Supporting information

Controllable fabrication of a flexible transparent metallic grids conductor based on the coffee-ring effect

Zhiliang Zhang *[a,b] and Weiyue Zhu [a]

[1]*Research Center of Analysis and Test, Qilu University of Technology, Jinan 250353, China.*
[2]*Beijing National Laboratory for Molecular Sciences (BNLMS), Institute of Chemistry, Chinese Academy of Science, Beijing 100190, China.*
Email: zhzhl@iccas.ac.cn

1. Materials and methods

1.1 Materials

Silver acetate, ascorbic acid, poly(acrylic acid) sodium solution (M_W=8000, 45 wt% in H_2O), poly(acrylic acid) sodium solution (M_W=15000, 35 wt% in H_2O) were purchased from Sigma-Aldrich. Ethanol, acetone and ethylene glycol were obtained from Beijing Chemical Co. The other chemicals were analytical or reagent grade, and all of these chemicals and materials were used as received without further purification. The water used throughout this work was ultrapure water (18.2 MΩ) produced by a Milli-Q system.

1.2 Characterization

The UV-vis spectra and thermogravimetric (TG) analysis of AgNPs were collected using a Hitachi U-4100 spectrophotometer and TA Q500 thermogravimetric analyzer, respectively. The size distribution of the AgNPs s was characterized by JEOL JEM-2100F transmission electron microscopy (TEM) operated at 200 kV, and the samples were prepared by dropping the solution onto a carbon coated copper grid. X-ray photoelectron spectroscopy (XPS) was recorded on ESCALab 220i-XL electron spectrometer from VG Scientific using 300 W Al Kα radiation, and the base pressure was about 3×10^{-9} mbar. The structure and morphology of the AgNPs grids were investigated by a Hitachi S-4800 scanning electron microscope, NSK SPA400 atomic force microscope, and an Olympus MX40 optical microscope. The adhesion of the conductive grids was tested by a usual adhesive tape method. The resistance of AgNPs

grids was measured at five different points by using a four-pin probe resistivity meter (Mitsubishi Chemical Analytech Co., Loresta-GP MCP-T610). The cross-sectional area of printed lines was determined in the Kosaka ET4000 surface profiler.

2. Experimental section

2.1 The synthesis of AgNPs

The AgNPs with an average particle size of 20-30 nm were synthesized according to the following procedure. In a typical synthesis process of AgNPs, 5.6 g silver acetate, 1.0 g poly(acrylic acid) sodium solution (M_W=8000, 45 wt% in H_2O) and 0.3 g poly(acrylic acid) sodium solution (M_W=15000, 35 wt% in H_2O) were firstly mixed and heated to 90 °C for 30 min in 50 mL of ultrapure water. Then, 4.2 g of 30 wt % ascorbic acid was slowly added added into the resulting solution with continuous stirring and reacted at 90 °C for 1 h before down to the room temperature. Subsequently, the obtained AgNPs were washed by centrifugation and vacuum-dried at room temperature. The UV-Vis spectra, XRD spectra, SEM and TEM image of synthesized AgNPs (Fig. S1) indicated that this procedure could synthesize AgNPs with 24 ±3.6nm size distribution in high yield. The TG analysis (Fig. S1b) indicated that PAA as a good capping molecule could be anchored on AgNPs surfaces and formed proactive layers to efficiently prevent further agglomeration.

2.2 Fabrication of AgNPs grids by inkjet printing

The synthesized AgNPs were redissolved into water, with ultrasonic for 30 min, followed by filtrating through a 0.45μm syringe filter to form the aqueous conductive ink. The final concentration of AgNPs in the ink was 0.5% by weigh, and the surface tension of the AgNPs ink was about 30 mN/m. According to the design, the grids were fabricated by ink-jetting the AgNPs ink onto PET substrates using Dimatix Fujifi lm DMP-2831 printer with 10 pL Dimatix materials cartridge controlled with the Dimatix Drop Manager software. The substrate temperature was set to 30 ℃, and the humidity within the printing chamber was 30–40% relative humidity (RH), and the printed AgNPs grids was dried for approximately 15-20 minutes. The printed AgNPs grids on PET substrates were placed 2 cm above a 37% HCl solution for a certain time to achieve low resistivity.

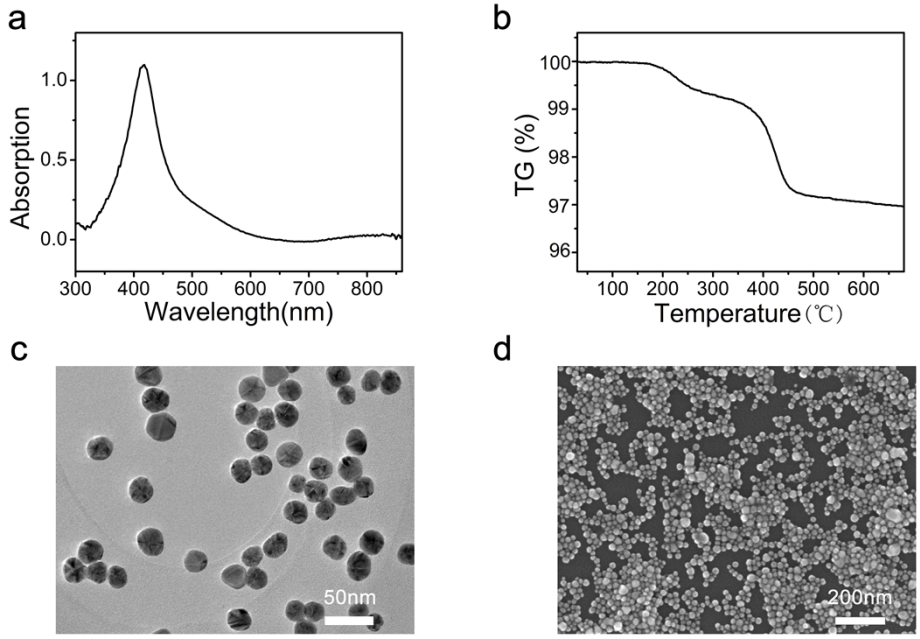

Fig. S1. (a) UV-vis spectrum, (b) TG analysis, (c) TEM and (d) SEM images of the synthesized AgNPs.

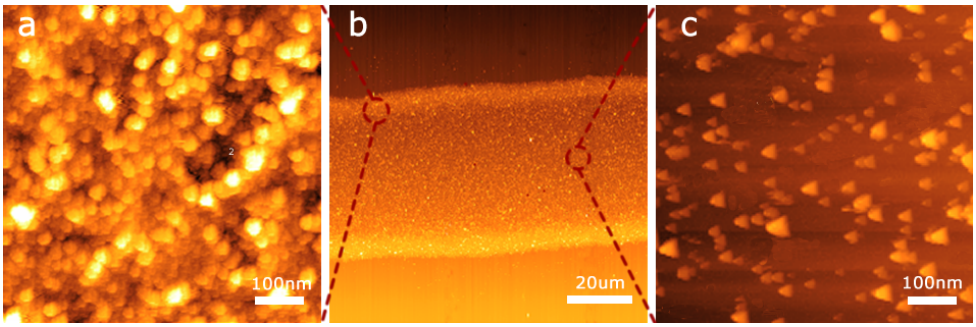

Fig. S2. (a) AFM images of printed c AgNPs grids rim (b) AFM images of printed AgNPs grid (c) AFM images of printed AgNPs grids center

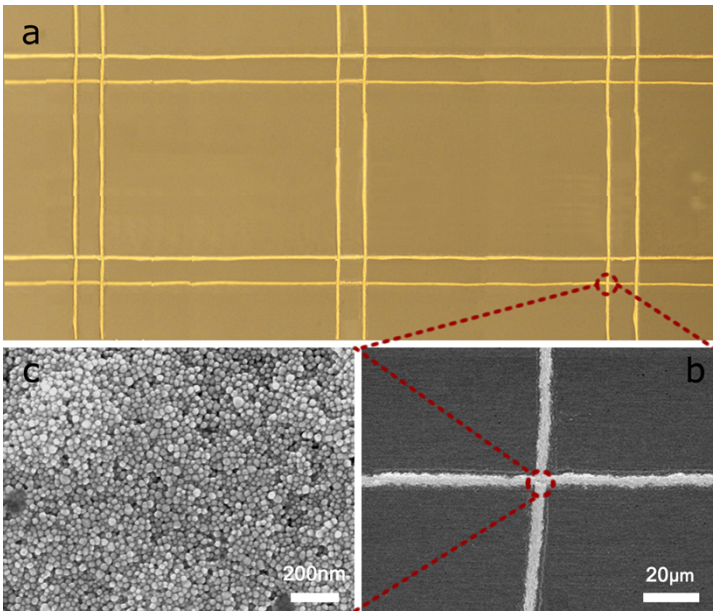

Fig. S3. (a) The optical microscope image of the AgNPs grids patterns junction, (b) (c) SEM images the junction of the printed reticular patterns