# Electricity Generation by using Sustainable Floor

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***Abstract:*** **It is a sustainable message across that kinetic energy as potential renewable energy. The Sustainable Floor uses the movement of people as source of energy. The kinetic energy of walking or dancing people converts into electricity which is used to make the floor react and interact visually and to power applications which show the direct electricity output of a person's moves. The electricity can also be fed back to the electricity grid, be used for energy application that create a unique Energy Experience, or power other customized local systems.**

***Keywords: Nanogenerator, Piezoelectric, Nanowire***

## I. INTRODUCTION

Sustainable floor works on the principal of Nanogenerator. Nanogenerator is a technology that converts mechanical as produced by small-scale physical change into electricity. Nanogenerator has three typical approaches: piezoelectric, triboelectric, and pyroelectric nanogenerators. Both the piezoelectric and triboelectric nanogenerators can convert the mechanical energy into electricity. However, the pyroelectric nanogenerators can be used to harvest thermal energy from a time-dependent temperature fluctuation.

Working principle of nanogenerator where an individual nanowire is subjected to the force exerted perpendicular to the growing direction of nanowire. (a) An AFT tip is swept through the tip of the nanowire. Only negatively charged portion will allow the current to flow through the interface. (b) The nanowire is integrated with the counter electrode with AFT tip-like grating. As of (a), the electrons are transported from the compressed portion of nanowire to the counter electrode because of Schottky contact

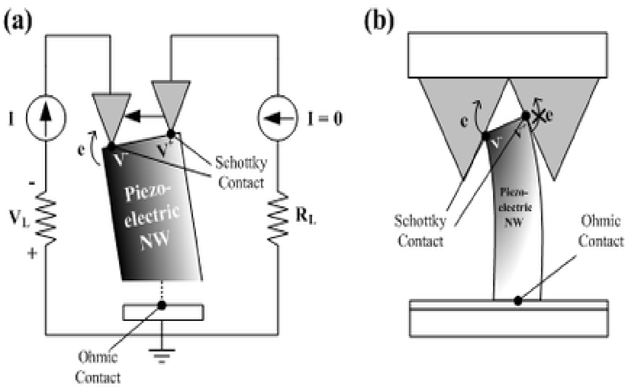


Fig:1

## II. WORKING PRINCIPLE OF NANOGENERATOR

where an individual nanowire is subjected to the force exerted parallel to the growing direction of nanowire.

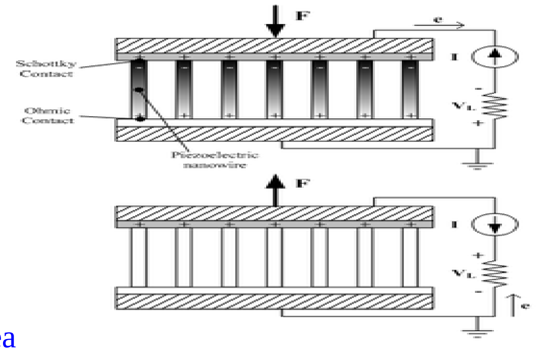


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Fig:2

The working principle of nanogenerator will be explained for 2 different cases: the force exerted perpendicular and parallel to the axis of the nanowire.

The working principle for the first case is explained by a vertically grown nanowire subjected to the laterally moving tip. When a pieoelectric structure is subjected to the external force by the moving tip, the deformation occurs throughout the structure. The piezoelectric effect will create the electrical field inside the nanostructure; the stretched part with the positive strain will exhibit the positive electrical potential, whereas the compressed part with the negative strain will show the negative electrical potential. This is due to the relative displacement of cations with respect to anions in its crystalline structure. As a result, the tip of the nanowire will have an electrical potential distribution on its surface, while the bottom of the nanowire is neutralized since it is grounded. The maximum voltage generated in the nanowire can be calculated by the following equation:[2]

$$V_{\max} = \pm \frac{3}{4(\kappa_0+\kappa)}\left[e_{33} - 2(1+\nu)e_{15} - 2\nu e_{31}\right]\frac{a^3}{l^3}\nu_{\max}$$

where $\kappa_0$ is the permittivity in vacuum, $\kappa$ is the dielectric constant, $e_{33}$, $e_{15}$ and $e_{31}$ are the piezoelectric coefficients, $\nu$ is the Poisson ratio, a is the radius of the nanowire, l is the length of the nanowire and $\nu_{max}$ is the maximum deflection of the nanowire's tip.

The electrical contact plays an important role to pump out charges in the surface of the tip. The schottky contact must be formed between the counter electrode and the tip of the nanowire since the ohmic contact will neutralize the electrical field generated at the tip. In order to form an effective schottky contact, the electron affinity ($E_a$) must be smaller than the work function (φ) of the metal composing the counter electrode. For the case of Zno nanowire with the electron affinity of 4.5 eV, Pt (φ=6.1eV) is a suitable metal to construct the schottky contact. By constructing the schottky contact, the electrons will pass to the counter electrode from the surface of the tip when the counter electrode is in contact with the regions of the negative potential, whereas no current will be generated when it is in contact with the regions of the positive potential, in the case of n-type semiconductive nanostructre (p-type semiconductive structure will exhibit the reversed phenomenon since the hole is mobile in this case). The formation of the schottky contact also contributes to the generation of direct current output signal consequently.

For the second case, a model with a vertically grown nanowire stacked between the ohmic contact at its bottom and the schottky contact at its top is considered. When the force is applied toward the tip of the nanowire, the uniaxial compressive is generated in the nanowire. Due to the piezoelectric effect, the tip of the nanowire will have a negative piezoelztric potential, increasing the Fermi level at the tip. Since the electrons will then flow from the tip to the bottom through the external circuit as a result, the positive electrical potential will be generated at the tip. The schottky contact will barricade the electrons being transported through the interface, therefore maintaining the potential at the tip. As the force is removed, the piezoelectric effect diminishes, and the electrons will be flowing back to the top in order to neutralize the positive potential at the tip. The second case will generate alternating current output signal.

Geometrical configuration

Depending on the configuration of piezoelectric nanostructure, the most of the nanogenerator can be categorized into 3 types: VING, LING and "NEG". Still, there is a configuration that does not fall into the aforementioned categories, as stated in other type.

## III.VERTICAL NANOWIRE INTEGRATED NANOGENERATOR (VING).

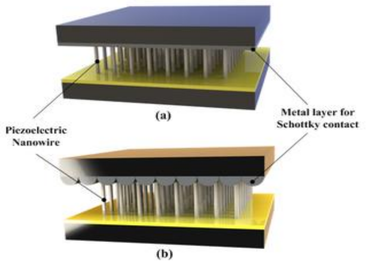


Fig:3

Schematic view of typical Vertical nanowire Integrated Nanogenerator, (a) with full contact, and (b) with partial contact. Note that the grating on the counter electrode is important in the latter case.

VING is a 3-dimensional configuration consisting of a stack of 3 layers in general, which are the base electrode, the vertically grown piezoelectric nanostructure and the counter electrode. The piezoelectric nanostructure is usually grown from the base electrode by various synthesizing techniques, which are then integrated with the counter electrode in full or partial mechanical contact with its tip.

After Professor Zhong Lin Wang of the Georgia institute of technology has introduced a basic configuration of VING in 2006 where he used a tip of atomic force microscope (AFM) to induce the deformation of a single vertical Zno nano wire, the first development of VING is followed in 2007.[3] The first VING utilizes the counter electrode with the periodic surface grating resembling the arrays of AFM tip as a moving electrode. Since the counter electrode is not in full contact with the tips of the piezoelectric nanowire, its motion in-plane or out-of-plane occurred by the external vibration induces the deformation of the piezoelectric nanostructure, leading to the generation of the electrical potential distribution inside each individual nanowire. It should be noted that the counter electrode is coated with the metal forming the schottky contact with the tip of the nanowire, where only the compressed portion of piezoelectric nanowire would allow the accumulated electrons pass through the barrier between its tip and the counter electrode, in case of n-type nanowire. The switch-on and –off characteristic of this configuration shows its capability of generating direct current generation without any requirement for the external rectifier..

In VING with partial contact, the geometry of the counter electrode plays an important role. The flat counter electrode would not induce the sufficient deformation of the piezoelectric nanostructure, especially when the counter electrode moves by in-plane mode. After the basic geometry resembling the array of AFM tips, a few other approaches have been followed for facile development of the counter electrode. Professor Zhong Lin Wang's group have generated counter electrode composed of ZnO nanorods utilizing the similar technique used for synthesizing ZnO nanowire array. Professor Sang-Woo Kim's group of Sungkyunkwan university (SKKU) and Dr. Jae-Young Choi's group of Samsung Advanced institute if Technology (SAIT) in South Korea introduced bowl-shaped transparent counter electrode by combining anodized aluminium and the electroplating technology.[4] They also have developed the other type of the counter electrode by using networked single-walled carbon-nanotube (SWNY) on the flexible substrate, which is not only effective for energy conversion but also transparent.[5]

The other type of VING has been also suggested. While it shares the identical geometric configuration with the aforementioned, such a VING has full mechanical contact between the tips of the nanowire and the counter electrode.[6] This configuration is effective for application where the force is exerted in the vertical direction (toward the c axis of the piezoelectric nanowire), and it generates alternating current (AC) unlike VINGs with partial contact.

## IV.LATERAL NANOWIRE INTEGRATED NANOGENERATOR (LING).

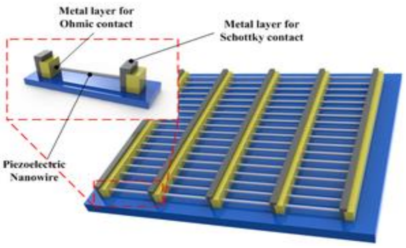


Fig:4 Schematic view of typical Lateral nanowire Integrated Nanogenerator

As of VINGs with full mechanical contact, LING generates AC electrical signal. The output voltage can be amplified by constructing an array of LING connected in series on the single substrate, leading the constructive addition of the output voltage. Such a configuration may lead to the practical application of LING for scavenging large-scale power, for example, wind or ocean waves.

## V. NANOCOMPOSITE ELECTRICAL GENERATORS (NEG).

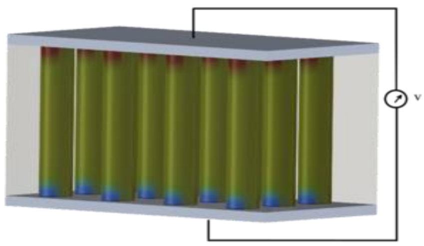


Fig:5 Schematic view of typical Nanocomposite Electrical Generator

"NEG" is a 3-dimensional configuration consisting three main parts: the metal plate electrodes, the vertically grown piezoelectric nanostructure and the polymer matrix which fills in between in the piezoelectric nanostructure.

NEG was introduced by Momeni et al.[7] It was shown that NEG has a higher efficiency compared to original nanogenerator configuration which a ZnO nanowire will be bended by an AFM tip. It is also shown that it provides an energy source with higher sustainability.

Other type. The fabric-like geometrical configuration has been suggested by Professor Zhong Lin Wang in 2008. The piezoelectric nanowire is grown vertically on the two microfibers in its radial direction, and they are twined to form a nanogenerator.[8] One of the microfibers is coated with the metal to form a schottky contact, serving as the counter electrode of VINGs. As the movable microfiber is stretched, the deformation of the nanostructure occurs on the stationary microfiber, resulting in the voltage generation. Its working principle is identical to VINGs with

**LING** is a 2-dimensional configuration consisting of three parts: the base electrode, the laterally grown piezoelectric nanostructure and the metal electrode for schottky contact. In most of cases, the thickness of the substrate film is much thicker than the diameter of the piezoelectric nanostructure, so the individual nanostructure is subjected to the pure tensile strain.

LING is an expansion of single wire generator (SWG), where a laterally aligned nanowire is integrated on the flexible substrate. SWG is rather a scientific configuration used for verifying the capability of electrical energy generation of a iezoelectric material and is widely adopted in the early stage of the development.

partial mechanical contact, thus generating DC electrical signal

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