Electronic Supplementary Information

Facile synthesis of highly conductive Ag/TiN nanofibers for cost-saving transparent electrodes

Sanyuan Hu, Heping Li, Zhen Su, and Youwei Yan*

State Key Laboratory of Materials Processing and Die & Mould Technology, Department of Materials Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, P. R. China. E-mail: liheping@hust.edu.cn

1. Experimental section

Materials

Tetrabutyl titanate (TBT, 99%, Aladdin Industrial Co., China), acetyl acetone (Hacac, 99%, Aladdin Industrial Co., China), silver nitrate ($AgNO_3$), N.N-dimethylformamide (DMF, 99%, Sinopharm Chemical Reagent Co. Ltd, China), polyvinylpyrrolidone (PVP, Mw=1300 000, Aladdin Industrial Co., China) and ethanol (EtOH, 99%, Sinopharm Chemical Reagent Co. Ltd, China) were used as received.

Electrospinning procedure

The precursor nanofibers were fabricated by an electrospinning instrument (Tlwnt Co., China). The instrument consists of four components: a high voltage power supply, a spinning nozzle, a flat-plate collector, and a syringe pump. The spinning nozzle is connected to the power supply, which can apply a certain voltage to the nozzle. The

collector, which is grounded, is placed below the spinning nozzle with a designed distance. During electrospinning process, the as-prepared solution was delivered into the spinning nozzle by the syringe pump. Once a high voltage was applied to the nozzle, a electric field force was generated between the nozzle and the collector, which could overcame surface tension of the solution and made the solution eject from the nozzle towards the collector. Accompanied with solvent evaporation, the solution jet was deposited on the surface of the collector, and accordingly the precursor nanofibers were obtained.

Preparation of Ag/TiN nanofibers

Ag/TiN nanofibers were fabricated in three steps. The schematic illustration is shown in Figure S1. First, we prepared sol-gel solution for electrospinning. A certain amount of $AgNO_3$ was dissolved in DMF, Ethanol, acetic acid, and TBT were subsequently added to the $AgNO_3$-DMF solution with an Ag/Ti atom ratio of 30%. After achieving a uniform mixture, PVP was further dissolved in the solution by stirring for two hours to enable the solution spinnable. Second, precursor composite nanofibers were fabricated by employing typical electrospinning technique using the as-prepared solution. In the electrospun procedure, the solution was delivered to a syringe with its stainless needle connected to a high voltage supply. When applying 10 kV to the needle, random precursor nanofibers were collected on the surface of an aluminum foil that was grounded and placed under the needle tip with a distance of 18 cm. Finally, the as-obtained precursor nanofibers were transformed into Ag/TiN

nanofibers through heat treatment at 500 °C in air and subsequent nitridation in ammonia atmosphere at varying temperatures from 700 to 1000 °C.

Characterization

X-ray diffraction (XRD, X'pert PRO, PANalytical B.V., Netherlands) coupled with Cu Kα radiation (λ=0.15406nm) and Raman spectrometer (LabRAM HR800, Horiba JobinYvon) were used to determine the phase constitution of the nanofibers. Field emission scanning electron microscopy (FESEM) equipped with energy dispersive spectroscopy (EDS) and transmission electron microscopy (TEM) were employed to investigate the morphology and structure of these fibers. The current-voltage (I-V) characteristics of Ag/TiN nanofibers were measured by a Keithley 2450 measurement system. The sheet resistance of the assembled Ag-TiN network was tested by a four-probe method, and its transmittance was carried out on an ultraviolet and visible spectrophotometer (UV, LabRAM HR800, Horiba JobinYvon).

2. Experimental results

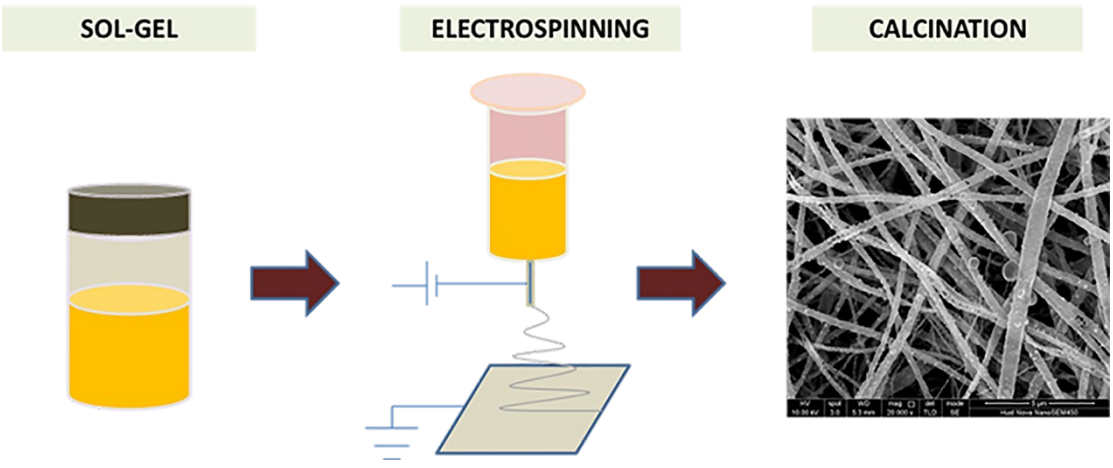
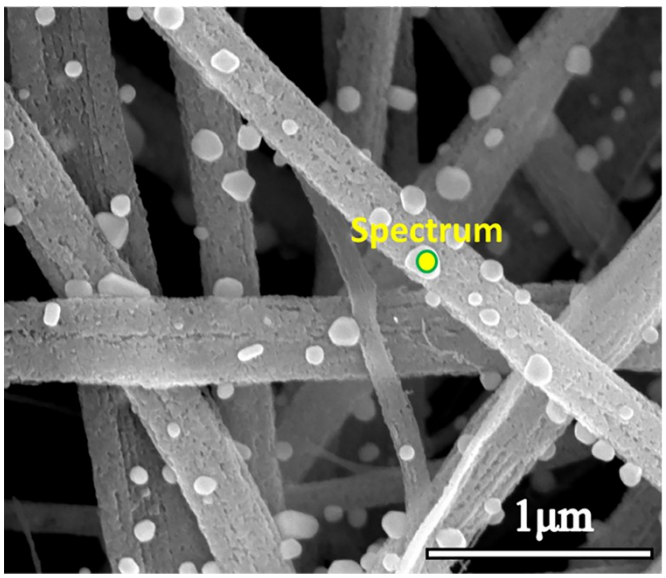
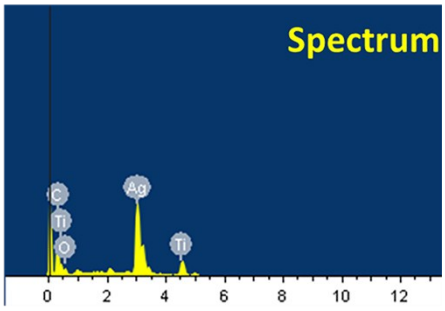


Fig. S1 A schematic illustration for fabricating Ag/TiN nanofibers.





Element	Percentage by weight
C	7.47
O	8.90
Ti	12.94
Ag	70.69

Fig. S2 Energy dispersive spectroscopy of Ag/TiN nanofibers.

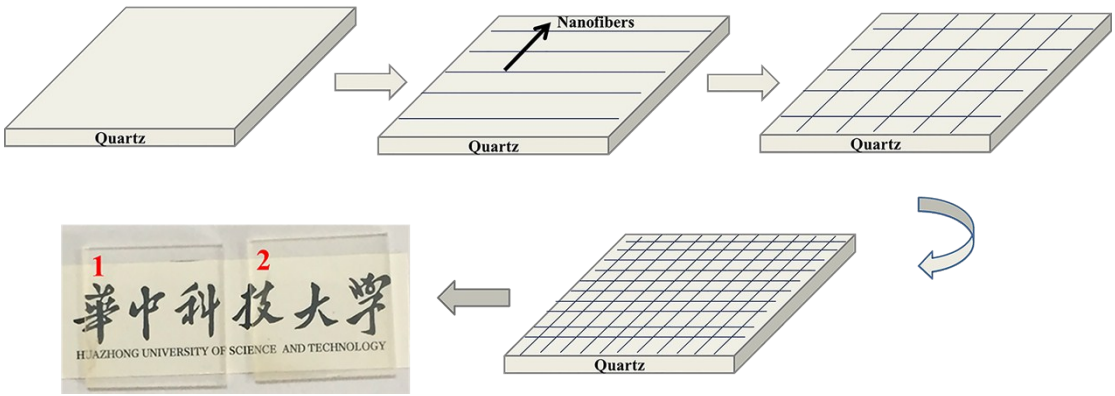


Fig. S3 A schematic illustration of the whole process for the fabrication of Ag/TiN nanofiber network device.

Table S1 Comparison of electrical conductivity between Ag/TiN nanofibers and Ag-contained composites as well as TiN-based composites

Materials	Preparation method	Electrical conductivity(S/cm)
Ag/$Li_4Ti_5O_{12}$ (Nanofiber)[29]	Solid-State	$5x10^{-7}$
Ag/ZnO (Nanofiber)[8]	Electrospinning	115
TiN (Bulk)	CVD	$4x10^4$
TiN (Nanofiber)[9]	Electrospinning	121
Cu/TiN (Nanofiber)[20]	Electrospinning	145
Ag/TiN (Nanofiber)	Electrospinning	1181