

Aligned Electrospun ZnO Nanofibers for Simple and Sensitive Ultraviolet Nanosensors

Zhengtao Zhu,^{a*} Lifeng Zhang,^a Jane Y. Howe,^c Yiliang Liao,^a Jordan T. Speidel,^a
Steve Smith,^b and Hao Fong^{a*}

^a Department of Chemistry, ^b Nano Program, South Dakota School of Mines and Technology, Rapid City, SD 57701, ^c Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831

Experimental:

Preparation of electrospun ZnO nanofibers: The solution for electrospinning was prepared by dissolving 0.9 g zinc acetate (Aldrich) and 2.7 g polyvinylpyrrolidone (PVP, Mw = 1,300,000, Aldrich) in 9.5 ml dimethyl formamide (DMF) at the room temperature. During electrospinning, a positive high voltage of 24 kV was applied through a copper wire to the solution held inside a glass pipette with the capillary tip diameter of ~0.5 mm. An electrically grounded copper plate was placed approximately 25 cm below the tip of the pipette. This process of electrospinning was very stable, and the electrospinning jet ran steadily between the pipette and the copper plate. To obtain uni-axially aligned nanofibers, a U-shaped metal device with the distance between the two legs of ~25 mm was used; by manually moving the electrically grounded device back and forth for several times under the electrospinning jet, tens to hundreds of highly aligned nanofibers were collected between the legs. After those precursor nanofibers were transferred onto a silicon (Si) substrate with 300 nm thermal oxide (SiO₂) layer, and then pyrolyzed at 500 °C for 4 hours in air to remove the organic components, the electrospun ZnO nanofibers with diameters of ~200 nm were obtained.

Characterization of electrospun ZnO nanofibers: A Zeiss Supra 40VP field-emission SEM and a Rigaku Ultima Plus XRD at the South Dakota School of Mines and Technology, as well as a Hitachi HF-3300 TEM/STEM at the Oak Ridge National Laboratory, were employed to characterize the morphological and structural properties of both the as-electrospun precursor nanofibers and the resulting final ZnO nanofibers. Prior to SEM examinations, the specimens were sputter-coated with gold to avoid charge accumulations. A rotating X-ray generator (40 kW, 40 mA) with CuK α radiation ($\lambda = 1.54\text{\AA}$) was used during the XRD experiments. The XRD profiles were recorded from 10 to 70° at the scanning speed of 2° min⁻¹. The TEM specimens were prepared by dispersing fibers onto lacey carbon films supported on 200-mesh copper grids. TEM study was sponsored by the U.S. Department of Energy, the Assistant Secretary for Energy Efficiency & Renewable Energy, Office of FreedomCAR and Vehicle Technologies, through the High Temperature Materials Laboratory (HTML) at the Oak Ridge National Laboratory (ORNL).

Fabrication and evaluation of the UV nanosensors made of uni-axially aligned electrospun ZnO nanofibers: The UV nanosensors were fabricated by placing the electrospun (zinc acetate/PVP) precursor nanofibers on the Si/SiO₂ substrate with two gold electrodes, followed by pyrolysis at 500 °C for 4 hours in air. The two electrodes were lithographically defined with the gap of 250 μm and the width of 3.0 mm. The

current-voltage characterization of the ZnO nanosensors were performed in the dark or under UV irradiation using Keithley 2612 SourceMeters. A 365 nm ultraviolet lamp (UVO B-100) was used as the light source, and the light intensities were modulated with a neutral density filter (Ocean Optics) and were measured with a photometer.

Results:

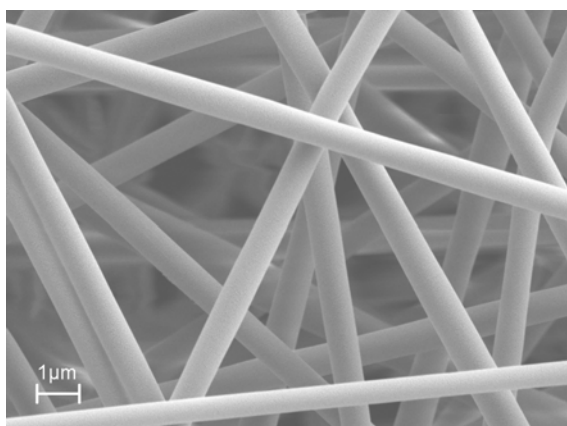


Figure S1: A representative SEM image showing the as-electrospun (zinc acetate/PVP) precursor nanofibers

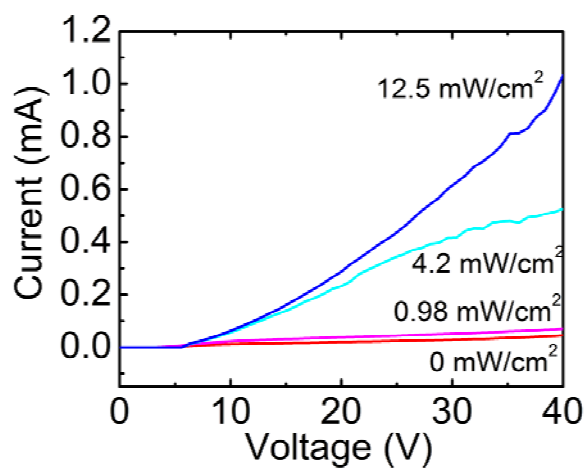


Figure S2: The current-voltage curves of a typical PVP-coated ZnO nanosensor under different intensity of UV irradiation