Piezoelectric Nanogenerator

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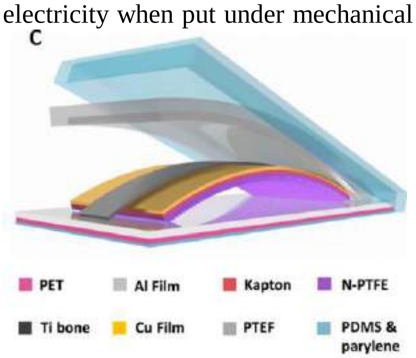
***Abstract*—the problem facing many medical devices is the lack of a reliable, sustainable and biocompatible power source. The use of piezoelectric nanogenerators will provide such a power source by converting the body's own mechanical energy into electricity. The function of these PENGs and their suitability in vivo will be discussed.**

I. Introduction

THE introduction of piezoelectric materials into the field of medicine will provide engineers the ability to power implantable devices with sustainable electricity. The past decade has given us multiple experiments that prove the in vivo harvesting of biomechanical energy is a legitimate possibility. The use of the crystalized structure of certain metals and the physiological actions of living things allow this technology to be possible. The PENG, although promising for the future, is still in the developmental phase and therefore the methods and results discussed will be of experiments done on living rats and swine.

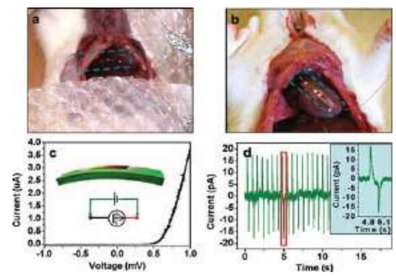
II. Methods

The PENG is a piece of nanotechnology composed of multiple materials in order to produce power. There are 3 main components to a PENG: the shell, the electrode, and the piezoelectric material. The most important is the piezoelectric material which through its crystalized structure produces electricity when put under mechanical stress. Experiments are still being done to determine the best material however, two possible solutions could be Zinc Oxide or PZT (lead zirconium titanium). The electrode allows for the transfer of power to the device and the shell is to project the PENG and the body from each other. Tests that are now under way determining if the use of PENG is possible in vivo (living body). Professor Zhong Lin Wang from Georgia Tech has successfully demonstrated the PENG on rats and hamsters. This year has marked the first successful test of the PENG on swine which has proven to produce enough power to sustain small devices.



III. Results

The results of Dr. Wang's rat tests and the more recent swine experiments prove to be promising. These trails tested the PENGs using Zinc oxide attached to both the lung and heart of lab rats. Wang's testing was successful, finding that the PENGs produce electricity when attached both to the lung and the heart. The lung produced less power as the heart with only 4pA and 2mV compared to the 30pA and 3mV of the heart. Although these were determined to be too low to power a device when hundreds of nanowires are placed in array the power increases drastically producing 100nA, 1.2V, and .12mW. In 2016 the same experiment was done using an adult swine. The results proved to be similarly successful and logically produced a larger amount of energy. When attached to the swine heart 2.8V was produced in 200 seconds.



IV. Discussion

As this technology advances many biomedical devices will be powered reliably and sustainably. The power that has already proven to be producible is a great sign that this technology is in the nearing human trail. The future for this device is already in development by again Dr. Wang. The new device is called a saTENG (shape-adaptive triboelectric nanogenerator) which is a more flexible PENG and it is in very early development. This device allows for 300 percent stretch with no loss of performance and therefore could be a key to providing sustainable energy. There are some limitations to the PENG mainly being biocompatibility. When materials are chosen their toxicity and restriction of the body has to be taken into account, these devices are being attached the important organs of which can cause serious health issues. Overall the continued development of this technology would have a huge impact on medicine.

References

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