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Designing of Nanogenerators for Embedding in Rails

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ABSTRACT

This paper deals with designing of nanogenerators and its implementation in rails. This adds a new dimension in generation of electricity using nanotechnology. We use array of zinc oxide to produce electricity. Around 0.7 watts of electricity can be produced by 1cubic cm layer of nanogenerators using silicon. While more with GaAs substrate but higher cost sanction us to go with Silicon, the abundant material in nature .Hence with 10 kilometer of rail we can produce 1.02 MW after considering losses. Use of nanotechnology ensures that there will be no degradation in strength of steel of which rails are made. Hence it also fulfills the safety criteria.

Key words: Array of electrodes, Flour structure, Nanogenerators, Nanowires, polysilicon, Tungsten carbide.

INTRODUCTION

The first nanogenerator prototype was fabricated by researchers at Georgia Tech, USA. Till now nanogenerators are used for supply to nanobots, used in medical operations and self-powered implantable medical devices[1],[2].But here we will use nanogenerators for generation of large amount of electricity by using high frequency vibrations in rails. When high speed and heavy weight trains run by means of rails then they will produce high frequency waves in rails work as a source for piezoelectric materials. Because of the length of rails is too much so zinc oxide nano wires can produce sufficient amount of electricity by working as a piezoelectric material . It is only possible by making specified nanogenerators for rails, different from nanobots in many aspects. This technology can eventually lead to 'smart railway system' that can power to internal requirements of trains or can be used in other parts of railway system.. Comparing it with conventional thermal power plant stations where we need huge investment in installation. After that running and maintenance cost is much more. Too much need of labor work and emission of tons of carbon di oxide make it worse. While production through nanogenerators needed only one time installation cost and this production of electricity is totally eco-friendly.

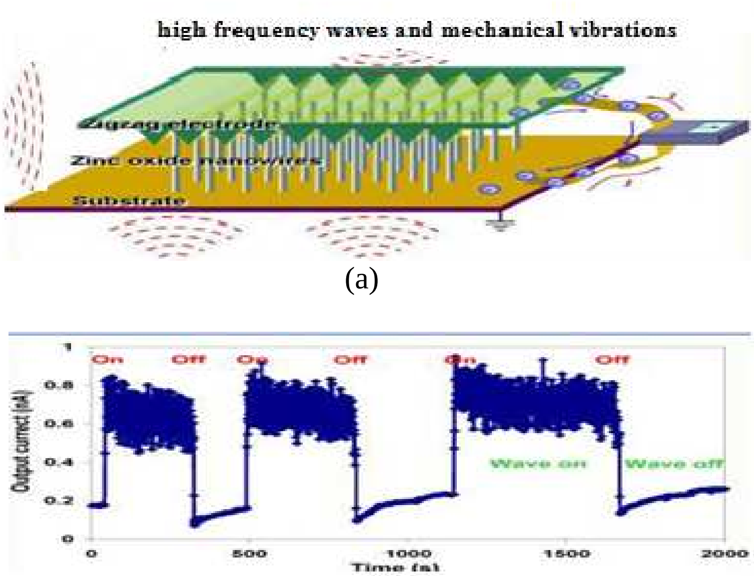
Objective of the work

1. Designing of array of nanowires for rails.
2. Implementation of the array of nanowires in rails.
3. Improving the structure of nanogenerators used in medical operations.

Methodology

The resulting arrays contained vertically-aligned nanowires. The wires grew approximately 220 nanometers apart, with attention on no contact between two nanowires. A film of zinc oxide also grew between the wires on the substrate surface, creating an electrical connection between the wires. The substrate will may be of GaAs for high performance and large current. Although GaAs substrate has a great efficiency but it's cost obstructs us. Hence n-doped Si substrate will result cheaper layer. We can attach electrodes of silicon for measuring current flow to that conductive substrate. According to theories nano devices have comparatively good efficiency for conversion of input mechanical energy into electrical energy for a single cycle of vibration. Using nanowires of zinc oxide will give more flexibility then carbon tubes [2].

There is a polarization mechanism as shown in the Fig.1 (a).In which the charges were preserved in the nanowire because a Schottky barrier was formed between the tungsten carbide and the nanowire [3].The output waveform of Fig.1(a) is shown in Fig.1(b). The use of tungsten carbide will make structure cheaper. We can use AFM Tip also. The coupling between semiconducting and piezoelectric properties resulted in the charging and discharging process when the tip scanned across the nanowire. When the tip lost contact with the wire, the strain was released and then there will flow of current.



(b)

Fig. 1. (a) Basic structure of nanogenerators. (b) Output waveform of (a) [4].

1. **Experimental work**

Implementing nanogenerators in open environment apart from medical operations is a great challenge. Lots of heat which again get amplified by steel and rain makes it more tough . But actually heat plays a supporting role in production of electricity because nanowires have higher mobility in hot conditions. For the implementation of nanogenerators in rails we have to see safety issues and efficiency of same at different places. For that layer should be inbuilt in the lower part of the flat surface of rail so that it can give optimum performance for vibrations while keeping safely production of electricity. If we implant it at any other place then due to compression and expansion of transverse depth of layer the problem may arise of safety. This is shown in the Fig. 2.

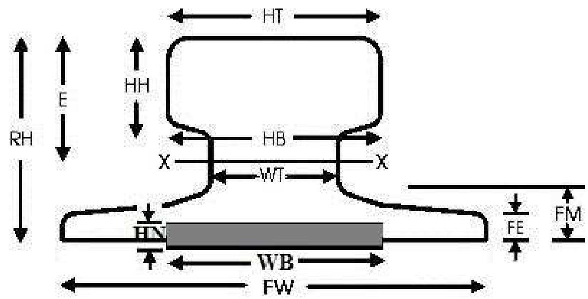


Fig. 2 Position of nanogenerator with height HN and width WB for it in rail

Tab. 1 International Rail Data(dimensions in millimeters) [5] with Nanogenerator Layer Width,WB and Height, HN

	Rail Height	Flange Width	Head Width at Top	Head Width at Base	Head Height	Web Thickness	Flange Thickness at Edge	Flange Thickness at Center	cm	**Nanogenerator Layer Width**	**Nanogenerator Layer Height**
Rail Type	**RH**	**FW**	**HT**	**HB**	**HH**	**WT**	**FE**	**FM**	**E**	**WB**	**HN**
A45 rail	55	125	45	45	24	24	8	14.5	3.31	**43.65**	**6.24**
A55 rail	65	150	55	55	28.5	31	9	17.5	3.88	**53.35**	**7.02**
A65 rail	75	175	65	65	34	38	10	20	4.44	**63.05**	**7.80**
A75 rail	75	200	75	75	39.5	45	11	22	5	**72.75**	**8.58**
A100 rail	100	200	100	100	45.5	60	12	23	5.21	**97**	**9.36**
A120 rail	105	220	120	120	55.5	72	12	30	5.7	**116.40**	**9.36**
A150 rail	150	220	150	150	50	80	14	41.5	76.3	**145.50**	**10.92**

The array of electrodes will give summation of total electric current produced by individual wires. Which can be collected at the extension of the layer by the metal (aluminum) crossing the Schottky barrier. The electrodes will be connected to each other in vertical manner by parallel strips of polysilicon or aluminum.

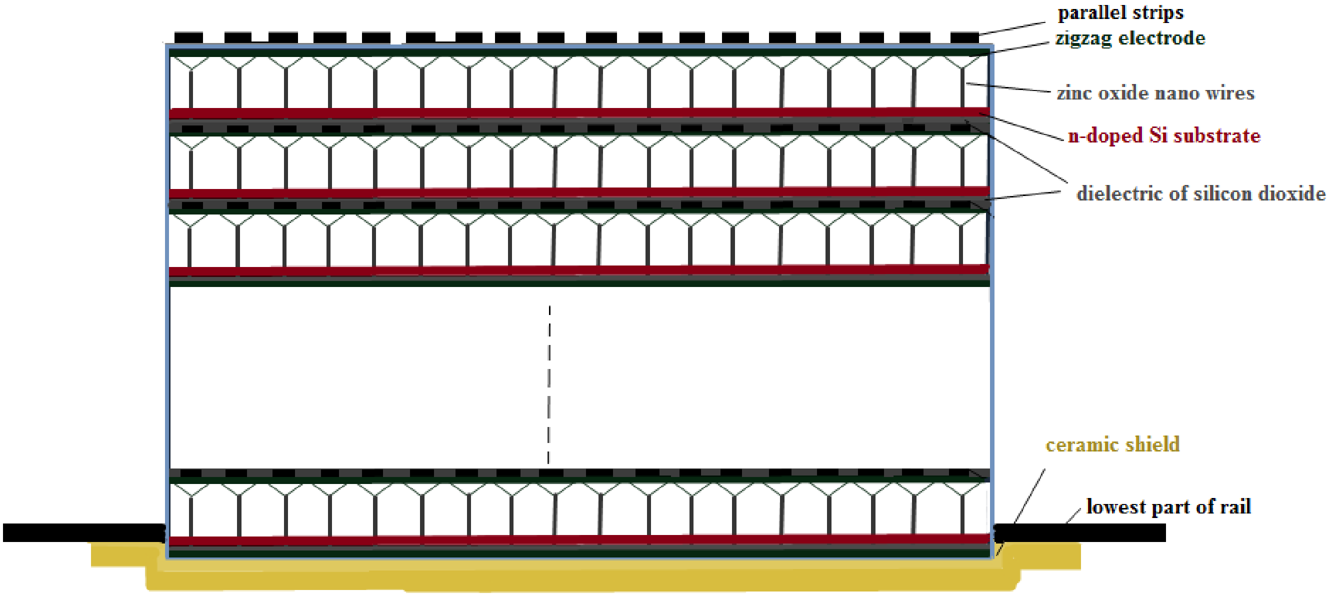


Fig. 3 Inside the layer of nanogenerator and Floor structure .Here the height of one floor is in nanometers

The arrays contained vertically-aligned nanowires that ranged from 350 to 750 nanometers in length and 40 to 90 nanometers in diameter. This range will give the optimum performance for railways. Thinner and smaller wires will create a problem in fabrication also wires will damage soon. While thicker and longer wires will be less susceptible to high frequency waves. Now considering flour structure for embedding in rail .Since each array consist a height in nanometer hence 80-300 floors give us a implantable feasible height. Turning parameters from nanometer to micrometer can make fabrication economical. In this structure beneath one array there will be another. This flour structure will consist of many flours which will be isolated by dielectric of silicon dioxide .This is shown in the Fig.3 .Shield of ceramic have to use for protection of the layer from outer effects of environment, especially in rainy seasons. The plastic coating may damage due to heat problems, more with steel. The production of electricity will be depend on traffic of trains and will be large with more traffic. For effective implementation of this layer we need fabrication in high traffic regions and should avoid hill areas. Also since fabrication is in kilometers hence here important is quantity rather than quality. This results cheap fabrication process. There will be generation of electricity even after passing of train since vibrations will be present in rails after departure also.

By taking regards with this floor structure and n-doped silicon substrate this design can lead to a better nanogenerator for medical operations because floor structure multiples output current .The substrate with n-doping maintains almost same current as with GaAs and silicon makes it cheaper.

RESULTS

If we talk about its implementation in rails then around 0.7 watts of electricity is produced by 1 cubic cm layer of nanogenerator with single floor and prediction for 10 kilometer of rail is 1.02 MW of electricity. These calculations are done by taking average traffic of trains. Also losses inside the layer and environmental effects are considered here. The produced current will be regulated and used further.

With each section of rails we can collect this power and can store for further use Since we are going through nanotechnology hence the height of the layer is small enough, not creating any problem while the width will almost same as of rail.. There will be no degradation in strength of material because the height will be in microns.

CONCLUSION AND FUTURE WORK

The electricity production of electricity through nanogenerators will be most successful in India because it is said to be the 4th largest railway network in the world [6].This system produces electricity with no extra cost, also the onetime cost of system is very low since zinc oxide is easily available and cheap. We change rails within almost 10 years. So the need is to just fabricate this nanomaterial with old models of rails and then this will be one of the most cheapest and efficient way of electricity production with fulfilling our current demand .

If we compare this with production of electricity by solar cell then this will ten times cheaper also the size of system reduced drastically .Obviously this will be better then all conventional and non conventional methods of electricity production. This structure of nanogenerator will give better performance in self powered devices. Attention of researchers and engineers could lead it with almost double in efficiency within 5 years.

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