Supporting Information

Junction-free Copper Wires with Submicron Linewidth for Large-area High-Performance Transparent Electrodes

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Keywords: electrospinning, transparent conductors, solvent annealing, scalable method, wet etching

General measurements and characterization:

The optical microscope images were obtained from a microscope (Phenix Optics, PH50-3A43L-A) equipped with an 8-megapixel camera (Phenix Optics, MC-D800U(C) TP). The morphology of electrospun fibers and final CuWs was evaluated by a field emission scanning electron microscopy (FESEM, Zeiss, Sigma HD). Tapping mode topography images (20 μm × 20 μm) of annealed fibers were acquired by AFM (SHIMADZU, SPM-9700). XPS measurements are performed on photoelectron spectrometer (Axis Ultra DLD, Shimadza-Kratos), with monochromatized Al Kα at 1486.6eV. Here also includes schematic illustrations such as parameters of metal wires, the isotropic character of wet etching, and the effect of

undercuts. SI video 1 demonstrates CuWs with a large-area of 33 cm × 21 cm. SI video 2 shows the excellent peeling resistance of the junction-free Cu wires.

Demonstration of a resistive touch screen:

SI Video 3 demonstrates the operation of a resistive touch screen. It was fabricated by Shenzhen Jinshenda Technology Co. Ltd. A 12 cm× 7 cm CuWs on PET replaces ITO/PET as a top electrode.

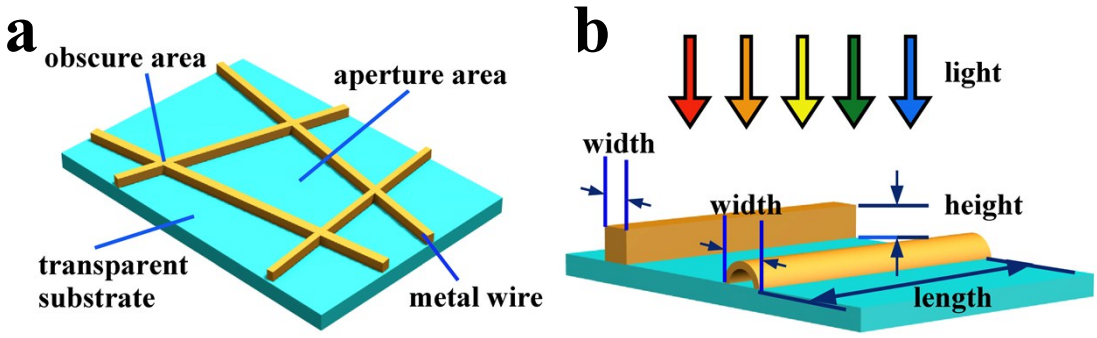

Fig. S1 Parameters that determine performances of metal wire transparent conductors. (a) Parameters of a metal wire network. (b) Parameters of a metal wire or a metal trough.

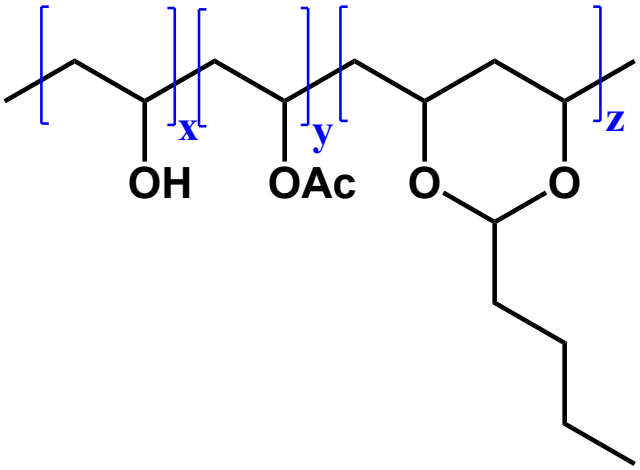

Fig. S2 Chemical structure of poly vinyl butyral (PVB).

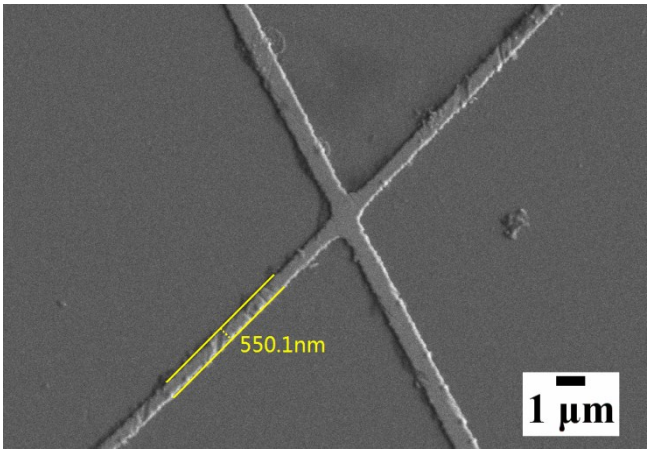

Fig. S3 A Cu wire with linewidth of 550 nm.

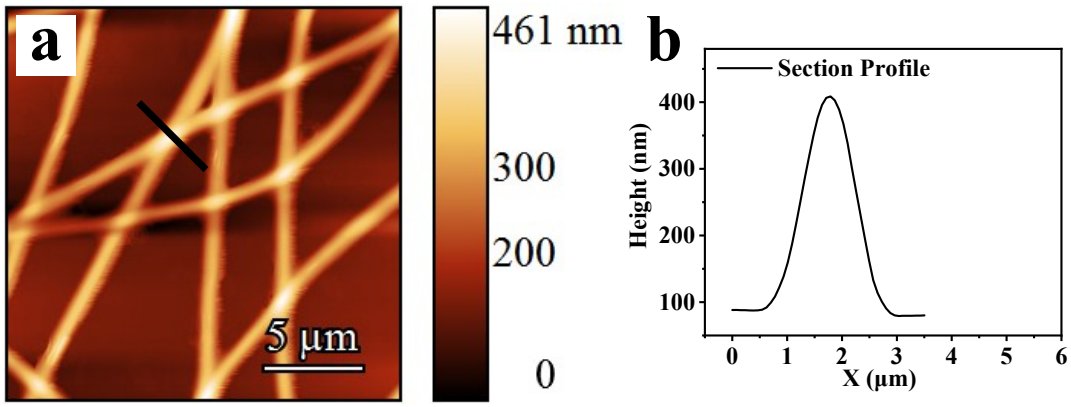

Fig.S4 (a) Tapping mode AFM topography images (20 µm × 20 µm) of annealed electrospun fibers of B-72 (b) A Section profile of a junction.

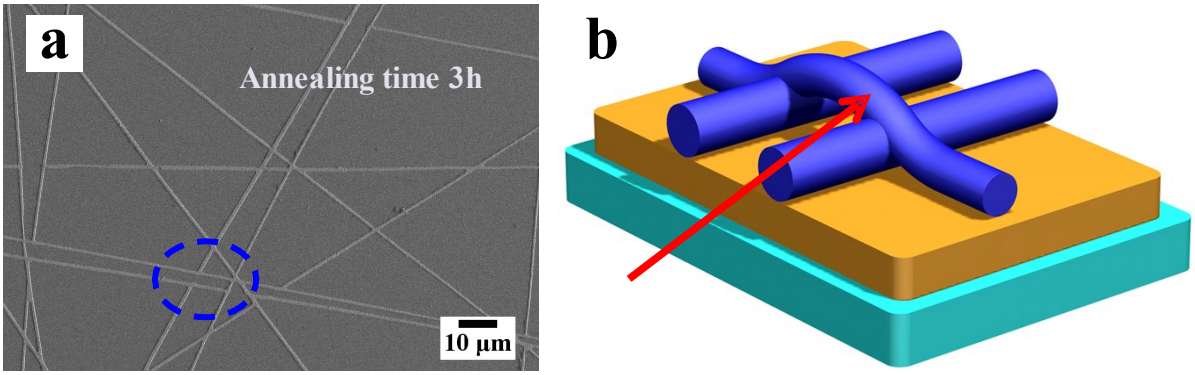

Fig. S5 (a) Undercuts in Cu wires when solvent annealing time is three hours. Some Cu wires between two junctions are totally removed. Blue ellipses are guides for eyes to locate undercuts. (b) Demonstration of partial adhesion of masking fibers to Cu surface. The red arrow indicates the region where severe undercuts take place.

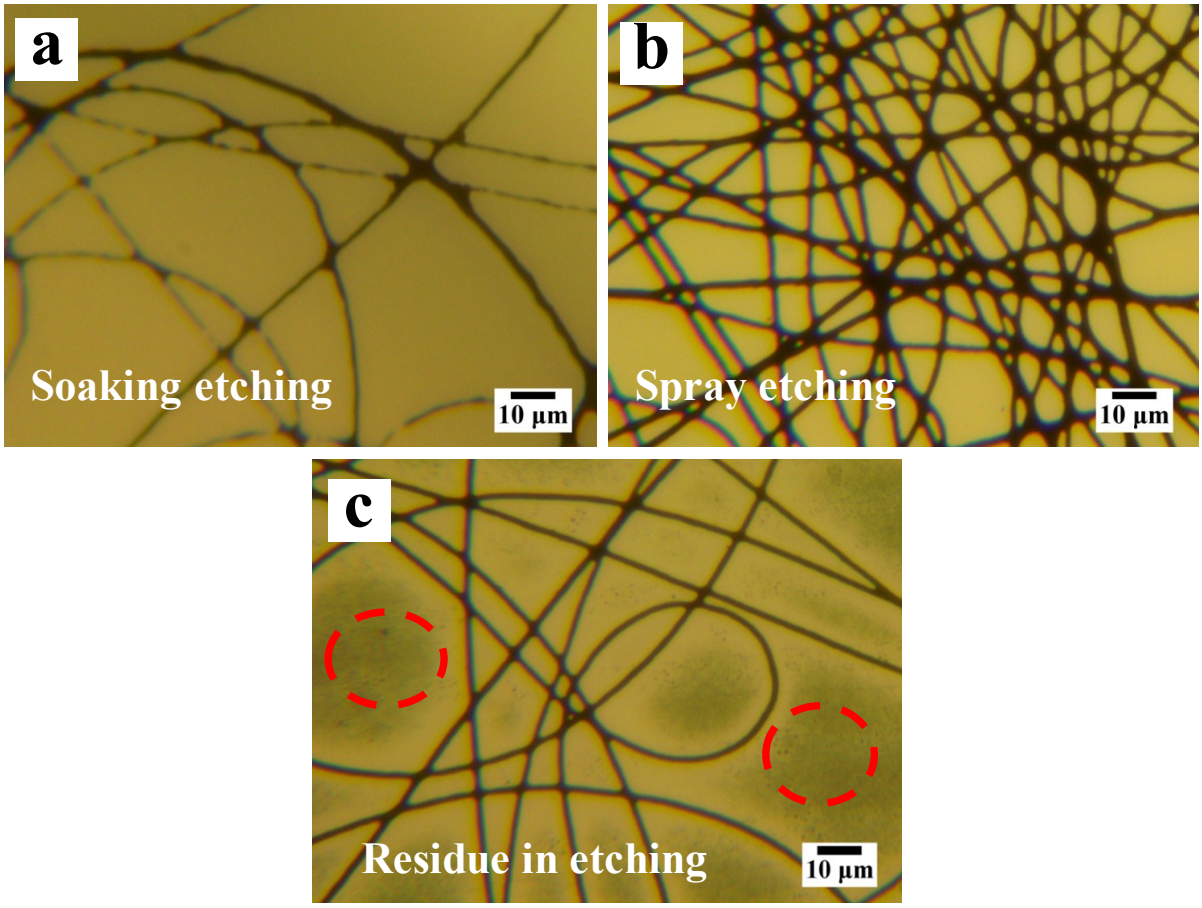

Fig. S6 Microscope images of (a) Cu wires fabricated by soaking etching, (b) Cu wires fabricated by spray etching and (c) Residue among Cu wires when etching is not complete. Masks in these images are electrospun fibers of B-76. Red ellipses are guides for eyes to locate the residue.

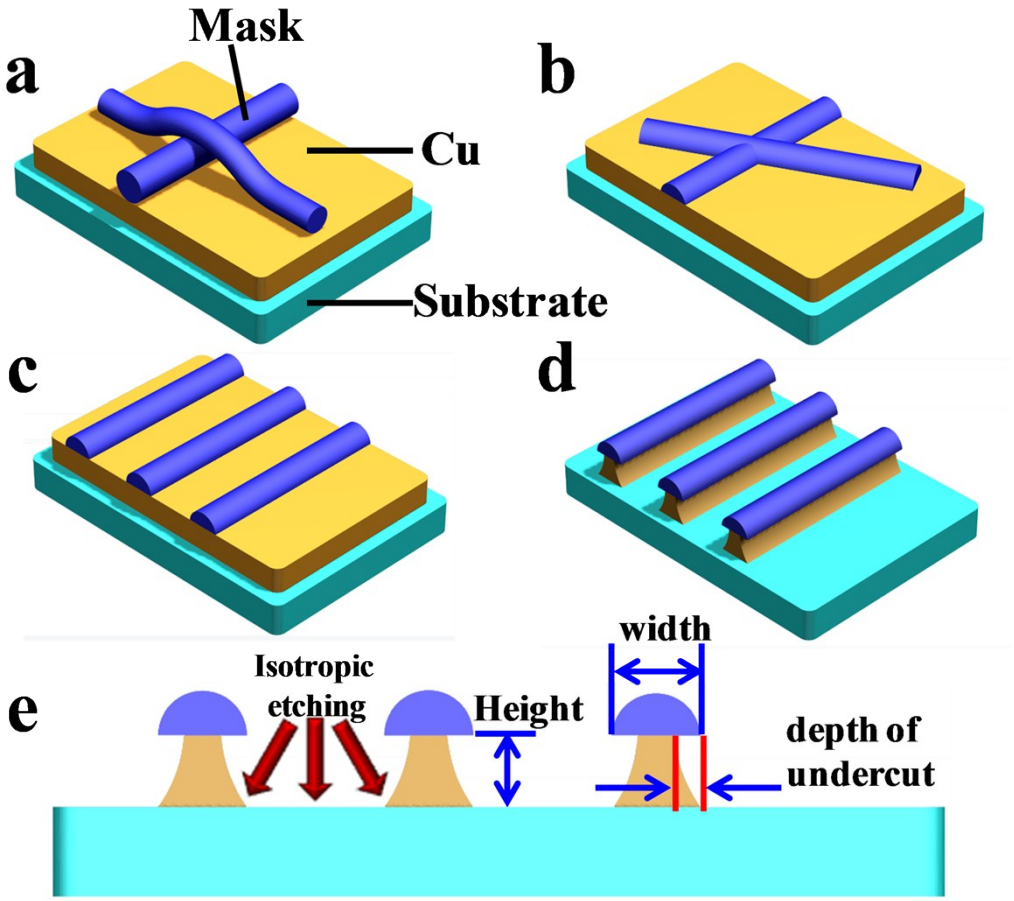

Fig. S7 (a) Partial adhesion of masks to substrates. (b) Full adhesion of masks to substrates. (c) Cu films covered by annealed electrospun fibers. (d) Cu wires with round sidewalls fabricated by an isotropic etching. (e) Front view of d, in which large ratio of width / height helps to avoid breaking Cu wires by limiting undercut depth.

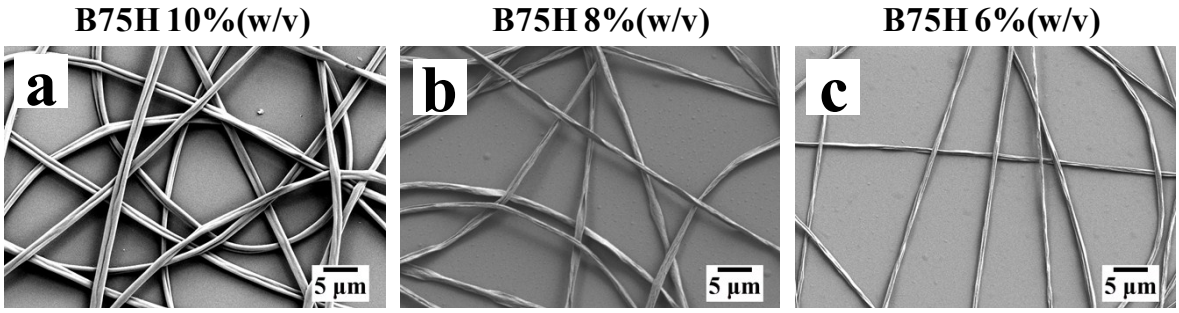

Fig. S8 SEM images of B 75H fibers electrospun from ethanol solutions with concentration of (a) 10% (w/v), (b) 8% (w/v) and (c) 6% (w/v).

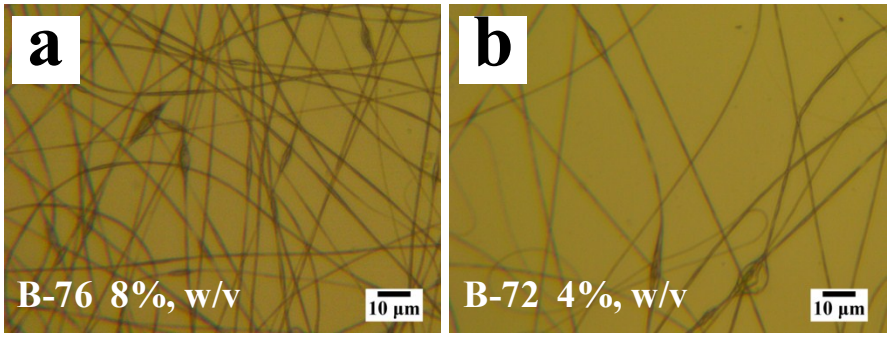

Fig. S9 Microscope images of beaded fibers electrospun from (a) B-76 with concentration of 8% (w/v) and (b) B-72 with concentration of 4% (w/v).

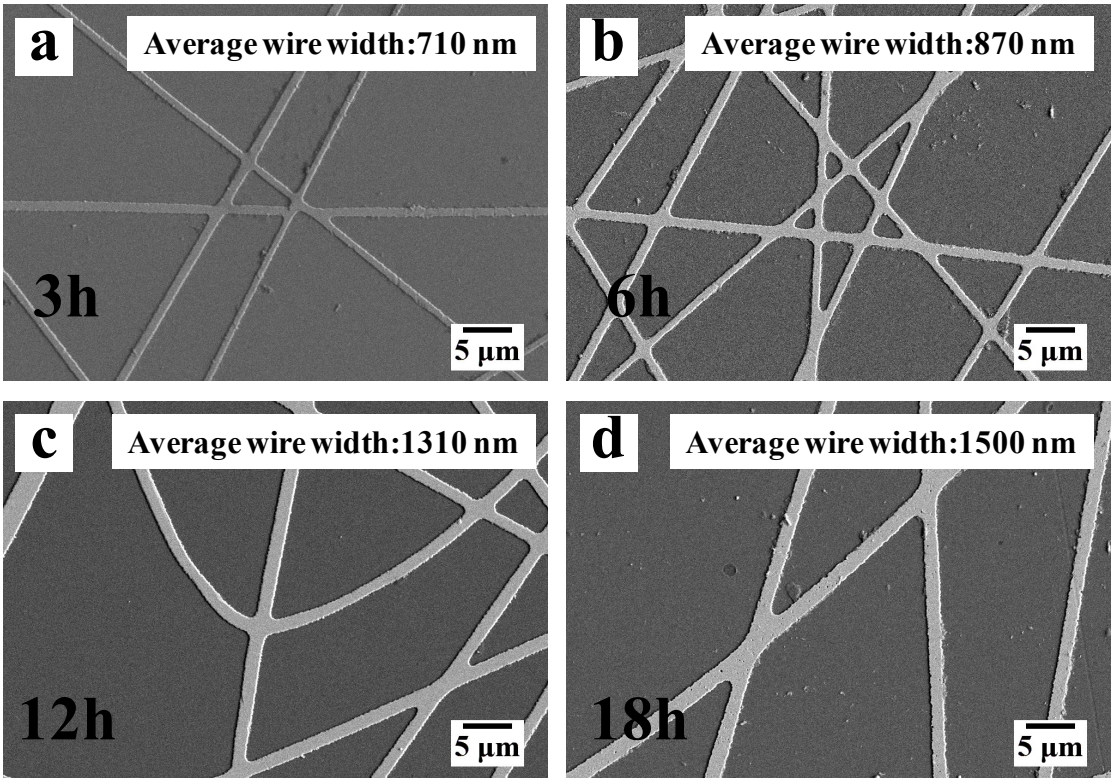

Fig. S10 Tuning solvent annealing time of B-72 fibers and resulting CuWs. Solvent annealing time and average wire widths are (a) 3 hours and 710 nm, (b) 6 hours and 870 nm, (c) 12 hours and 1310 nm and (d) 18 hours and 1500 nm

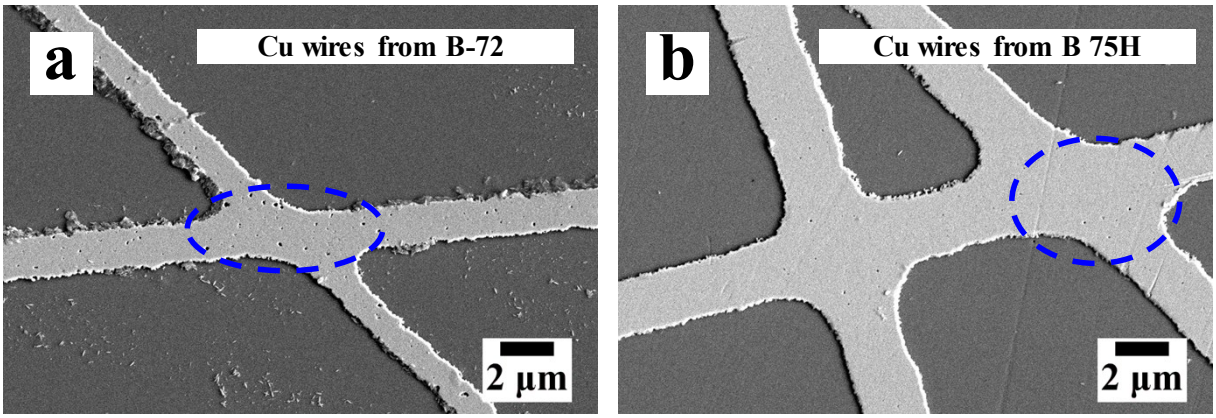

Fig. S11 Point defects on the top surface of Cu wires from (a) B-72 and (b) B 75H Blue ellipses are guides for eyes to locate point defects as cavities.

Table S1 The atomic concentration of elements by XPS measurements

Peak	Atomic concentration (%)
C 1s	66.18
O 1s	24.69
Cu 2p	0.00
Ni 2p	0.91
Cr 2p	1.20
Si 2p	4.49
N 1s	2.53

The sample is prepared by etching a commercial Cu film on polyethylene terephthalate (PET). The residue of Cu is below the detectable concentration (0.1%) of X-ray photoelectron spectroscopy (XPS) measurements. The trivial contents of Ni, Cr, Si, and N may come from the sophisticated formulation of a bonding layer.