

Supporting Information for

**Coaxial Ag–Base Metal Nanowire Networks with High Electrochemical Stability for
Transparent and Stretchable Asymmetric Supercapacitors**

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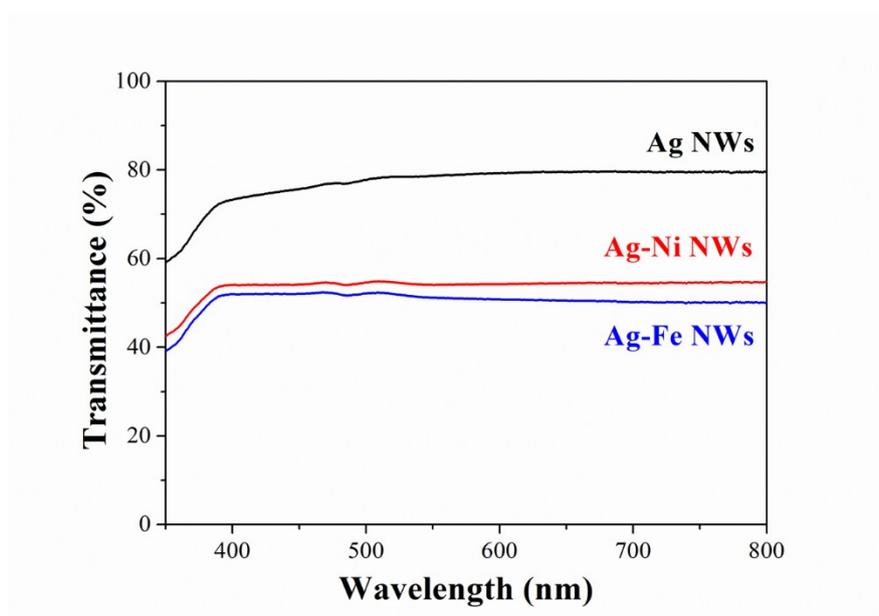


Fig. S1 Optical properties of Ag NWs and Ag–metal NWs electrodes. Optical transmittance of Ag NWs, Ag–Ni NWs and Ag–Fe NWs (sheet resistance: 3.1, 1.2 and 2.9 Ω sq⁻¹, respectively) embedded PUA substrates in the wavelength range from 350 to 800 nm.

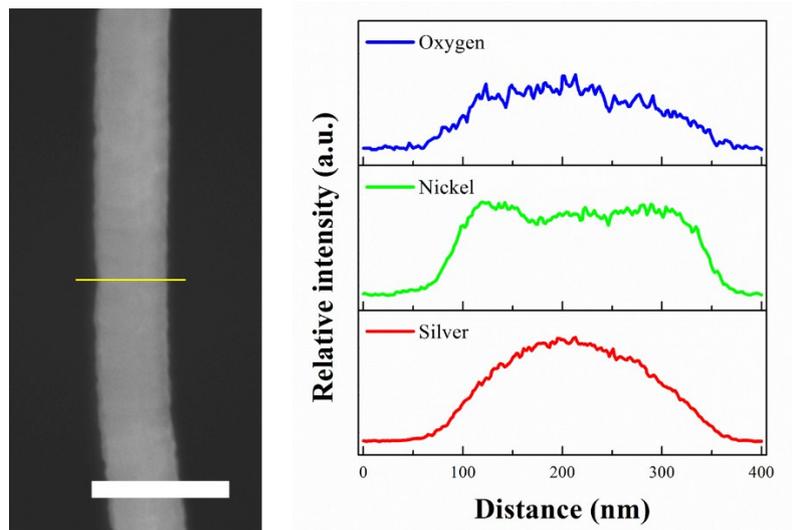


Fig. S2 EDS line-scan profiles of the elements Ag, Ni, and O, across the Ag–Ni core-shell nanowire as indicated by the line. Scare bar: 500 nm.

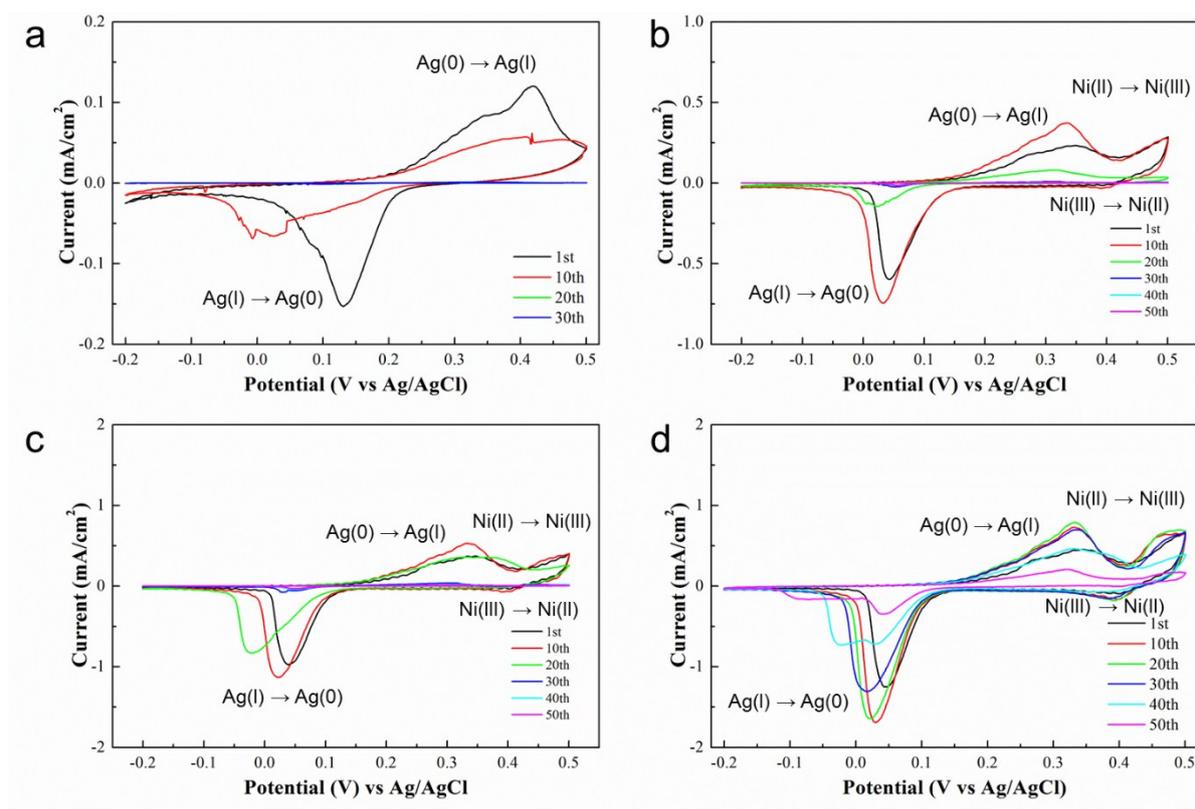


Fig. S3 Electrochemical properties of Ag NWs/PUA and Ni coated Ag NWs/PUA electrodes with measurements at every 10th cycle. The CV curves of (a) Ag NWs/PUA and (b-d) Ni coated Ag NWs/PUA with Ni shell thickness of (b) 40, (c) 300 and (d) 550 nm.

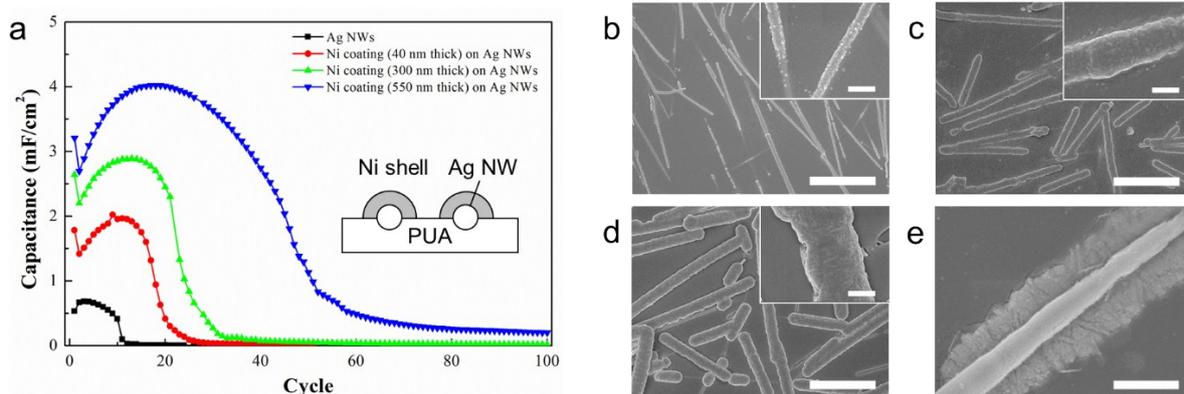


Fig. S4 Electrochemical stability and morphology characterization of Ni coated Ag NWs/PUA electrodes. (a) Cycling performance of Ag NWs/PUA and Ni coated Ag NWs/PUA with Ni shell thickness of 40, 300 and 550 nm. Inset illustrates that Ni shell only covers the exposed area of Ag NWs from the PUA substrate. (b-d) SEM images of Ni coated Ag NWs/PUA with Ni shell thickness of (b) 40, (c) 300 and (d) 550 nm. Scare bar: 6 μm (inset: 500 nm). (e) A SEM image of the Ni coating (160 nm) on Ag NWs peeled off from PUA (Scare bar: 300 nm), indicating the Ni cannot be deposited on the bottom of Ag NWs by coating of Ni on Ag NWs embedded polymer electrodes.

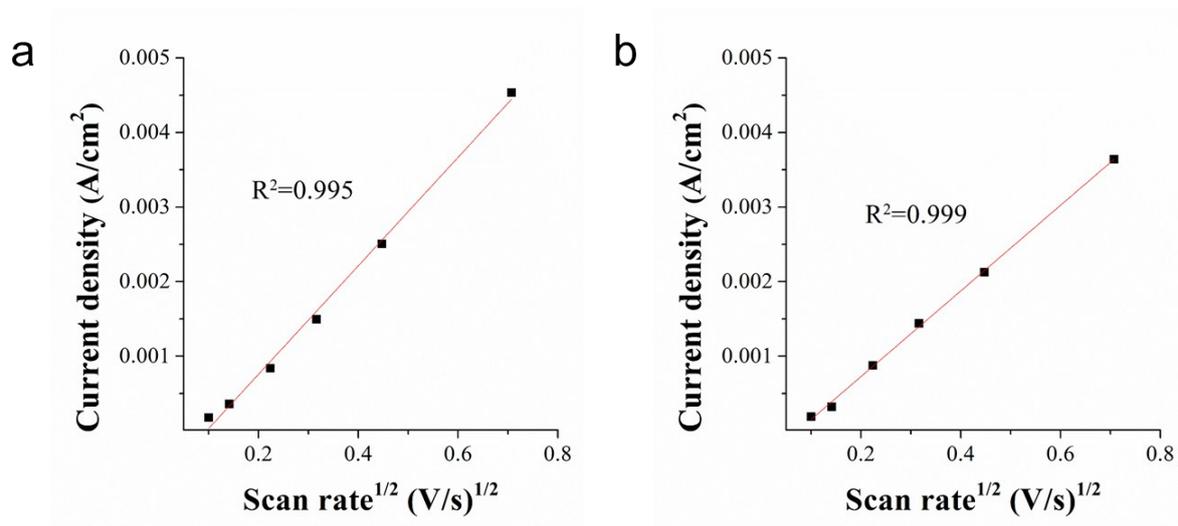


Fig. S5 Electrochemical characterization of Ag-Ni and Ag-Fe NWs. The current density of cathodic peak as a function of the square root of scan rate for (a) Ag-Ni NWs and (b) Ag-Fe NWs electrode.

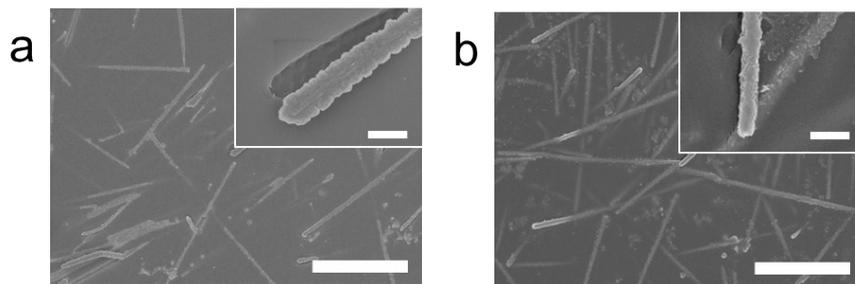


Fig. S6 Microstructure characterization of Ag–Ni and Ag–Fe NWs after cycling. SEM images of (a) Ag–Ni NWs and (b) Ag–Fe NWs on PUA substrates after cycling for 1000 cycles at a scan rate of 50 mV s^{-1} . Scare bar: $6 \mu\text{m}$ (inset: 500 nm).

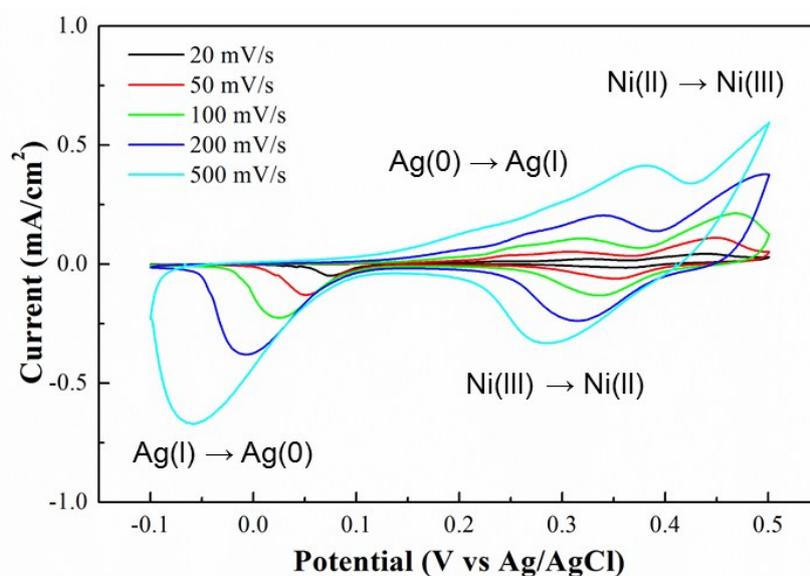


Fig. S7 Electrochemical properties of a Ag–Ni NWs electrode by Ni electrodeposition during 15 s instead of 25. CV curves were measured at various scan rates from 20 mV s^{-1} to 500 mV s^{-1} in a 1 M KOH electrolyte with a three-electrode system.

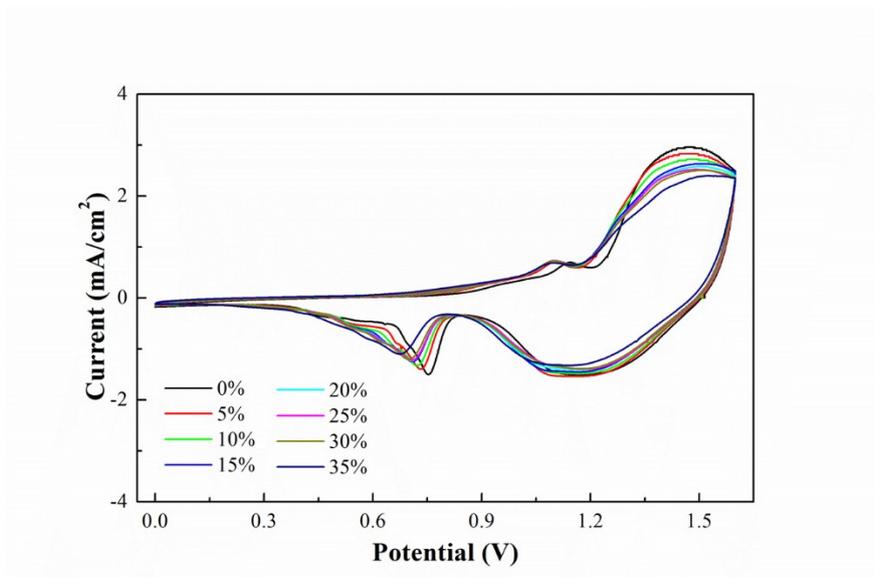


Fig. S8 Device characterization of an asymmetric supercapacitor. Change of the CV curves along with different strains in a sandwich-type supercapacitor based on Ag–Ni and Ag–Fe NWs with PVA–KOH gel electrolyte.

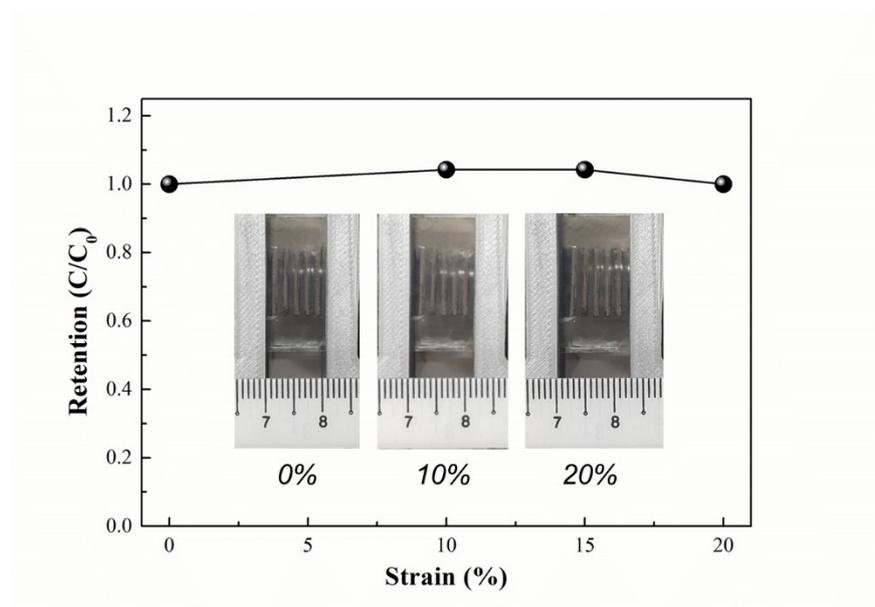


Fig. S9 Device characterization of a micro-patterned supercapacitor. Change of the specific capacitance of the MP device with increasing strain. Inset shows photographs of the device at various strains.

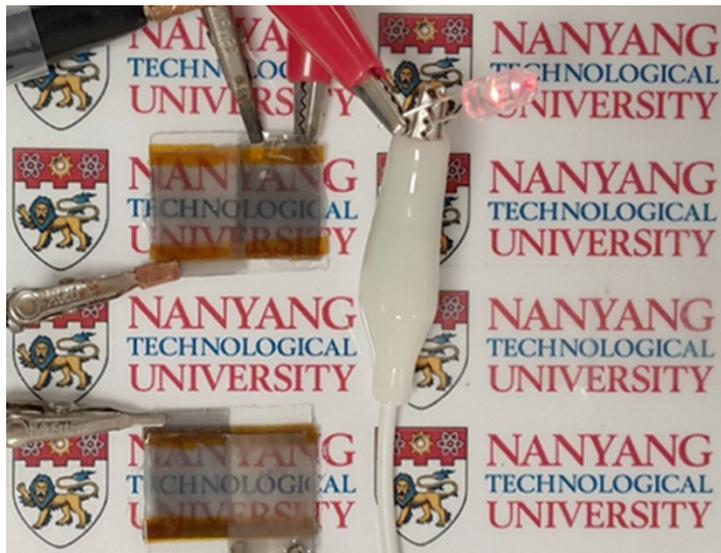


Fig. S10 Two series connected Ag–Ni NWs₍₊₎//Ag–Fe NWs₍₋₎ asymmetric supercapacitors turned on a commercial LEC, demonstrating that optical transparency and performance during power delivery.

Experimental Section

Fabrication of Ag–Ni and Ag–Fe nanowire network electrodes: Ag NWs (diameters of 120–150 nm and lengths of 20–50 μm , Smart Memories Pte. Ltd.) dispersed in isopropanol (concentration of 4 mg ml^{-1}) was deposited onto pre-cleaned glass substrates by a spin-coating method and then post-annealed at $250\text{ }^\circ\text{C}$ for 20 min to form junction between Ag NWs. To make a Ag–Ni core-shell nanowire structure, Ni layer was electrodeposited directly on the Ag NWs/glass substrate before the transfer of Ag NWs into a polymer matrix. A constant potential of $-0.9\text{ V vs. Ag/AgCl}$ was applied for 25 s in a three electrode cell where a platinum plate and saturated Ag/AgCl electrode was used as a counter and reference electrode, respectively, in a typical Watts bath consisting of 10.5 g $\text{NiSO}_4\cdot 6\text{H}_2\text{O}$ (Sigma Aldrich), 1.90 g $\text{NiCl}_2\cdot 6\text{H}_2\text{O}$ (Sigma Aldrich) and 1.24 g H_3BO_3 (Sigma Aldrich) in 40 mL DI water. The product was heated again at $250\text{ }^\circ\text{C}$ for 20 min to form the nickel oxide layer on the surface of Ag–Ni NWs. In the same manner, the electrodeposition of Fe was conducted at a potential of -1 V vs. Ag/AgCl for 50 s in the electrolyte consisting of 1.11 g $\text{FeSO}_4\cdot 7\text{H}_2\text{O}$ (Fluka), 0.99 g H_3BO_3 (Sigma Aldrich) and 2.84 g Na_2SO_4 (Sigma Aldrich) in 40 mL DI water. For the transfer of Ag NWs and Ag–base metal NWs into a polyurethane acrylate (PUA) polymer, the precursor solution composed of Siliconized urethane acrylate oligomer (UA, CN990, Sartomer), ethoxylated bisphenol A dimethacrylate (EBA, SR540, Sartomer) and 2,2-Dimethoxy-2-phenylacetophenone (DMPA, Sigma Aldrich) with weight ratio 100:20:1 was poured onto the nanowires coated glass substrates and then coatings were cured under UV light for 1 min and peeled off.

Assembly of asymmetric supercapacitors: To prepare the PVA–KOH polymer electrolyte, 6 g polyvinyl alcohol (PVA, M_w 146000–186000, Sigma Aldrich) was dissolved in 60 mL DI water at $100\text{ }^\circ\text{C}$ for 2 hours and 3 g KOH (Sigma Aldrich) was dissolved in 20 mL DI water, and then these two solutions were mixed together at $80\text{ }^\circ\text{C}$ for 1 hour. The electrolyte was coated onto the electrodes and dried in a fumehood for several hours. After the gel electrolyte was solidified, two electrodes were assembled together as an asymmetric cell followed by conformal pressing to glue them tightly.

Material Characterization: The X-ray diffraction (XRD, Bruker D-8 Advance with Ni-filtered $\text{Cu K}\alpha$ -radiation ($\lambda = 1.5406\text{ \AA}$)) and scanning electron microscopy (SEM, JEOL 7600F) were used to characterize the structure and morphology of the electrodes. The

transmission spectra of Ag–Ni and Ag–Fe electrodes were measured on a SHIMADZU UV-3600 spectrophotometer over the wavelength range from 350 to 800 nm.

Electrochemical measurements: The electrochemical tests of Ag–Ni and Ag–Fe electrodes were carried out in a three electrode system by an electrochemical analyzer (Autolab potentiostat, PGSTAT30). A platinum plate, saturated Ag/AgCl electrode and 1 M KOH solution were applied as the counter electrode, reference electrode and electrolyte, respectively. The cyclic voltammetry (CV) curves were obtained at various scan rates ranging from 10 to 500 mV s⁻¹. Electrochemical impedance spectroscopy measurements were carried with alternate current amplitude of 5 mV in a frequency range of 0.01–100 kHz at open circuit voltage. The total capacitances (*C*) were calculated by integrating the area of a stable CV curve as follows.

$$C = \frac{1}{2\nu\Delta V} \int IdV$$

where ν is the scan rate and ΔV is the potential window. The total capacitances also were derived from galvanostatic charge/discharge measurements as follows.

$$C = \frac{I\Delta t}{\Delta V}$$

where I is the discharge current and Δt is the discharge time. Areal and volumetric specific capacitances were estimated by dividing the total capacitance by the area of the electrode and the volume of the device, respectively. Volumetric energy density and power density were calculated following the equations below.

$$E = \frac{1}{2} \times C_{specific} \times \frac{(\Delta V)^2}{3600}$$

$$P = \frac{E}{\Delta t} \times 3600$$

where E is the energy density, $C_{specific}$ is the volumetric stack capacitance, P is the energy density and Δt is the discharge time.