Investigating the Feasibility of Energy Harvesting using Material Work Functions

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There is an on-going search for miniaturized efficient energy harvesting devices which will capture energy from the environment and transform and supply enough electrical power for the autonomous operation of small low power-demand electronic devices [1]. The concept of energy harvesting is especially attractive as it could be applied when battery replacement is difficult or when recharging in a conventional sense may prove to be not cost effective. Also this concept could be used successfully when continuous operation without maintenance is required.

Electronic devices, with low power demand, can be energized using vibration energy harvesters which gather and transform energy from mechanical vibrations. This investigation looks at the feasibility of a method of energy harvesting from mechanical vibrations using the naturally occurring charging phenomenon within a system of two bodies which possess different work functions. A work function is defined as the minimum thermodynamic work (i.e. energy) needed to remove an electron from a solid to a point in the vacuum immediately outside the solid surface. A work function is not a characteristic of the bulk material but rather is a property of the surface of the material and depends on the material crystal face and presence of contaminants. The critical difference between a work function energy harvester (WFEH) and the electrostatic energy harvester is that the former does not require any electrets (dielectric materials that has a quasi-permanent electric charge or dipole polarisation) or external power sources.

In this work, a brief review of similar technologies, namely piezoelectric, electromagnetic and electrostatic energy harvesters is first given. This is followed by the development of a theoretical model and an investigation of different WFEH operation modes and miniaturization of a WFEH, with conclusions on a possible optimum mode of operation and method of miniaturization. The design of an experiment to test the developed theory is then presented followed by some preliminary results. Generally it is found that WFEH has potential for use in energy harvesting applications with the possibility of giving equal or better output power when compared to traditional electrostatic harvesters.

References

[1] B.E. White Jr, Nat. Nanotechnol. 3 (2008) 71-72