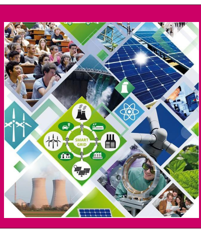

Electrostatic energy harvesting micro devices with up-frequency effect for medical implants

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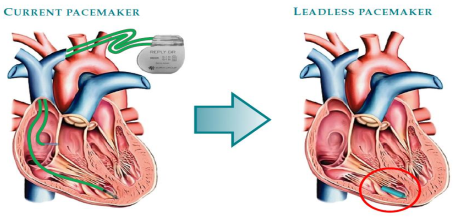
Introduction

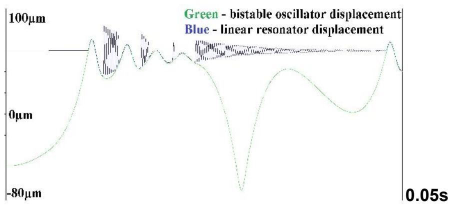
This project aims at studying micro devices dedicated to harvest ambient mechanical energies in order to power standalone electronic devices. The targeted application is to power biomedical implants (pacemaker) using the human motion mechanical energy.

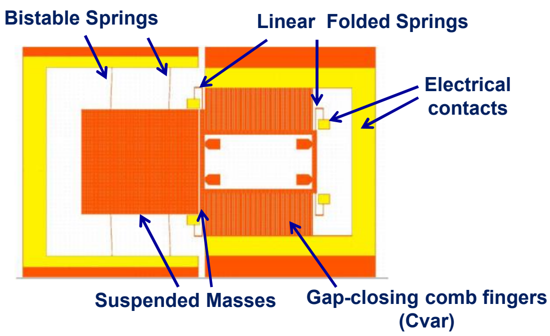


Offered concept combines mechanical bi-stability and mechanical oscillators non-linearly coupled by electrostatic effect. It is expected to bring outstanding performances in terms of frequency bandwidth and power density. Design, fabrication and characterization of the energy harvester with frequency up-conversion mechanism that will function under the excitation of human heartbeat (at frequency range of 1-50Hz, with acceleration of the order of 1g) and deliver the output power of the order of several µW, with total volume <1cm³.

Design & Simulation

To model the performance of the device, both finite element modelling (FEM) of the static performance and numerical modelling of dynamics is performed. Evolution of the system is studied using equivalent circuit approach.





On the top picture the evolution of the displacement of coupled resonators is shown. On the bottom – schematics of the bistable energy harvester with frequency up-conversion mechanism (MEMS device) with size of 1.5mm x 1mm x 85µm.

Operating principle:

- Bistable oscillator gets excited from the medium;
- Pull-in contact leads to energy transfer to linear oscillator;
- Capacitance variation as a result of linear system movement generates electrical energy.

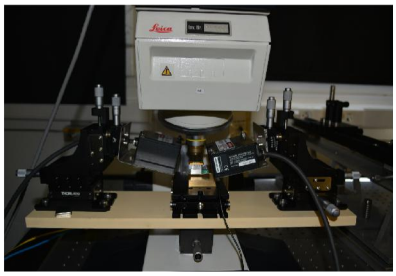
Simulatied maximum power output: 2.4µW;

Power density: up to 185µW/cm3.

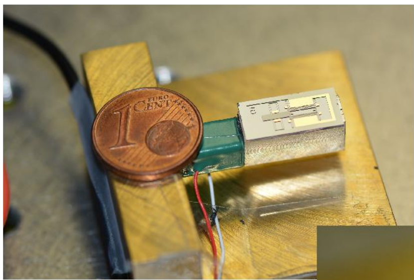
Experimental

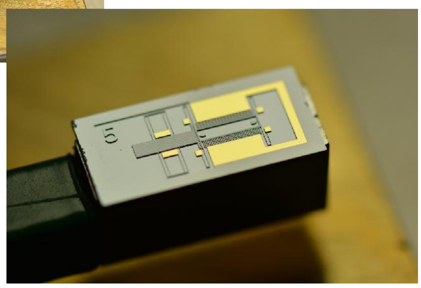
Conventional clean room technologies are used to fabricate the MEMS energy harvester. Main benefit comes from rather simple production – only two layers are developed by widely used methods (lift-off, DRIE) that could be easily implemented in industrial lines.

Innovative characterization method for MEMS is used in this work – a simultaneous observation of a displacement for each movable part. This technique allows to ensure the desirable functioning regime of the device.



In the future, more sophisticated system is going to be introduced – it is expected to remove gravitational offset, which will allow the energy harvester to function not only when it is placed horizontally, but at any position.





Linear frequency up-converter prototype. Typical dimensions: 1cm x 0.5 cm x 85µm (DRIE).

Further opportunities

The possibility of development miniaturized energy harvester using silicon technologies widely used in industries will is an extremely interesting scientific challenge with benefit for future application in biomedical business.

Due to the wide availability of mechanical vibrations, the creation of miniaturized energy harvester that is capable of absorbing the low frequency – low amplitude excitation grants energy sorts for plenty of applications. It could be used not only for powering a pacemaker, but also for a small standalone devices such as sensors and detectors (which makes it particularly interesting in the context of Internet of things).

Contacts

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