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NANO TECHNOLOGY BASED SELF-RECHARGABLE MOBILE PHONES

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Abstract. Use of non-conventional sources to recharge portable devices is the need of the hour. Silicon-Nanowires and Macro fiber composites (MFC) of piezoelectric materials have been found to serve the purpose just enough. Various test-results of the Si-Nanowires and MFC's were studied. The voltage and power graphs obtained from the existing prototypes of these materials have proven to cater the needs of the proposed model.

Keywords: Non-Conventional power generation technique, Nano-Technology, Environment-friendly energy.

1. Introduction

Mobile Phones have become an integral part of our lives. As the fastest growing telecommunication market in the world India is projected to have 1.159 billion mobiles subscribers by 2013. An incredibly huge power is being consumed for the charging of mobile phones. Various researches are being conducted all over the world to find alternative means for charging mobile phones. Using conventional sources like temperature and body vibrations have been proved to be one of the best leads. This paper concentrates on harvesting these energies into useful electrical energy.

2. Power Consumption due to Conventional charges

With most people today using one or more cell phones the energy these devices collectively consume is huge. Although it would be impossible to expect people to minimise phone use, they can certainly opt for alternative energy resources for charging their cell phones.An average mobile phone requires to be charged with a 3.5V 500mA charger for 2 hrs. It adds up to 7.36Wh per day. Considering 1.159 billion mobile users, mobile charging solely becomes responsible for 8530Mwh of electricity country wide per day. The power loss due to idle chargers (i.e.) plugging of charger chord, even after the phone is fully charged alone accounts to 30% of the charging current, i.e. 2559MWh per day. In India, base load requirement was 861,591 (MU) against availability of 788,355 MU which is a shortage is 73,236 MU i.e. 8.5% deficit. During peak load the demand was for 122,287 MW against availability of 110,256 MW which is a shortage of 12,031 MW i.e. 9.8%. In order to bridge the gap between supply and demand, engineers have been coming up with ideas for alternative power generation. Considering the large load due to charging of mobile phones we have proposed an idea for self-rechargeable mobile phones using environmental physical conditions.

3. Objective

The objective of the research is to get cell phones to harvest about 50 mill watts of power. Currently the prototypes are able to harvest up to 5 mill watts, but at least 20 mill watts is needed to keep phones running in standby mode indefinitely without the need for a recharge. The proposal is to achieve the 50 mw goal using multiple harvesting such as

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- Thermoelectric conversion using silicon Nano wires
- Vibration pick ups

4. Silicon Nano wires

The concept of converting heat to electricity is not new. Devices based on thermo electrics would seem to be ideal for this application. However, for this process to continue, one end of the wire must remain hot, and the other cold and this presents a materials design challenge because most materials that conduct electricity will also conduct heat. This is true, for example, for bulk silicon, which conducts heat while conducting electricity, leading most scientists to conclude that this otherwise attractive material is not a very good candidate for thermoelectric conversion devices.

4.1. Requirement for Nano Technology

Though bulk silicon wires do not efficiently convert heat to electricity, fashioning the material into nanowires with diameters of 10 to 100 nanometers (as illustrated in Fig-3) and introducing defects in the silicon would slow the flow of phonons(the acoustic vibrations in the crystal lattice of a material that carry heat).

Normally, a wire would carry two types of phonons: one that causes the wire's diameter to expand or contract, and one that causes it to lengthen or shorten. But when the nanowires get small enough, the two phonons merge into a single type of phonon, and that slows down the heat transport even more. Thus an efficient thermoelectric material could be fabricated. Now, when the ends of the wire are maintained at different temperatures, flow of electrons from one end towards the other could be achieved. The process of converting the heat energy into electrical power and storing it in the battery is depicted in the Fig-2.

4.1.1. Manufacturing

- A Si Wafer is immersed in a chemical solution of etchant.
- A microscopic forest of silicon Nano wire is formed on the surface of the wafer.
- However, unlike theoretical expectations the surface of the Nano wires would not be smooth.
- But this roughness is found to be a function of the silicon Nano wires’ thermal conductivity.
- By optimizing the roughness of the wires the room temperature thermal conductivity could be reduced up to a factor of 100.

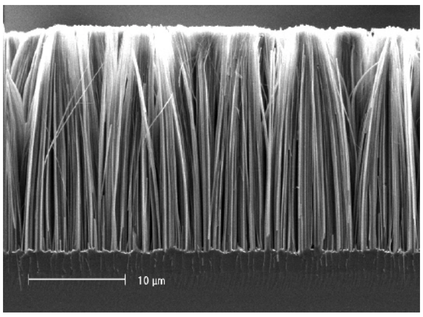

Fig-1 Si-Nanowire forest

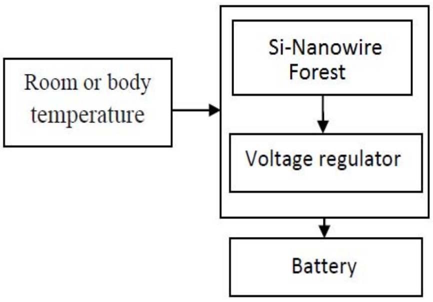

Fig-2

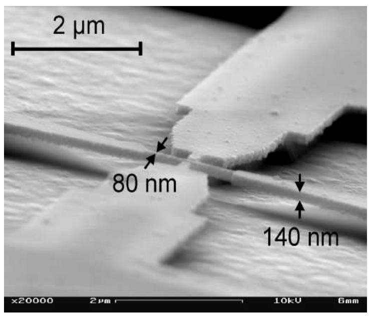

Fig-3 Si-Nanowire dimensions

4.2. ZT Ratio

Thermoelectric conversion efficiency is measured in terms of ZT. It depends on various factors, the primary two being Thermal conductivity and Electrical conductivity. Bulk silicon at room temperature has a ZT of 0.01. But experiments on Si Nano wires have recorded a ZT ratio up to 0.6, which puts it on par with bismuth telluride, the compound from which commercial converters are made.

5. Vibration pickups

Unused power exists in various forms such as automobile vibration, speech, environmental noise, etc. With the present commercial technologies available one would suggest the use of piezo electric materials for harvesting these vibrations. But their use in portable devices would cause the following practical limitations:

- Mechanical stability of the piezoelectric transducer under large mechanical stress,
- Electrical breakdown of the material under high fields, and
- Reduction in efficiency due to dielectric losses and depolarization.

These limitations of piezo ceramic components could be overcome by the use of a composite material such as the MFC-Macro Fibre Composites.

The macro-fibre composite (MFC) is a new actuator that was recently developed at the NASA Langley research centre. The actuator is constructed using piezo-fibres surrounded in an epoxy matrix and covered with a Kapton shell. The Construction of this actuator allows it to be extremely flexible, making it ideal for applications such as the inflatable satellite. The flexibility of this piezoelectric device as well as the epoxy and Kapton shell, that envelopes it allows the actuator to be robust to damage and environmental conditions. Its flexibility is illustrated in the Fig-5. Fig-4 depicts the conversion of speech and vibrations into electrical energy.

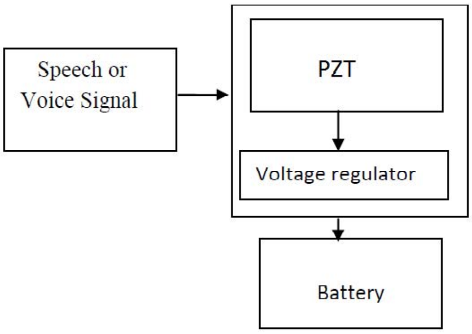

Fig-4

Fig-5A person holding MFC, illustrating tis flexibility

5.1. Power Generation

Before the mentioned circuits were used to generate energy, the amount of power harvested by the proposed substrate thickness of each material is studied. According to maximum power transfer theorem, 'maximum power output occurs when the impedance of the piezoelectric element and the load resistance are matched'. However, this cannot be always achieved in a piezo electric crystal since it is a capacitive device (as the impedance varies with frequency). An experiment was done with a prototype MFC crystal by vibrating it at resonant frequency and measuring the voltage drop across a 10 kΩresistor. The power generated by the crystal can be calculated using ohms law $P = V^2/R$.

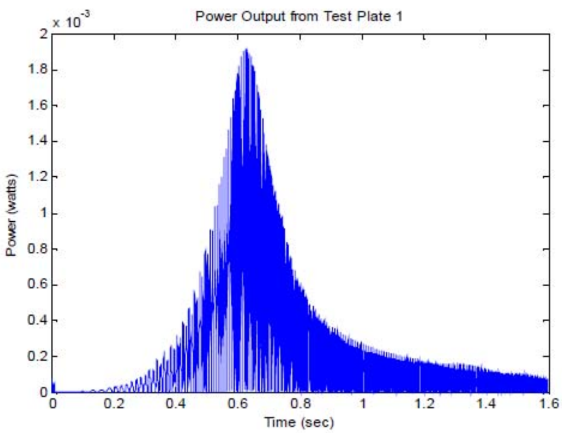

Fig-6

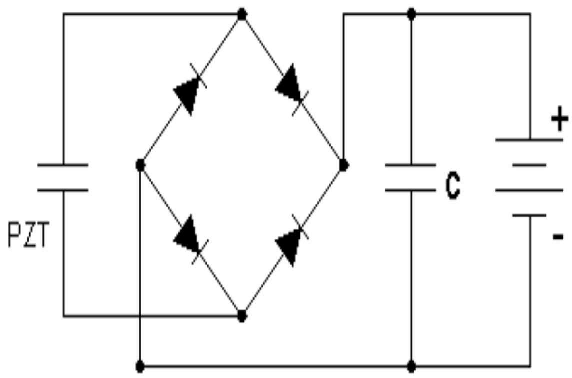

Fig-7 Battery charging circuit

As can be seen in the Fig-6, the maximum instantaneous power is identified as 2mW, which occurs at the resonance of the test plate. Three PZT plates were tested with the same configuration, and all produce a maximum power in the range of 1.5-2mW, and an average power of 0.14-0.2mW.

5.2. Battery Charging Circuit

The circuit constructed to charge the battery is very simple, it consists of a full-wave rectifier; capacitor and the battery intended to be charged, as shown in Fig-7. The voltage produced by the PZT or the Si-forest is first full wave rectified then accumulated in a large capacitor (greater than 1000µF), then the battery intended to be charged is placed in parallel with the capacitor. The simplicity of the circuit ensures the effective power storage onto the battery.

5.3. Test Results from a MFC PZT

Illustrated below are the test results from a prototype MFC crystal, when subjected to simulated vibrations, both under resonance and under random excitations. The time required to charge a 40mA battery is plotted as a function of the charge stored across the battery. The simulated vibrations were

1. Resonant frequency at 63Hz
2. Random frequencies at 0-1000Hz

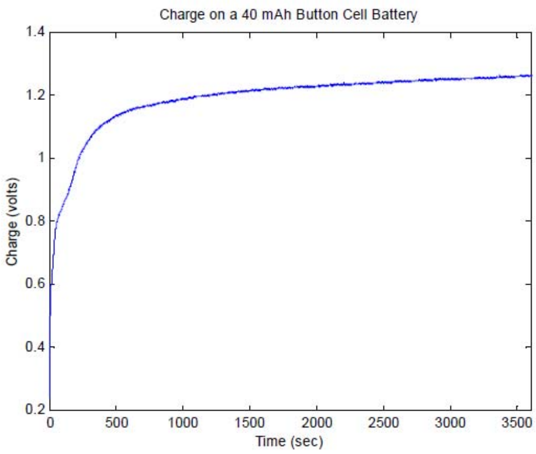

Fig-8

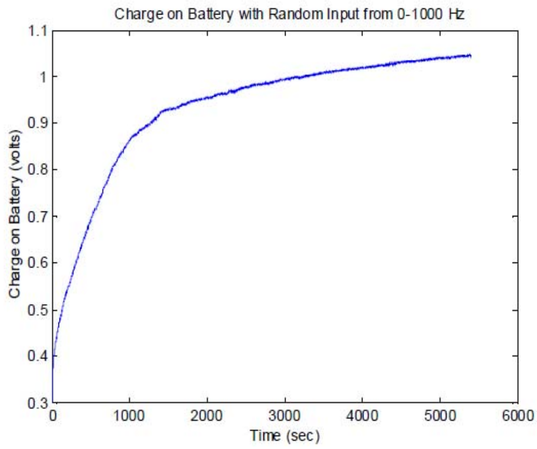

Fig-9

It can be inferred from the above tests that it takes almost just 58 minutes to charge the 40mAh battery at resonance, and 1.6 hours at random frequency. This could imply that the mobile battery (1000mAh) could be fully recharged within 40 hours, without the effect of the Si-Nanowire forest. These results prove the feasibility of the idea.

5.4. Emergency Override Charging

Though the energy generated from the Si-nanowires and the MFC PZ material is more than sufficient, an override charging socket is also fabricated on the circuit board like the usual mobile phones.

6. Mobile Phone design for efficient implementation

A large variety of non-traditional designs for charging have already hit the market. But selecting the most apt design would play a major role in the marketing of this technology. The most convenient way of implementation of the self-recharging is by fabricating the entire recharging circuit into a single module, as the back panel of the handset. By this,

- The basic hardware of the mobile could still remain untouched.
- The phones could be marketed with the '*Self-rechargeable back panel*' as an accessory.

The whole idea was inspired from an existing wireless charging mobile phone, 'Palm-Touchstone'. It transfers the electric power from the panel to the charging circuit through two leads of the panel that come in contact with the two pins in the circuit board, beneath the battery.

The estimated thickness of the panel is about 3mm, which does not pose noticeable discomfort to the user. It houses the MFC vibration pickup in the outermost surface so as to efficiently capture the vibrations without considerable damping. The inner layer houses the Si-Nanowire forest which extends to only one half of the length of the panel, as the other half needs to provide the electric leads onto the circuit board, which performs the power conditioning operations and aids in recharging the battery. Also it holds space for the cold insulated portion of the Si-Nanowire forest. The cold portion is insulated using superior Polymers for efficiencies nearing absolute insulation.

Back Panel of Palm-Touchstone

7. Conclusion

Thus, a theoretically proven and practically feasible idea of self-rechargeable mobile phones has been proposed. A prototype of the designed model is expected to be developed in a couple of years. This technology, in addition to catering to the increasing power demand, also helps making life simper, and the World, a better place to live in. With considerable research and sophistication to this technology, we can expect a world with no external chargers for mobile phones in the future.

8. Acknowledgement

We have taken efforts in the research. However, it would not have been possible without the kind support and help of many individuals and faculties. We would like to extend our sincere thanks to all of them. Our thanks and appreciations also go to our colleague, E.Vaidhiyanathan for developing and assisting the research and people who have willingly helped us out with their abilities.

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