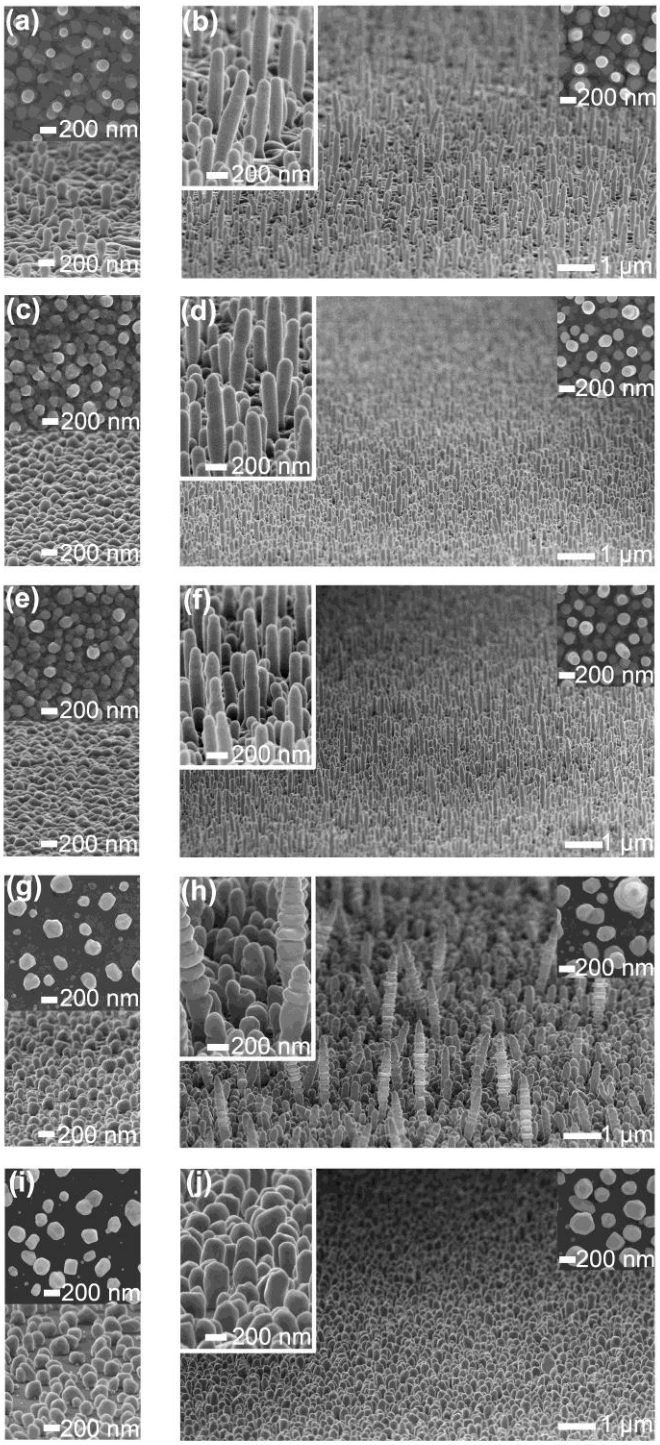

Figure S8. SEM images of silver NWs deposited on different substrates in a 0.1 mM Na_2SO_4-supporting electrolyte, (a and b) Ag film, (c and d) Pt film, (e and f) Au film, (g and h) ITO film, (i and j) P-doped Si. The left column (a, c, e, g, and i) indicates the plan-view and the 13º-tilted SEM images of silver nanocrystals at the nucleation stage. The right column (b, d, f, h, and j) provide the 13º-tilted SEM images of silver NWs. The left and right insets in (b, d, f, h, and j) denote the enlarged tilt and plan-view SEM images, respectively.

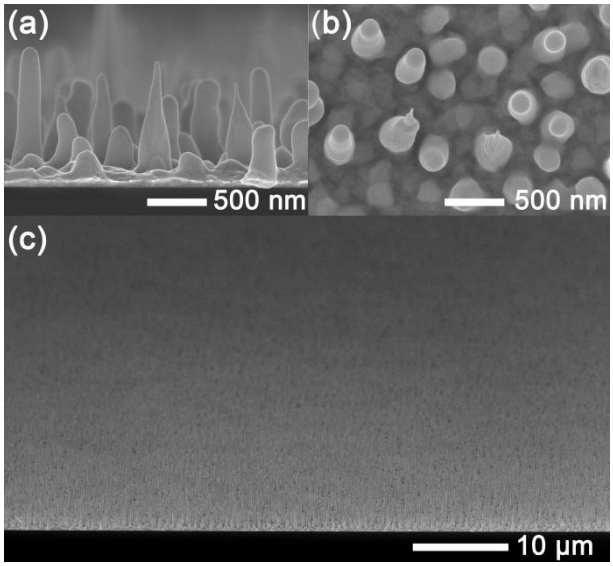

Figure S9. (a) Cross-sectional, (b) top-view, and (c) 13°-tilted SEM images of silver NWs remaining on Au film after delamination of ACTF film.

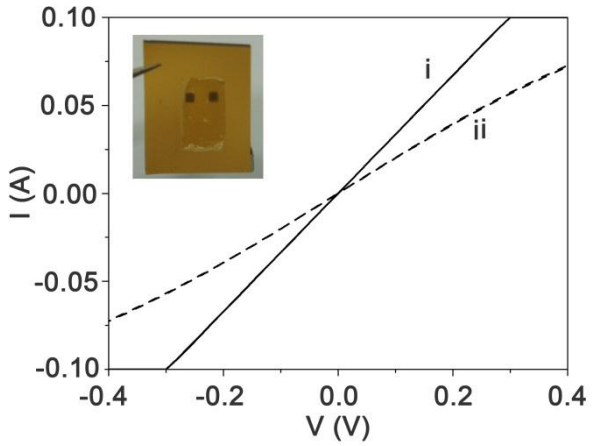

Figure S10. I-V curves of (i) bare Au film and (ii) ACTF film attached on Au film. Inset indicates the optical image of ACTF film attached on Au film using some water vapor.

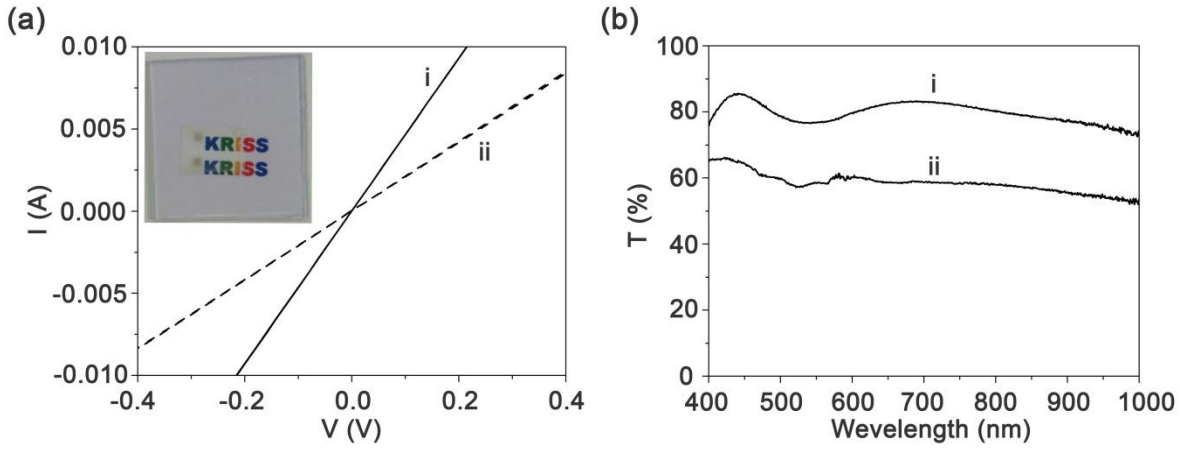

Figure S11. (a) I-V curves of (i) bare ITO-coated glass and (ii) ACTF film attached on ITO-coated glass substrate. Inset in (a) indicates the optical image of ACTF film attached on ITO coating. (b) Variation of optical transmittance (T) of (i) bare ITO-coated glass and (ii) ACTF on ITO-coated glass with the wavelength in the range of 400 to 1000 nm.

Table S1 Compositions, electrical conductivities, and pH values of electrolytes used for the deposition of silver NWs.

Solution		σ ($\times 10^{-6}$ S·cm^{-1})	pH
DI water		1	5.74
$AgNO_3$, 0.02 mM		5	6.32
$AgNO_3$, 0.02 mM	NH_4OH, 0.26 mM	18	9.25
	NH_4OH, 0.79 mM	30	9.72
	NH_4OH, 1.32 mM	35	9.92
	NH_4OH, 2.11 mM	48	10.07
	H_2SO_4, 0.026 mM	23	4.53
	Na_2SO_4, 0.1 mM	29	7.78
	NaOH, 0.1 mM	40	9.68
	CH_3COONH_4, 1 mM	105	6.52