System to Transform Sound Energy into Electricity

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SYSTEM TO TRANSFORM SOUND ENERGY INTO ELECTRICITY FOR PROCEEDINGS ON ICNNEE2019

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Abstract:

In the recent developments taking place over past decades we have witnessed tremendous success in upgrading technology, the lifestyles of people, the degree of science intelligence and the environment around us. Root aspects of all such development lies with respect to the concept that involves the study of conversion of one form of energy to other desired forms. It's an endeavour to bring out the technology that are human beneficiary and it is achieved by the proper utilization of the energy from our surroundings such as the present developments includes energy conversion from sun(solar), wind, ocean, tides, biogas chemical energies and so on. Similarly we have brought up with an idea of new energy conversion which involves the utilization of sound energy, mainly those mechanical waves (sound waves), that are above the human audible range and which tend to be hazardous to humans. The attempt is done to convert the sound energy to any desired energy form; basically the output of this conversion is focused to get in form of electrical energy. This energy can then be utilized to many events such as for tube lights, charging the batteries, fans etc., The sources for the input sound can be from engines, horns in railways, the sonic sounds in airplanes and jet planes, the loud Mike systems, the speaker systems in large functions, the traffic sounds such sound waves are used to convert into electrical energy which will be tremendously beneficial to humans. The attempt is to achieve the aim of producing/supplying free electricity to the world.

Keywords: *Sound energy, free electricity, nanotechnology diaphragms*

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I. INTRODUCTION

Sound energy, which is one of the freely available energy sources likewise the solar energy, hydraulic energy from water, can be brought to a form beneficial to humans as well as indirectly to the nature. The sound energy is one of the widely available energy in abundant form as if it seems wherever there's human activity exists there we could find sound energy. Therefore as mentioned in title a system is designed to transform all such sources of sound into electricity as shown in Fig. 1. As we all acknowledge that in the current system of world, electricity is an important aspect of life, it can be either in industries, manufacturing units, factories, schools, universities, markets, and so on we require electricity everywhere. But the plants that have been setup for generating electricity requires lots of complex and sophisticated mechanisms in order to produce electricity and requires more maintenance cost.

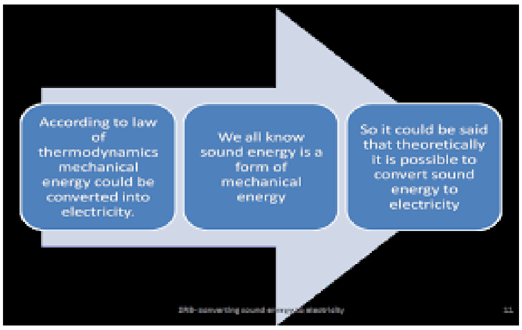


Fig.1 Possible ways to convert new form of energy

Sound waves consist of vibrating particles, which knock into other particles, causing those particles to vibrate and knock into more particles, and so on and so forth; this is how sound waves travel away from their source. We hear sounds because the vibrations in the air cause our ear drums to vibrate, and these vibrations are converted into nerve signals that are sent to our brains. Similarly, microphones detect vibrations in the air and convert them into electrical signals.

The particles that vibrate as part of a sound wave move back and forth along the axis along which the sound wave is travelling. This movement creates areas where particles are more bunched up (areas of high pressure, or compressions) and areas where particles are more spread out (areas of low pressure, or rarefactions). Fig. 2 shows Propagation of sound with its impact pressure on air molecule in sinusoidal form.

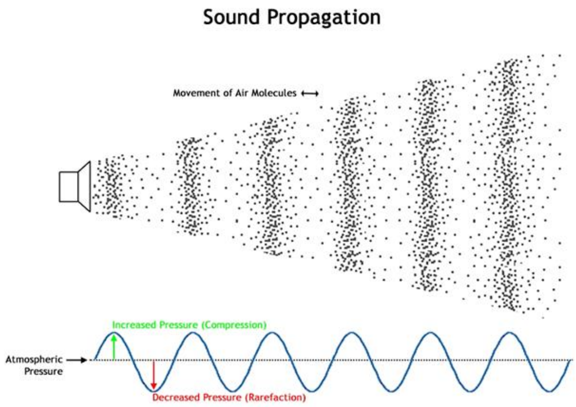


Fig. 2 Propagation of sound with its impact pressure on air molecule in sinusoidal form

Hence this is system that is designed to generate free electricity to all involving lesser complexity in design and maintenance. This system is a small volunteer in order to produce electricity of larger scale involving higher degree of simplicity in its production and making it a portable device.

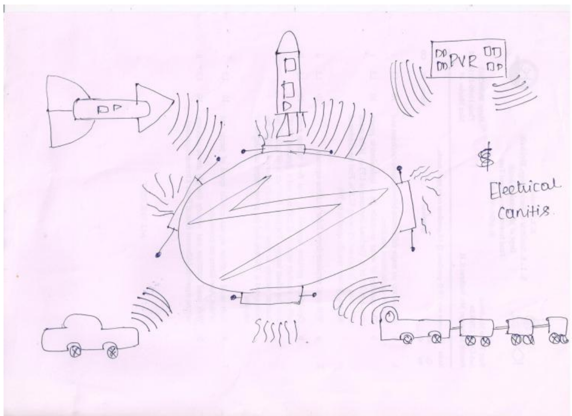


Fig3. Schematic diagram shows the sources of sound energy

Fig 3 shows the schematic diagrams of sources of sound energy like, Vehicles, trains, cinema halls, racket launching stations, airplanes etc.,

II. OBJECTIVES

The main objective of this project is to supply free electricity involving the latest technologies. In the design of this system nanotechnology is been used. The secondary objective involves making it reliable in a way that is capable of utilizing electricity 24x7 anywhere and at anytime without any charges. It is attempt to get the success over the challenge of generating free electricity from sound energy.

III. ANALOGY

The idea of converting sound energy into electricity comes from the inspiring human body part, the ear. Hearing loss in adults is associated with destruction of stereo cilia, tiny little Nanofibres within inner ear that converts sound waves into electrical signals that our brains can detect. Sound consists of little pressure waves in air. These pressure waves enter the ear, hit eardrum and make it vibrate. The other structures in ear transfer these vibrations into pressure waves in fluid that fills a special organ called cochlea. Inside cochlea fluid some special cells (hair cells) sprouts bunch of tiny nanofibres called stereo cilia that converts pressure waves into electrical signals.

This was the entire mechanism which inspired to design this system that converts sound energy into electrical energy.

IV. METHODOLOGY

To produce electricity from sound waves (mechanical waves) the entire system is designed in two possible setups, one which uses nanotechnology and other one without the application of nanotechnology. Both the systems of either design are capable of producing electricity.

Following are the equations for the sound energy conversion [1]

Sound energy, $l_w = 10\log(\frac{W}{Wo})$ ....(1)

Where, W – sound energy and Wo – reference sound energy level of 10^{-12}joules.

Energy equation of progressive wave, for a particle vibrating simple harmonically, the general equation of displacement is given as,

$$y = a\sin(\omega t + \alpha) \text{..........................(2)}$$

Where y – displacement, a – amplitude, ω – angular velocity, α – epoch of vibrating particle.

The total (kinetic and potential) energy of vibrating particle is given as

$$E = 2\pi^2 ma^2 n^2 \text{.................................(3)}$$

This energy is supplied by the source. The energy transfer per unit area per second is = $2\,\pi^2\ \rho n^2\ a^2\ \vartheta$.................................(4)

Equations for the working conditions of diaphragm [2], for a diaphragm clamped on its edges, from a mathematical point of view, the diaphragm can be viewed as thin plate and exact solution for different equation describing oscillations is given by Load – Deflection method, where deflection is measured as function of applied pressure. The load deflection relation of flat square diaphragm is

$$\frac{Pa^4}{Eh^4} = \frac{4.2}{(1-\vartheta^2)}\left[\frac{y}{h}\right] + \frac{1.58}{(1-\vartheta)}\left[\frac{y}{h}\right]^3 \text{........................(5)}$$

Where P - applied pressure, a – half side length, E – young's modulus, y – center deflection of diaphragm, h – diaphragm thickness, ϑ – Poisson's ratio.

The deflection range is divided into 2 regions: a small deflection region and the deflection less than 25% of diaphragm thickness described by linear term in above equation and large deflection region described by the non-linear cubic term in above equation.

As per the general rule, deflection of diaphragm at center must be no greater than diaphragm thickness. For the linear part,

$$y = \frac{Pa^4(1-\vartheta^2)}{4.2Eh^3} \text{...............................(6)}$$

The low pressure sensing performance of the boss diaphragm pressure sensor has been reaching its inherent limit with the diaphragm area in the range of mm^2. A further shrinkage in diaphragm diameter/length will significantly reduce the sensitivity due to a lower resultant resistivity change generated by the deflection induced stress/strain, which is proportional to the square factor of the diaphragm dimension

The device drawing of our annularly grooved diaphragm pressure sensor is shown in Fig. 4 with the detailed groove geometry and diaphragm cross section provided in inset I & II (In Inset II, the top passivation layer (Si3N4) has been turned into transparent for a clearer view). According to the previous study reported by Yasukawa et. al. [4], the induced surface strain of the both circular boss diaphragm (structure – B) and circular boss diaphragm with rib (structure – B&R) can be expressed as following:

$$\varepsilon total = \frac{3hr\,\xi}{wg}\ \omega + \frac{\pi^2}{16(1+\beta)w_g^2}\ \omega 2 \text{ ....(7)}$$

$$\beta = \frac{hrwr\ Er + h(\pi a\ Ed - wr\ Er)}{\pi awgks} \text{ ....(8)}$$

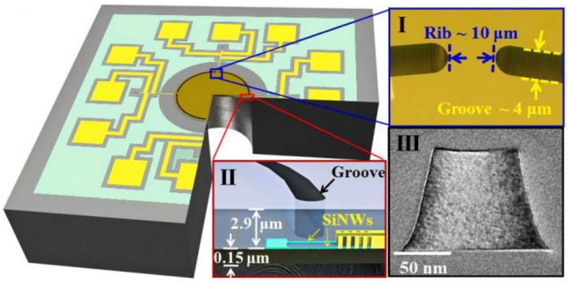


Fig.4.Schematic of SiNWs embedded pressure with groove and rib structures on the circular sensing diaphragm (released from the back side) [6]

Where εtotal is the total induced surface strain. hr and h are the thickness of the rib/center boss and hinge region, which is the remaining diaphragm portion below groove structures and connected to the device substrate. ω is the diaphragm deflection, wg is the width of the groove, wr is the width of rib, and ξ is the nondimensional coordinate of the gauge position (varies from 1 to -1). β is defined in (8), a is the radius of the diaphragm, Ed and Er are the equivalent Young's modulus of the diaphragm and rib respectively. ks is the support stiffness.

Fig. 5(a) & (b) illustrates the resistance change of the traditional flat diaphragm pressure sensor, the maximum average percentage change (~0.6 %) occurs for the 1 μm SiNWs embedded pressure sensor among other designs with longer length of embedded SiNWs.

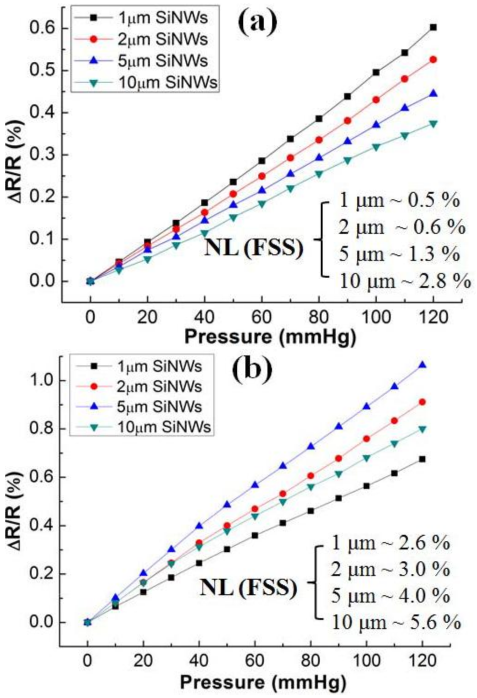


Fig. 5. Plots of the percentage changes of resistance (_R/R (%)) with respect to pressure changes for (a) the conventional flat diaphragm SiNWs pressure sensor and (b) the annularly grooved diaphragm SiNWs pressure sensor. The calculated nonlinearity for pressure sensors with different lengths of SiNWs (1 μm, 2 μm, 5 μm and 10 μm). [6]

The relationship for the fundamental frequency for square plate of density ρd and oscillating medium ρm is

$$f = \frac{10.21}{a^2\sqrt{1+\beta}}\sqrt{\frac{gD}{\rho dh}} \text{ ....(9)}$$

Where $\beta = 0.6689\frac{\rho m\, g}{\rho d\, h}$ and $D = \frac{Eh^3}{12(1-\vartheta^2)}$

According to the Equation (10), the sensitivity of diaphragm can be stated as [5]:

$$S = \frac{V_{out}}{P} = \frac{1}{P}\frac{\Delta R}{R_0}V_{DD} \propto \frac{1}{h^2} \text{.............................(10)}$$

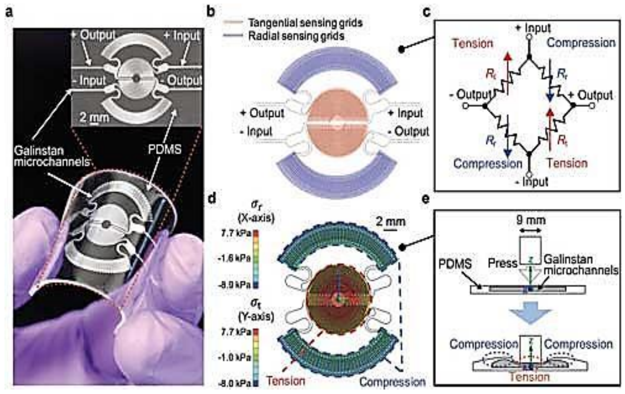


Fig. 6: a typical nano-diaphragm (Courtesy: nanowerk.com)

The system involving the application of nanotechnology: in this system setup, there are three sections, the third section involves drawing and storing of electric energy from the second section, which involves the nanotechnology based diaphragm as shown in Fig.6, which is similar to kind of Nano foam and the first section is of funneling the sound so that the waves get concentrated on the diaphragm in a higher intensity over the cross-section.

The diaphragm made of nanofiber by electro spinning have notable characteristics such as a high surface area to volume ratio, good pore inter connectivity, high porosity and the ability to incorporate active components on a nano scale. These characteristics make nanofiber layers have different properties in comparison with conventional material like glass wool and felts used for sound absorption.

Unique characteristics of nano material and recent development in the area of nano technology make the nano material more suitable to use in the field of noise control and the correction of acoustic environments, because it is possible to get advantage of improving the acoustic characteristics of traditional material without increasing their weight and size. Possible applications of these new materials are in the automotive and the aerospace industries where weight reduction is needed to increase the fuel efficiency. Nanofibers are fibers with a diameter of 1micrometer and this material is fabricated by electro-spinning method. Fig. 7 shows the schematic diagram of electro spinning apparatus without needle and with needle.

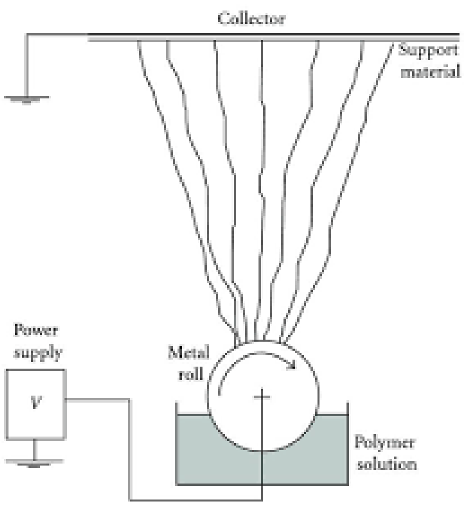


Fig.7. 2FProduction-of-nanofibers-layer-by-electrospinning-process [7]

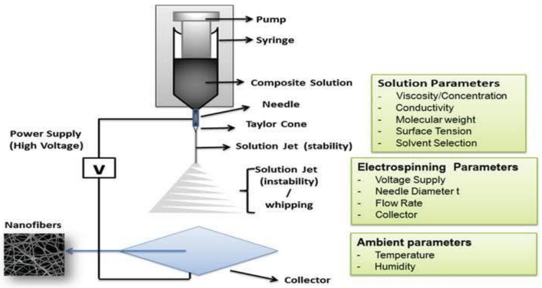


Fig. 8(a) Fnovel-nanomaterials-synthesis-and-applications%2Fnanofibers-and-electrospinning-method (Alpha-cabin-measurement)

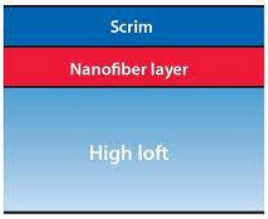
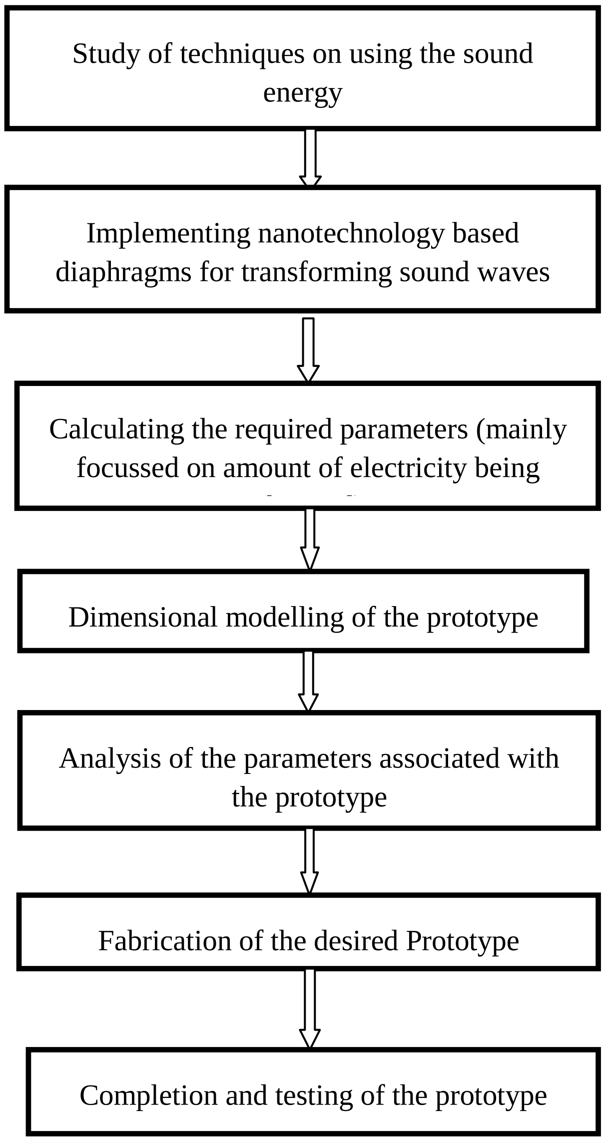


Fig. 8(b) Fnovel-nanomaterials-synthesis-and-applications%2Fnanofibers-and-electrospinning-method (Alpha-cabin-measurement)

Nanofibrous layer represents a membrane that vibrates at low frequencies. This characteristic is given by nano dimensions of the inter fiber areas. Sound wave landing on the acoustic resonating membrane makes the membrane oscillate and its amplitude is in its maximum in the case of resonance as shown in Fig. 8 (a) & (b). Fibrous underlay material ensures the sufficient suppressing of the resonant membrane, so that most of the sound energy accumulated in the resonator is transferred in to the heat energy. Individual elements are accumulated in to one resonant system by laying these elements on each other.

While the other setup also involves three sections, the first section has the same function of funneling the sound waves, the second section makes use of special diaphragm that is capable to vibrate without undergoing the wear and tear of material, and the third section of the setup makes use of Faraday's principle to produce electric energy. The output (electric energy) can then further be used in several ways depending upon the desired results. The steps involved to carry out the process are as follows:



Since our view of presentation has to be with respect to Nanotechnology, the most important

requirement for Nanotechnology is the nanostructure which has the special properties due to Nanoscale proportions. The Nanotech consists of processing of separation, consolidation, and deformation of materials by 1 atom or 1 molecule.
We here are using the Nanotech processing of consolidation. As a result of which collection of sound waves so as to get the desired impact gets simplified by its concepts, one such of which gives us the knowledge that 'Nanoparticles have greater surface area per weight than large particles'. This concept is useful in obtaining the Nanotechnology based diaphragm which is one of the most important elements of the system setup. Fig. 9 shows operating principle of nanotechnology diaphragm.

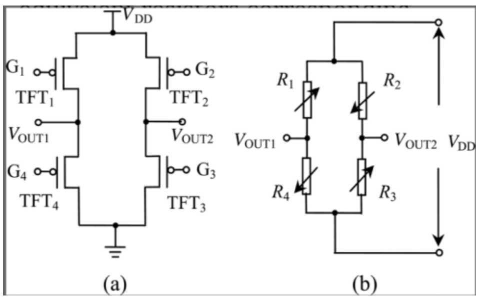


Fig.9 Operating principal of the pressure sensor based on nano-polysilicon
(Courtesy: aip.scitation.org)

V. The Experimental Setup

The system consists of

- Funnelling device
- Nanotechnology based diaphragms
- Electric energy storage and production system

The funnelling device is used so that the sound waves can be easily concentrated on the diaphragm. It is also meant to avoid the dispersion or wide spreading of sound waves so that maximum amount of sound waves gets concentrated on the diaphragm.
The diaphragm used can be of any type. A special diaphragm having the capacity to withstand to vibrate continuously for a long duration of time without undergoing wear and tear and also being very sensitive to sound waves. But when we used Nanotechnology based diaphragm the sensitiveness is very high from -30dB to 300+ dbs. Such diaphragms are of sandwiched form of Nanocomposite materials, of which the conducting sections can be directly connected to electric energy storage devices. There are Nanofoams which can also be used in place of diaphragms that have nanoporous grits (about 15nm pores). The porous granules (up to 100 micrometers) of silica/silicon and magnetite nanoparticles dissipate energy of sound waves transforming it into heat. This heat can further be utilized in a way that leads to desired outputs. Nanofoams such as those of carbon particles and other replacing parts include miniature device made by the University of California – San Diego, which is sensitive enough to feel the forces generated by beating of heart muscle cells.
The electric energy whatever produced by using nanotechnology based diaphragms can be directly stored in storage devices such as batteries, and the electric energy produced by conventional means using special kind of diaphragms includes the application of Faraday's principle. The magnet is attached to diaphragm by plunger means. From the diaphragm, about a very small (desired) distance a stand is placed which holds coil and it is fixed. When the diaphragm vibrates as a cause of impact by collective sound waves, the magnet reciprocates, and if this reciprocation is continuous, the flux being generated produces electric power. Hence as we connect the coils to batteries or say charging devices, then the current flows through it. The amount of current flow is directly proportional to the number of times the magnet reciprocates in the coil and it can be regarded as this step is the crucial backdrop for the failure tendency when we opt for conventional (having no application of nanotechnology) diaphragms. Fig. 10 Shows circuit diagram of charging the battery after absorption of wave from diaphragm.

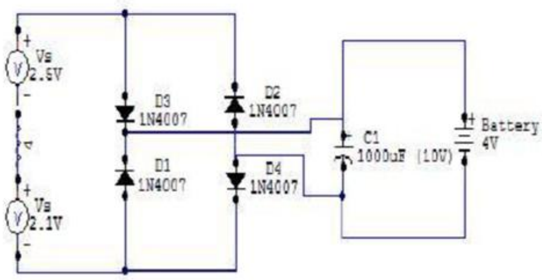


Fig. 10 . Circuit diagram of charging the battery [1]

VI. Expected Outcomes

- The expected outcome comes from the purpose of supplying free electricity.
- The output of conversion of sound waves must be electric energy in desired amperes.
- The electric energy obtained must be of high beneficiaries to the events in the professional world. Right now the system is designed for the sound waves of decibels more than human range(say, 40dB), but its futuristic approach would be to make it suitable for even human range or even less than it which may be possible by the advancements in nanotechnology.

VII. Applications

- ✓ The system can be implemented alongside the pathways in traffic prone areas.
- ✓ The system can be used in the large functions such as during visarjans, student events, musical nights, DJ events, and such similar events.
- ✓ The system can be implemented in factories which produce lots of noise such as those of industrial machinery processes, automobile sectors etc.
- ✓ The system can be implemented in railways (trains), where the sound waves of engines and its corresponding systems can be transformed into electricity supply (charging ports, fans, lights in trains).
- ✓ The system can also be used in aerospace industries too.
- ✓ Testing pipelines for leaks.
- ✓ To monitor machines and medical implants to catch faint sounds/unusual vibrations before components fail.
- ✓ Remote noise detection in the fiels of security and surveillance applications.

For acoustic sensor, Tao Deng, Wen Shang and their colleagues sandwiched piece of butterfly wing between 2 steel films and cut 5mm wide hole in middle. They direct sound from speakers onto the wing, it shine bright white light on it and use of photo detector to look at reflected light. The wing vibrates due to acoustic wave causing nanostructures to deform. Practical sensors would use artificial butterfly nanostructures made with lithographic processes [3].

VIII. Conclusion:

As we know the pressure being created on diaphragm is purely dynamic pressure, by the following equations we can have a conclusion that for the dynamic pressure, the output voltage variation is similar to that of shown in Fig. 11.

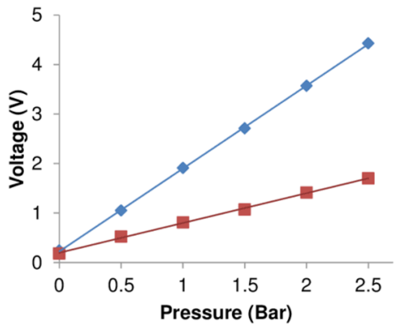


Fig. 11. Variation output voltage with respect to absorbed pressure.

$$Pressure = \left(\frac{C_{fs}}{V_{ex}}\right)\left(\frac{V_{meas}}{CF}\right) \text{.................(11)}$$

Where C_{fs} = Full Scale Capacity- maximum pressure received by transducer

V_{ex} = Excitation Voltage – recommended input voltage

V_{meas} = Measured Voltage – raw voltage returned by the sensor

CF = Calibration Factor- the output of the transducer, expressed in mV per input V

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