ZnO Nanogenerator as a Wind Speed Sensor for Human Respiration Detector

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A wind speed sensor which can detect the air flow rate from human respiration based on ZnO nanowire system has been fabricated in this work. The concept of wind-driven strategy transferring wind forces to electricity have been studied recently.[1] For a real human respiration at rest, the wind speed is typically from 0 to 2.0 ms^{-1}. That is, for a wind speed sensor to detect air flow rate from human respiration, the cut-in wind speed of the sensor should be less than 2.0 ms^{-1} or even more.

ZnO nanowires (NWs) with piezoelectric characteristic can generate electricity under pressure.[2] To fabricate the wind speed sensor based on a ZnO nanogenerator system, it should possess flexible and lightweight. The ZnO nanogenerator composed of ZnO NWs and the flexible substrate. First, the Si wafer was rinsed with a standard cleaning process and acted as the ordinary substrate. Second, a thin layer of polymethylglutarimide (PMGI) was coated on the Si substrate by spinning. Then, Au/Ti layers were deposited on the surface of PMGI layer and annealed the whole structure at 300 °C for 1 h. The structure was immersed in an equal molar aqueous solution containing $Zn(NO)_3.6H_2O$ and hexamethyl-enetetramine at 80 °C for 24 h using hydrothermal method to grow ZnO NWs. The size of ZnO NWs was 100-250 nm in diameter and 2 μm in height. A thin layer of polydimethylsiloxane (PDMS) layer was spin-coated on ZnO NWs. The PDMS elastomer is mixed with the cross-linker (curing agent) (Sylgard 184, Dow Corning) in a weight ratio of 10:1. Finally, the whole structure was immersed into the developer, and ZnO NWs and the PDMS film were lift-off from the initial Si substrate. That is, the PMGI layer was considered a sacrificial layer. The thickness of the whole structure was 12.5 μm. Figs.1 and 2 are the scanning electron microscopy (SEM) images of the PDMS-coated on ZnO NWs before and after lifting-off from the Si substrate, respectively. The transferring ZnO NWs from the initial Si substrate to the PDMS film can be fabricated into the ZnO nanogenerator. It can be easy-triggered by the wind force which is an important factor for a wind speed sensor driven by human respiration.

The ZnO nanogenerator can generate electricity by human respiration blowing on the structure. To actual mimic human respiration, a respiratory machine (Respironics Lifecare PLV-100) was used. Raising the wind speed blowing on the ZnO nanogenerator can generate increasing piezoelectricity, as shown in Fig. 3. By observing the different electrical performances, the air flow rate from human respiration can be detected by ZnO nanogenerator.

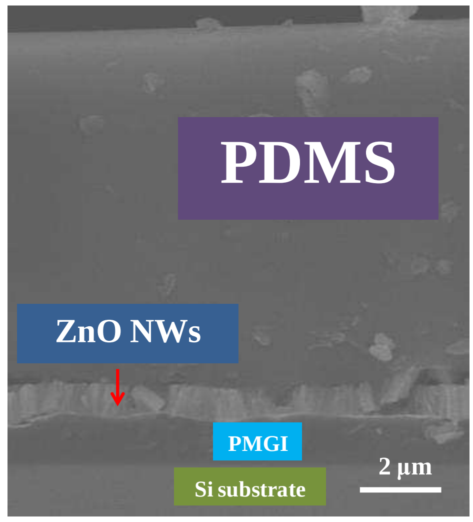

Figure 1. Cross-sectional view of SEM image of PDMS spin-coating on ZnO NWs.

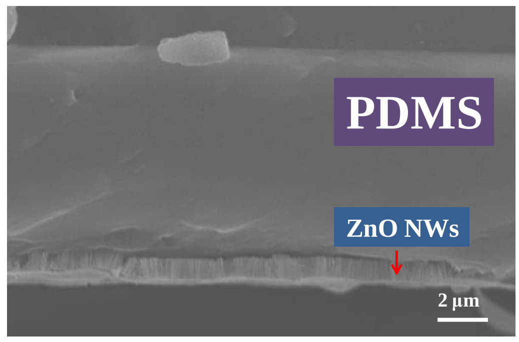

Figure 2. Cross-sectional view of SEM images of ZnO NWs embedded in PDMS after lifting-off from the Si substrate.

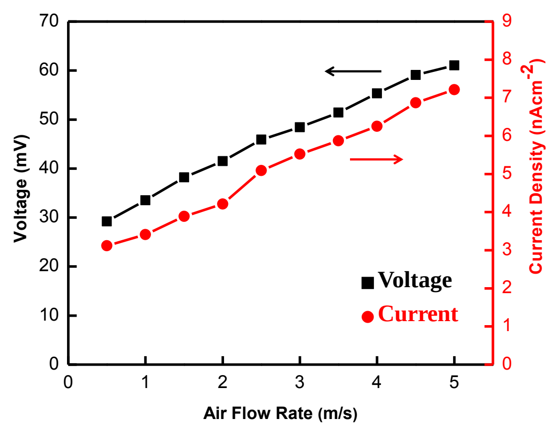

Figure 3. Open-circuit voltage and closed-circuit current-density measured with increasing air flow rate at a tidal volume of 500 mL.

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