Modeling the effect of nanowire size on the piezoelectric nanogenerators output

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INTRODUCTION

The emergence of portable and light-weight mobile devices has led to the need for alternative power sources instead of conventional batteries. In many applications such as biomedical drug-delivery implants, implantable medical electronic devices and wireless micro-sensors in remote locations, batteries are not feasible. So harvesting energy from the environment is becoming essential for self-powered devices. One of the promising methods of energy harvesting is the use of piezoelectric materials to capitalize on the ambient vibrations [1-4]. The conversion of mechanical energy to electrical energy has been well demonstrated using piezoelectric cantilever-based MEMS devices [5]. However, the large unit size, large triggering force and specific high resonance frequency of the traditional cantilever-based energy harvesters limit their applicability and adaptability in nanoscale devices and systems. From this point of view, nanostructure materials such as nanowires and nanofibers have been the focus of much research as promising nanogenerators [6]. However, due to the presence of free carrier in semiconductor piezoelectric materials, the physics underlying such semiconductor nanogenerators such as ZnO NWs has not been completely or universally applied [7]. Hence, the application of piezoelectric semiconductor nanowires (NWs) requires a good understanding of their electrical and piezoelectric properties. Herein, one of the main concepts for design of ZnO NWs-based nanogenerators (NGs) is addressed.

RESULTS AND DISCUSSIONS

By determining the piezoelectric induced charge density, in terms of an equivalent density of charges, the effect of piezoelectric charges on the distributed electric potential in the nanowire have been investigated. The surface potential is derived by considering a non-depleted region and a surface depleted region and solving the Poisson equation [8]. Figure 1 shows the surface potential of ZnO NWs with different radii. As shown in case of the ZnO NWs with smaller radius, a higher surface potential is seen. Figure 2 presents the effect of piezoelectric charges on the surface potential of ZnO NWs. The numerical results demonstrate that induced piezoelectric charges result in a stronger surface potential perturbation in ZnO NWs with smaller radius.

CONCLUSION

The effect of ZnO NWs size on surface potential modulation caused by piezoelectric charges was investigated. It was shown that ZnO NWs with a radii around the critical radius are the best candidates for use as nano-generators.

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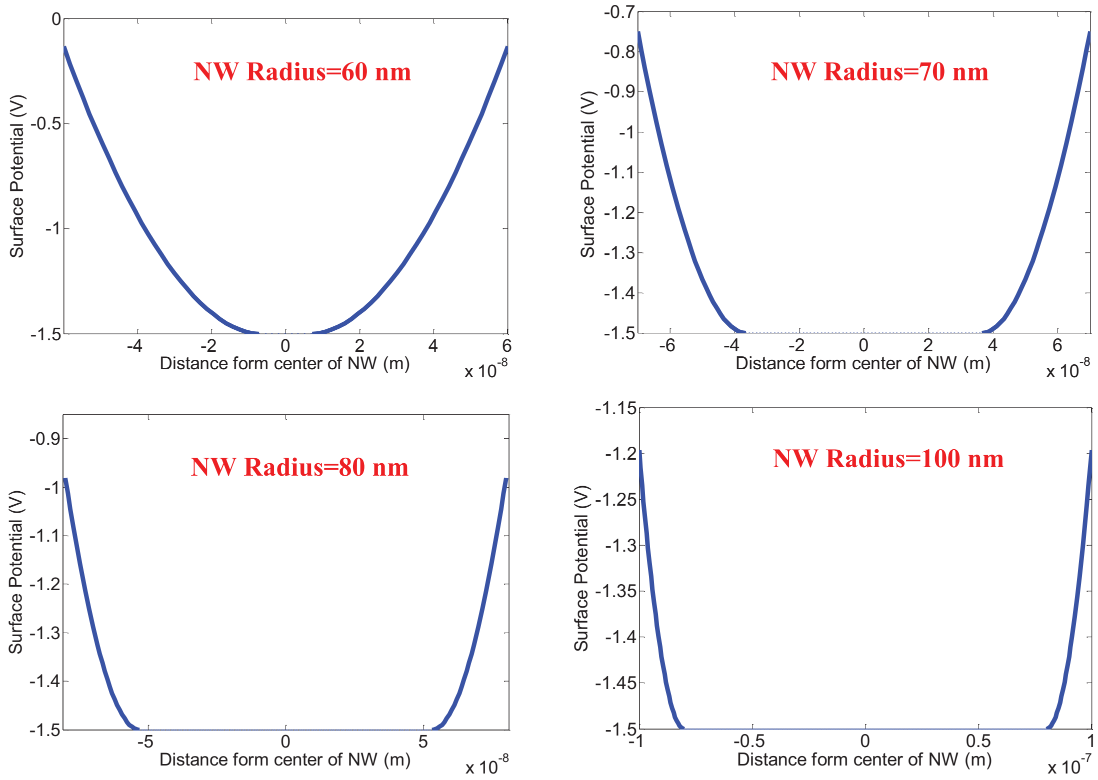

Fig.1. The surface potential of ZnO NWs with different radii.

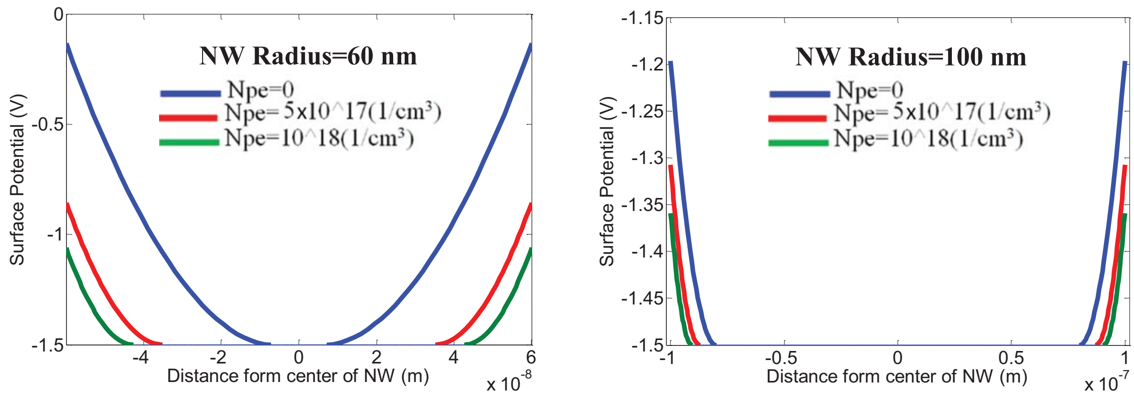

Fig.2. The surface potential of ZnO NWs with two different radius (60 nm and 100 nm) at presence of different piezoelectric charge densities.