Supporting Information

Simultaneous Sensing of UV Light and Strain with a Single-Layer Network Structure of Self-Assembled ZnO Nanorods

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1. Experimental

1.1 Synthesis of ZnO NRs

Zinc acetate dihydrate ($Zn(CH_3COO)_2 \cdot 2H_2O$, Sigma Aldrich 99.999%) and potassium hydroxide (KOH, 99% pure, Sigma-Aldrich) were used in this work. ZnO NRs were synthesized through a solvothermal process in a 200-mL methanol solution of 16.6 g $Zn(CH_3COO)_2 \cdot 2H_2O$ mixed with 7 g of KOH by stirring at 60 °C for 48 h. After 48 h, the solution was cooled at room temperature and purified three times with pure ethanol using centrifugation at 3500 rpm. Finally, the ZnO NRs were then stored in alcohol at 4 °C for future use.

1.2 Evaluation of floating efficiency

To estimate the floating efficiency of the ZnO nanorods on the water surface, UV–vis absorbance spectroscopy was used. After dropping a fixed amount of the various alcohol suspensions (MeOH, EtOH, PrOH, and BuOH) on the water, the mixed solution in the bottom was taken for UV absorbance measurement. The intensity of absorbance at 550 nm was compared with that in which the same amount of alcohol suspension was fully mixed in the same volume of water as a reference. The floating efficiency of the ZnO nanorods was

calculated by the following equation. Efficiency (%) = $[(A_{ref} - A)/A_{ref}] \times 100$.

1.3 Preparation of the ZnO NR Single-Layer Network Structure and Device Fabrication

A monodispersed ethanol solution of ZnO NRs was dropped onto water. During the dropping events, an SLNS spontaneously formed within a few seconds. The ZnO NR SLNS was then transferred onto various substrates (glass substrate, standard bare Si wafer, SiO_2/p-Si wafer, and polyethylene terephthalate (PET) film) and was further annealed at 100 °C for 1 h. The SLNSs on a glass substrate and standard bare Si wafer were used to investigate the material properties. For the fabrication of a UV sensor and dual UV-strain-sensing device, a Ti/Au electrode gap with a length of 3 μm and a width of 300 μm was defined on a SiO_2/p-Si wafer and PET film using photolithography and an e-beam evaporator. Another black-ink dot-printed PET film covered the dual UV-strain-sensing device and aligned the position of the black-ink dot to be at the site of the strain-sensing device.

1.4 Characterization

A zeta-potential analysis was conducted by electrophoretic measurements (ELS-Z2) of ZnO NRs at the air/water interface for various alcohols. The absorbance and transmittance spectra were obtained with a UV–VIS spectrometer (JASCO, V-570). The morphology of the ZnO NR SLNS was observed by using field-emission scanning electron microscopy (FESEM, JSM-6701F). To verify the sizes and crystalline features of the ZnO NR SLNS, the samples were examined using high-resolution transmission electron microscopy (HRTEM, JEOL, JEM-2100F). The change in the crystalline characteristics of a ZnO NR SLNS was determined using an X-ray diffractometer (XRD, Ultima IV, Rigaku). The work function of the ZnO NR SLNS was measured using a surface-analysis photoelectron spectrometer (AC-2, Riken Keiki Co. Ltd) with a specific amount of light irradiation of 500 nW. The current–voltage (I–V) characteristics of the UV sensing devices were measured using a semiconductor parameter analyzer (Agilent B1500A, Agilent Technologies) at room temperature. A UV detector was used to quantify the incident UV (λ = 370 nm) intensity. Five different UV intensities from 0.13 to 1.02 mW cm^{-2} illuminated the devices at 5 V repeatedly. The bending-induced properties were assessed using a custom-built bending tester with a bending radius varying from infinity to 2 mm.

2. Figures

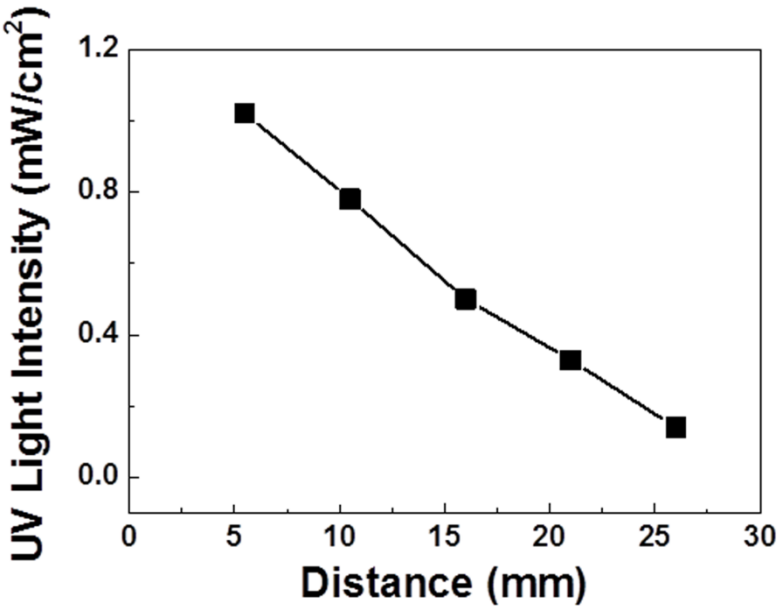

Fig. S1. 370 nm UV-light intensity as a function of distance.

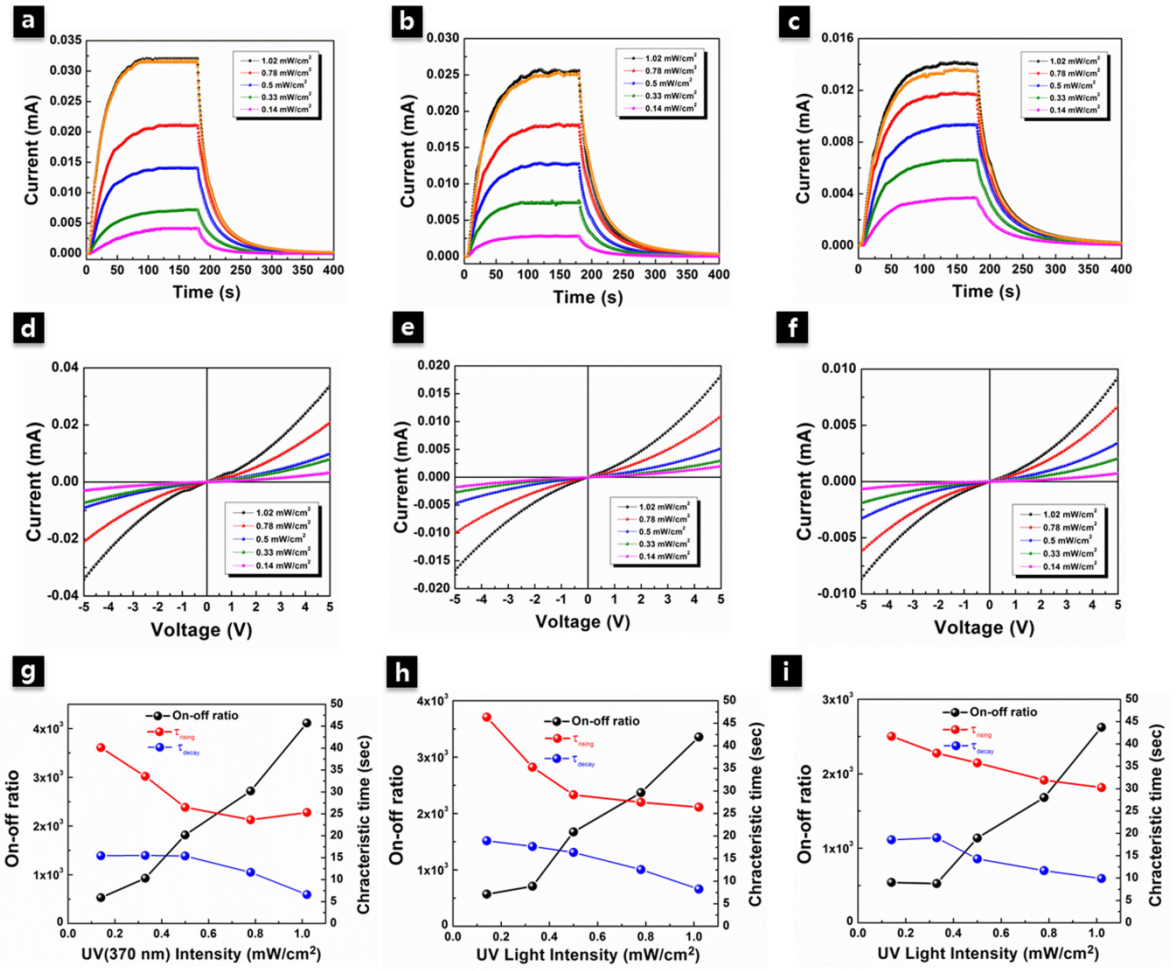

Fig. S2. Photo-response, I-V characteristic, on-off ratio, rising characteristic time, and decay characteristic time for various bending radius, R=5 mm ((a),(d),(g)) , 3 mm((b),(e),(h)), 2 mm ((c),(f),(i)), respectively.

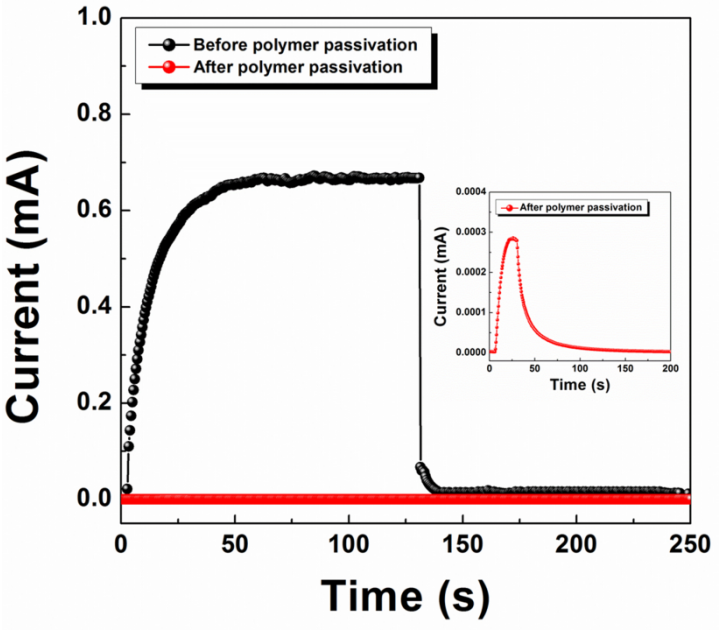

Fig. S3. UV-sensing results before and after polymer passivation