나노제너레이터를 토대로한 ZnO Piezoelectric micro wire 의 제작과 특성

Fabrication and characteristics of ZnO Piezoelectric micro wire based Nanogenerators

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1. Introduction

One dimensional (1D) nanostructures of ZnO has attracted a huge interest for self- powered nanodevices [1-3], because of its coupled piezoelectric and semiconducting properties, beside its potential application in optoelectronic and sensing devices due to its many exciting properties, such as transparency, wide band gap, high emission, wide electrical conductivity range, stability, biocompatibility [4-6]. When a ZnO fine wire is elastically deformed, a piezoelectric potential field is created in the micro wire. The piezoelectric potential is created by the polarization of ions in the crystal rather than the free-mobile charges. Since the charges associated with the ions are rigid and affixed to the atoms, they cannot freely move. Free carriers in the semiconductor fine wire may screen the piezoelectric charges, but they cannot completely deplete the charges. The connection between bending and charge creation is to be used to create nanogenerators that produce measurable electrical currents when an array of zinc oxide fine wires is bent and then released [1]. These nanogenerators at a much smaller scale, can provide power for implantable biosensors, chemical and biomolecular sensors, nanorobotics, micro-electromechanical systems (MEMS), remote and mobile environmental sensors, and wearable personal electronics. The fabrication of these nanogeneration is an important step towards independednt and self sustainable selfpowered nanodevices. In this paper we report the fabrication of nanogenerator using ZnO piezoelectric micro wires (PMW). The fabricated nanogenerators were then characterized for power generation by applying the bending to the PMW.

2. Experimental Procedure

Vapor transport technique was used for the growth of ZnO PMW. The experimental system was consists of a horizontal quartz tube furnace, temperature controller, a gas control system, Mixture of ZnO and graphite, in 1:1 ratio (by weight) was used as source material. It was loaded in alumina boat and placed in the center in the center of 1 meter long quartz tube. High purity argon gas was introduced through one side of the furnace and other side of the quartz tube was connected to a water bubbler. The material was heated to 1100°C at 360 °C/h rate under a constant flow of 500 sccm argon gas. When the temperature reaches 800 °C Oxygen gas is also introduced with a flow rate of 25 sccm. The furnace was maintained under these conditions for 30 mins and then cooled to room temperature at a rate of 6ºC/min. ZnO micro wires were found to grow on the upstream end of the alumina boat. Surface morphology of fine wires was studied using a scanning electron microscope (FESEM JEOL model JSM 6700F). A flexible polystyrene substrate was used for the device fabrication. After standard cleaing and drying of the substrate, a thin layer of polymer was spin coated. Under optical microscope, a single ZnO PMW was placed on of the spin coated substrate.

Fig.1 Schematic of the fabricated ZnO PMW nanogenerator device.

Ag paste was used to fix the thin copper wires with two ends of the ZnO PMW for electrical characterization. Over this again a thin layer of polymer was spin coated for the device protection. The electrical characteristics were measured using Agilent semiconductor device analyzer.

3. Results and Discussion

The wurzite phase crystal structure of ZnO PMW was confirmed by the XRD measurement [7] The synthesized have radii in the range of 2 -20 μm and length upto 5 mm.The SEM image of the surface of an individual fine wire showing the perfect hexagonal morphology is shown in inset of Fig. 2. Before the power generation measurements, we have measured the *I-V* characteristic of the fabricated devices. For these fabricated devices we found various characteristics like linear, near linear and non linear I-V curves. The nonlinearity in the I-V characteristics is caused by the Schottky barriers formed between the semiconductor and the metal electrodes in the semiconductor device, and the shape of the *I-V* curve depends on the heights of the Schottky barriers formed at the source and drain due to different interface properties. In the present study we focused only on the devices that have Schottky contacts at the two ends of the PMW [8]. The room temperature I-V characteristics of such devices is shown in Fig. 2.

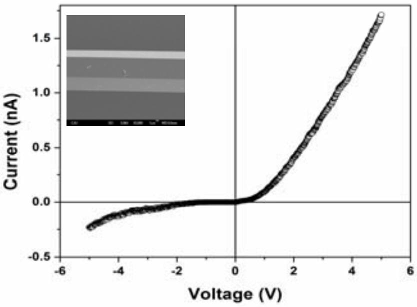

Fig. 2 I-V characteristics of the fabricated device showing schotky contact; inset surface morphology of ZnO PMW showing perfect hexagonal morphology.

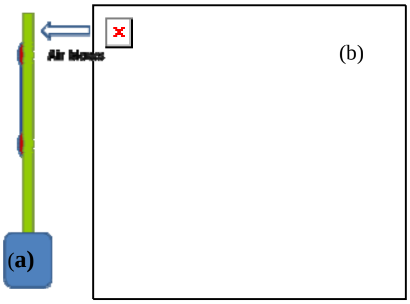

Fig. 3 (a) The schematic diagram of the experimental system for power generation by air blows (b) the generated current versus time with periodic air blows.

The schematic diagram of the experimental system for power generation is shown in Fig. 3 (a), and one end of the prepared device was fixed on the platform. The stretch was given at the free end of the device, which can make substrate be bent. The thickness of the silver electrodes and the polymer thin layers are much smaller than that of PS substrate. The bending the substrate and thus the ZnO PFW we used periodic air blows. When the air blow is given to the device the ZnO PMW undergoes compressive strain while coming to the initial, it will undergo tensile strain. The results of these measurement are presented in Fig. 3 (b), where current generation versus time with periodic blow is shown. In this figure 4(b), we can clearly see the when air blow is given there is a jump in the current. The curent recovered almost fully when the streain is relieved. Artifacts may occur in the measurements due to various sources, such as a change in system capacitance as a result of sample mechanical deformation, movement of wires, coupling with measurement system. Therefore , we have applied the tests [9] to identify true signals vs artifacts.

4. Conclusion

We have reported a simple and cost effective fabrication procedure for making nanogenerator by exploiting the piezoelectric and semiconducting properties of ZnO. The nanogenerator devices were fabricated using piezoelectric fine wires of ZnO. The devices were fabricated on flexible plastic substrates. The device is fully packed by a thin layer of polymer. The power generation characteristics of the fabricated devices were measured by bending the substrates with air blows. The periodic bending produced the tensile and compressive strain the ZnO PMW, which resulted in the electric current

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