A

Seminar Report

On

**NANOGENERATOR**

*Submitted in partial fulfillment of*

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Bachelor of Engineering

In Electrical (Electronics & Power )

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Certificate

The seminar report entitled **“NANOGENERATOR** ” is hereby approved as a creditable study carried out and presented by **Mr. Mandar Dinkar Kulkarni** in a manner satisfactory to warrant its acceptance as a pre-requisite in a partial fulfillment the requirements for degree of **Bachelor of Engineering in Electrical ( Electronics & Power)** of Sant Gadge Baba Amravati University, Amravati.

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Place: Shegaon Mandar D. Kulkarni

.**Contents :**

1. Abstract
2. Introduction
3. Mechanism
4. Types of nanogenerator
5. Materials used
6. Applications
7. Conclusion
8. References

**ABSTRACT**

NANO…means one billionth of one and one third of micro, to be precise (10−9 meters). Nanotechnology is simply an emerging frontier and the future science paving the best way for most of cutting edge technologies. NEMS technology has been a realm in which machines operate at scales of billionth a meter. Recent innovations in nanotechnology revealed many  potential applications in fields such as energy, medicine, electronics, computing and many more.The most advanced innovation in the field of nanotechnology is nanogenerators .These are futuristic and most advanced technologies which are quiet compact and harvest mechanical energy from the environment using an array of tiny nanowires. These nanogenerators find many applications in very small electronic devices; self powered micro devices and many more practical applications.

These nanogenerators develop energy from body movements, environmental changes, and even from the rustle of a fiber .these develop power in the range of nanoamperes and integrating their contributions results in energy which is quiet sufficient to charge up a mobile phone or an I pod just from body movements which results in energy conservation .so these nanogenerators are going to play a key role in the future generations. In recent days these nanogenerators are being used to drive commercial devices such as LCD (Liquid Crystal Display), LED (Light Emitting Diodes), laser diodes. So focus is held on further improvements of nano generators.

The paper deals with history, construction, merits, uses, future applications of nano generators.

**INTRODUCTION:**

Nanoscale devices that harvest mechanical energy from the environment using an array of tiny nanowires are called nano generators. A nanowire is a nanostructure, with the diameter of the order of a nanometer (10−9 meters). Alternatively, nanowires can be defined as structures that have a thickness or diameter constrained to tens of nanometers or less and an unconstrained length.

**Nanogenerator**

A silicon nano generator is an energy harvesting device converting the external kinetic energy into an electrical energy based on the energy conversion by nano-structured piezoelectric material.

**WHAT IS PEIZO ELECTRICITY?**

The word piezoelectricity means electricity resulting from pressure. Piezoelectricity is the charge which accumulates in certain solid materials  in response to applied mechanical strain. Piezoelectricity is the direct result of the piezoelectric effect, which is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials. The internal generation of electrical charge resulting from an applied mechanical force is called as piezoelectric effect piezoelectric effect is due to the occurrence of electric dipole moments in solids.

**PEIZO-ELECTRIC EFFECT**

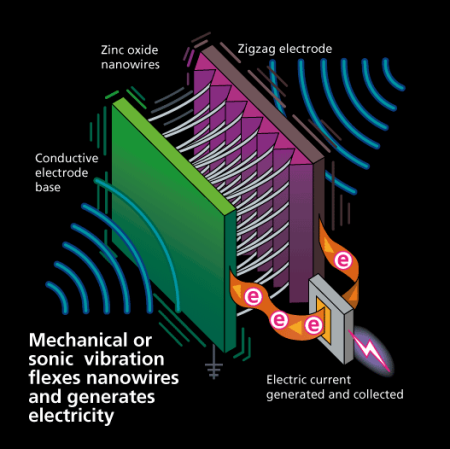
Nanogenerators  may include any types of energy harvesting devices with nano-structure converting the various types of the ambient energy (e.g. solar power and thermal energy), it is used in most of times to specifically indicate the kinetic energy harvesting devices utilizing nano-scaled piezoelectric material. The mechanical energy from compressing a nanogenerator between two fingers, from a heart beat, the pounding of a hiker's shoe on a trail, the rustling of a shirt, or the vibration of a heavy machine is converted into electrical energy by these generators.

          Although nanogenerators will not produce large amounts of electricity for conventional purposes, they could be used to power nanoscale and micro scale devices -- and even to recharge pacemakers or iPods.. By simplifying design and making it more robust and integrating the contributions from many more nanowires, we can successfully boost the output of a Nanogenerator enough to drive devices such as commercial liquid-crystal displays, light-emitting diodes and laser diodes, very small devices which are used in applications of health care, environmental monitoring and personal electronics   "How to power these devices is a critical issue." And the answer is nanogenerators.

**Mechanism**:

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 piezoelectric 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 depends on ‘the permittivity in vacuum the dielectric constant radius and length of the nano wires.

The maximum voltage generated in the nanowire can be calculated by the following equation:

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

, where κ0 is the permittivity in vacuum, κ is the dielectric constant, e33, e15 and e31 are the piezoelectric coefficients, ν is the Poisson ratio, a is the radius of the nanowire, l is the length of the nanowire and νmax is the maximum deflection of the nanowire's tip.

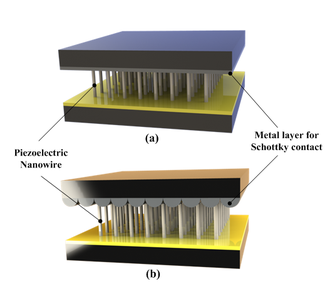
For the second case, a model with a vertically grown nanowire stacked between the ohmic contact at its bottom and the schottky contact at its top is considered. When the force is applied toward the tip of the nanowire, the uniaxial compressive is generated in the nanowire. Due to the piezoelectric effect, the tip of nanowire will have a negative piezoelectric 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 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

**GEOMETRIC CONFIGURATION**

Depending on the configuration of piezoelectric nanostructure, the most of the nanogenerator can be categorized into 2 types: VING and LING. Still, there is a configuration that does not fall into the above mentioned categories, as stated in other type.

**1. VERTICAL NANOWIRE INTEGRATED NANOGENERATOR (VING):**

 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 counterelectrode.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.

[](http://en.wikipedia.org/wiki/File:NG_VING.png)

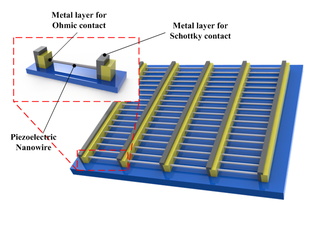
[http://bits.wikimedia.org/static-1.22wmf18/skins/common/images/magnify-clip.png](http://en.wikipedia.org/wiki/File:NG_VING.png)

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.

Motion in-plane or out-of-plane occurred by the external vibration induces the deformationofthe 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.

**2. LATERAL NANOWIRE INTEGRATED NANOGENERATOR (LING):**

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.

[](http://en.wikipedia.org/wiki/File:NG_LING.png)

Schematic view of typical Lateral nanowire Integrated Nanogenerator

**MATERIALS:**

Among various piezoelectric materials studied for the nanogenerator, many of the researches have been focused on the materials with quartzite structure such as ZnO, CdS and GaN. The greatest advantage of theses material arises from the facile and cost-effective fabrication technique, hydrothermal synthesis. Since the hydrothermal synthesis can be conducted in a low temperature environment under 100°C in addition to vertical and crystalline growth, these materials can be integrated in various substrates with reduced concern for its physical characteristics such as a melting temperature.

**APPLICATIONS:**

Nanogenerator is expected to be applied for various applications where the periodic kinetic energy exists, such as wind and ocean waves in a large scale to the muscle movement by the beat of a heart or inhalation of lung in a small scale. Nanogenerators are now close to producing enough current for a self-powered system that might monitor the environment for a toxic gas, for instance, and then broadcast a warning. The system would include capacitors able to store up the small charges until enough power was available to send out a burst of data. If we can sustain this rate of improvement, we will reach some true applications in healthcare devices, personal electronics, or environmental monitoring recent improvements in the nanogenerators, including a simpler fabrication technique. The further feasible applications are as follows

Self-powered nano/micro devices.

One of the feasible applications of nanogenerator is an independent or a supplementary energy source to nano/micro devices consuming relatively low amount of energy in a condition where the kinetic energy is supplied continuously. One of example is the self-powered pH or UV sensor integrated VING with an output voltage of 20~40 mV onto the sensor.

Still, the converted electrical energy is relatively small for operating nano/micro devices; therefore the range of its application is still bounded as a supplementary energy source to the battery. The breakthrough is being sought by combining the nanogenerator with the other types of energy harvesting devices, such as solar cell or biochemical energy harvester this approach is expected to contribute to the development of the energy source suitable for the application where the independent operation is crucial, such as Smartdust.

Smart Wearable Systems:The outfit integrated or made of the textiles with the piezoelectric fiber is one of the feasible applications of the nanogenerator. The kinetic energy from the human body is converted to the electrical energy through the piezoelectric fibers, and it can be possibly applied to supply the portable electronic devices such as health-monitoring system attached with the Smart Wearable Systems. The nanogenerator such as VING can be also easily integrated in the shoe employing the walking motion of human body.

Another similar application is a power-generating artificial skin. There is a possibility of generating AC voltage of up to 100 mV from the flexible SWG attached to the running hamster.

Transparent and Flexible Devices

Some of the piezoelectric nanostructure can be formed in various kinds of substrates, such as flexible and transparent organic substrate. The recent researchers have developed the transparent and flexible nanogenerator which can be possibly used for self-powered tactile sensor and anticipated that the development may be extended to the energy-efficient touch screen devices. Their research focus is being extended to enhance the transparency of the device and the cost-effectiveness by substituting Indium-Tin-Oxide (ITO) electrode with a graphene layer.

**Implantable Telemetric Energy Receiver:**

The nanogenerator based on ZnO nanowire can be applied for implantable devices since ZnO not only is bio-compatible but also can be synthesized upon the organic substrate, rendering the nanogenerator bio-compatible in overall. The implantable device integrated with the nanogenerator can be operated by receiving the external ultrasonic vibration outside the human body, which is converted to the electrical energy by the piezoelectric nanostructure.

**CONCLUSION:**

                In future a day may come when nanogenerators power the entire globe. The  nanogenerators would  certainly bring up a new industrial revolution in the power generation .With the application of nanotechnology in every sphere of the life  many compact  designs can be expected which constitute  for the technological development .With their size, precision and accuracy nanogenerators are definitely going to be an un-avoidable part of our future.

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