Supporting Information

Electric Field Induced Assembly of Ag Nanoparticle on CuO Nanowire by Ambient Electrospray Ionization

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Experimental Section

1.1 The preparation of CuO nanowires on Cu grid

The CuO nanowires were grown on the copper grids (a transmission electron microscopy (TEM) grid) by thermal oxidation method (Fig. S-1A), which has been improved by Y. Xia.[1] The nanowires were CuO, according to the report by Y. Xia. The copper grids were placed in an alumina boat (Hefei Kejing Materials Technology Co., Ltd, China). After temperature of muffle furnace (KSL-1100X-S, Hefei Kejing Materials Technology Co., Ltd, China) rising to set-point temperature (500 ^{o}C, at ambient pressure), the alumina boat was immediately placed into muffle furnace, then heated in air at 500 ^{o}C for 4 h. Naturally cool to room temperature and then take out the samples. As shown as Fig. S-1. A, the CuO nanowires from the inner wall of the hole were much straighter and longer as compared with wires formed on the top surface of copper grid. This structure is very meaningful for spontaneous electric field induced assembly. The XRD pattern (Fig. S-1. B) shows that the sample includes CuO and Cu_2O except from Cu. Most part of the oxidation of copper grid was turned into Cu_2O, and a small amount of CuO was produced to form nanowires. The copper meshs treated by thermal oxidation method were used as collectors.

1.2 The preparation of dandelion-like CuO-Ag hybrid hierarchical nanostructures

For all assembly experiments, a home-made nanospray emitter was adopted to spray charged microdroplets containing aqueous solution of silver acetate (AgOAc, Aladdin, 99.5%) onto the collector, placed on top of copper sheet. The home-made nanospray emitter was made by hand pulling a glass tube (7 mm outer diameter and 5.5 mm inner emitter tip was measured to be 20-30 μm under the microscope (Ti-S, Nikon). The aqueous solution of silver acetate (10 mM) was filled into the nanospray emitter, ensuring that there was no bubble in the tube. A platinum (Pt) wire (the diameter is 0.2 mm), connected with a high voltage power supply (Boher High Voltage Power Supplies Co., Ltd, China), was inserted into nanospray emitter and a high voltage (1.5-2.0 kV) was applied. The copper sheet was grounded through an electrometer (Keithley 6517B Electrometer/High Resistance Meter). The collector was prepared from the copper grid (transmission electron microscopy (TEM) grid) by thermal oxidation method. Ultrapure water (Milli-Q Integral 3) was used to dissolve the AgOAc, in the assembly experiments. A static

positive voltage (1.5-2 kV) was applied to the solution through the Pt wire electrode. The distance between nanospray emitter and collector was controlled to be 5 mm by three dimensional control platform and the deposition was done.

1.3 Material characterization

The scanning electron microscopy (SEM) was performed with a FEI Helios Nanolab 600i double beam scanning electron microscopy. All of the transmission electron microscopy (TEM) measurements and elemental mappings were carried out on a Tecnai G2 S-Twin F20 electron microscope operating at 200 kV. X-ray powder diffraction patterns were accumulated on a X-ray diffractometer (Ultima Ⅳ, Japan Rigaku) using graphite monochromatized Cu Kα radiation (λ=1.5418 Å). To confirm the presence of solvated Ag^+ ions, mass spectra were collected using an Orbitrap Fusion (ThermoFisher Scientific, USA) mass spectrometer. X-ray photoelectron spectra (XPS) were recorded with an ESCALAB 250Xi electron energy spectrometer from Thermo company using Al Kα (1486.6 eV) as the X-ray excitation source.

Figures

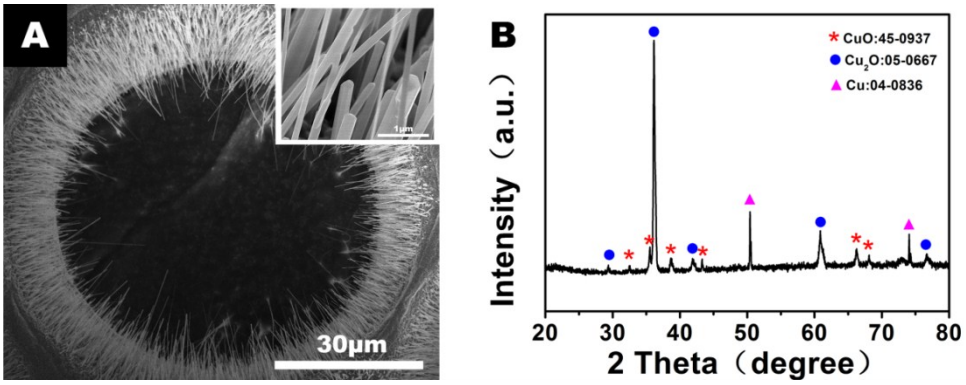

Fig. S-1 The CuO nanowires prepared with the thermal oxidation method. A) the SEM image and B) the XRD pattern.

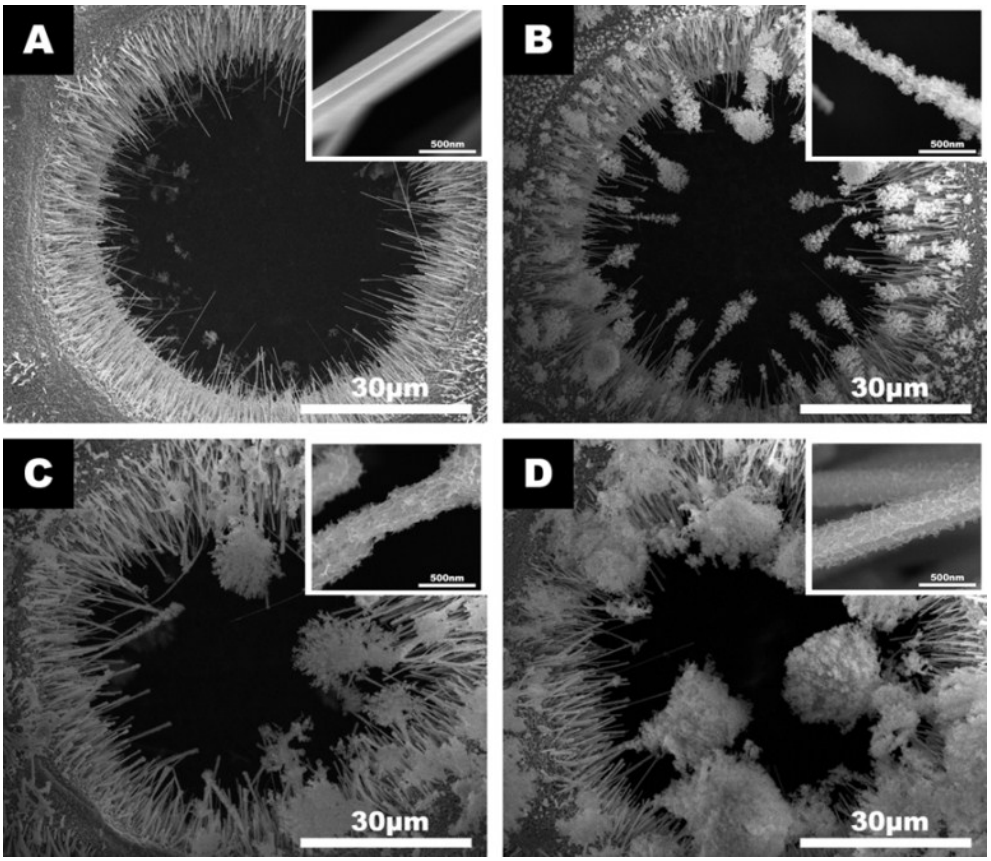

Fig. S-2 The SEM images of the CuO/Ag Nano-dandelion prepared with different deposition time. The precursor concentration is 10 mM. The typical deposition current was 150 nA A) 5 min; B) 15min; C) 30 min; D) 60 min.

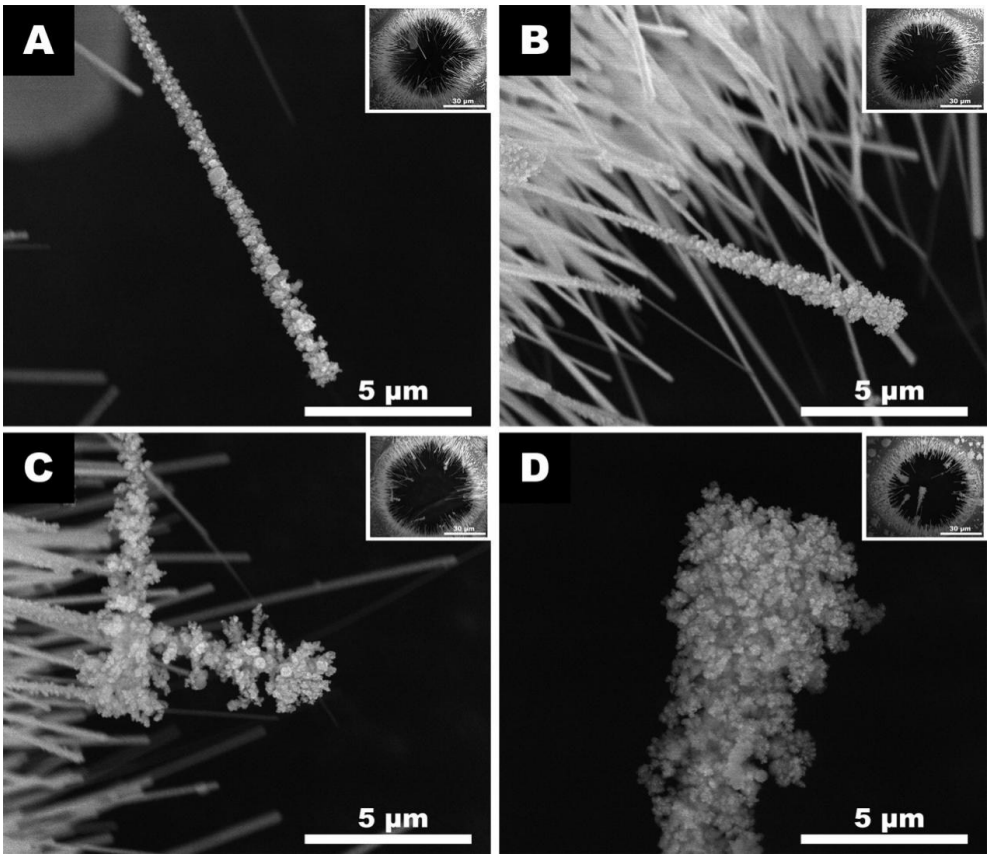

Fig. S-3 The SEM images of the CuO/Ag Nano-dandelion prepared with different deposition currents. The precursor concentration is 10 mM and the deposition time is 15 min. A) 10 nA; B) 50 nA; C) 100 nA; D) 150 nA.

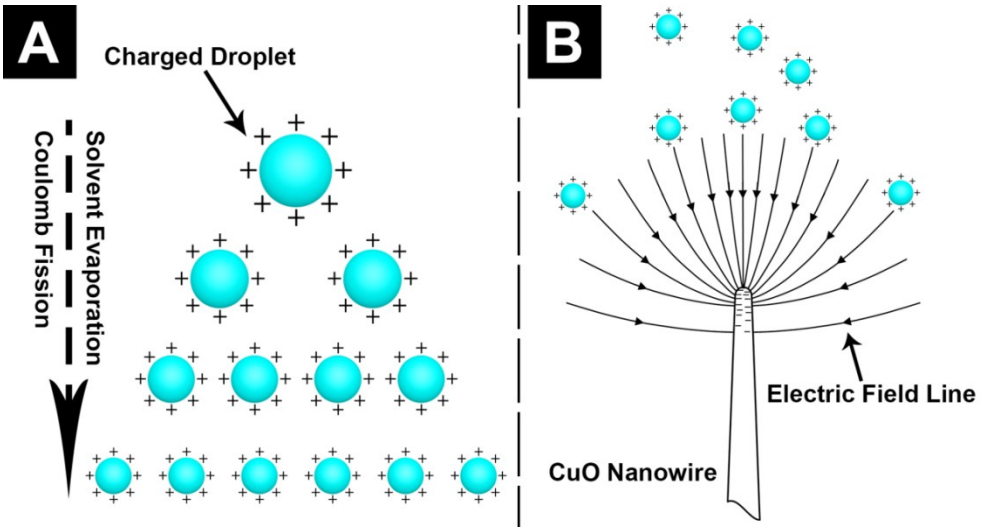

Fig. S-4 A) The schematic representation of Coulomb fission process of charged microdroplets, B) schematic representation of microdroplets soft-landed onto the CuO nanowires driven by the electric field force.

References

1. X. Jiang, T. Herricks and Y. Xia, *Nano Lett.*, 2002, **2**, 1333-1338.