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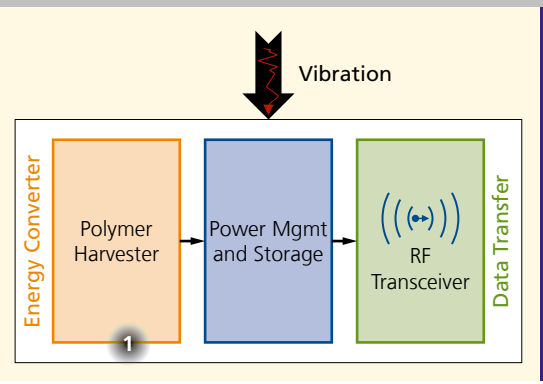

1 *Energy harvesting-based wireless RF transceiver.*
2 *Shoe-embedded polymer energy harvester for powering an RF telegram transmitter module (demonstrator).*

POLYMER ENERGY HARVESTER FOR POWERING WIRELESS SYSTEMS

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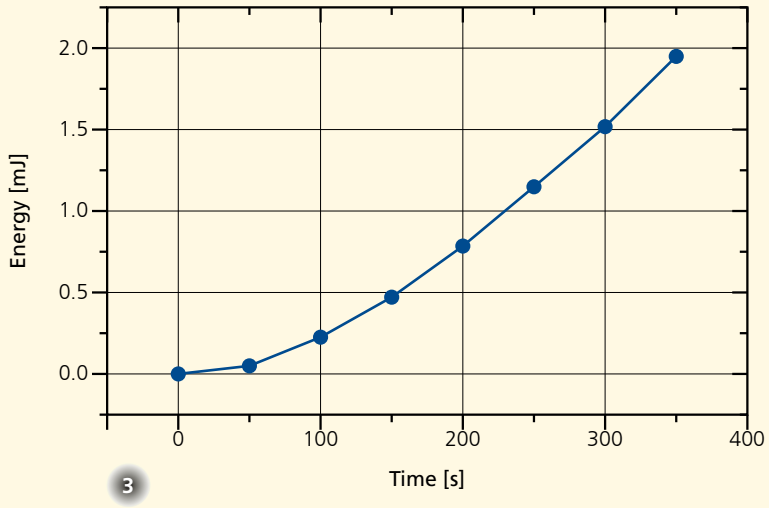
Harvesting energy from the surrounding environment and converting it into usable electrical energy has become an attractive approach to producing sustainable power sources for wireless sensors and low-power electronics. Mechanical power exists in various forms such as machine vibration, human motion, wind, flowing water, ocean and shock waves. For harnessing energy from human motion, for example, harvesters can be connected to electronics in garments and footwear that are able to track physical parameters such as speed, movement and temperature. It is yet really challenging to generate in this way enough energy to power today's applications.

Conventional piezoelectric harvesters work at fixed resonance frequencies, with issues existing in the mechanical stability of the device under large mechanical stress and the reduced device efficiency due to dielectric losses and depolarization.

Emergent polymer materials are of great interest for electromechanical energy converters due to their large relative permittivity, large mechanical deformation, CMOS compatibility and simple processing.

At Fraunhofer IPMS energy could be generated by subjecting structures made of electroactive polymers to a quasi-static mechanical deformation. In particular, the device is based on thin films of dielectric and electrostrictive polymers of large relative permittivity. Mechanical work is converted into electrical energy by varying the capacitance of structured polymer stacks. As compared with traditional piezoelectric configurations, this concept works non-resonantly and can be optimized for capturing energy from mechanical power sources in the low frequency range.

A particular concept of a low power harvester circuit designed for electrostatic



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Technical specifications

Parameter	Unit	Value
Harvested energy	µWs	> 1.5
Frequency (non-resonant)	Hz	0.5 – 10
Current	µA	1.5
Output voltage*	V	3.8 – 5
Applied pressure	bar	0.5 – 4
Sizes	mm³	~ 20 × 20 × 18

* Adjustable as required by the application (i.e. sending of an RF signal)

harvesting allows energy conversion of high efficiency. The circuit ensures further the power management for the entire system, i.e. energy conversion, energy storage and the control electronics of a wireless micro-system (fig. 1).

The developed device is small, flexible and easily embeddable into, for instance, the sole of a shoe. Further miniaturization is also possible.

Polymer harvesters are fabricated at the Fraunhofer IPMS in an easy, straightforward way, making use of standard microtechnological processes. The prerequisites for cost efficient manufacturing are therefore fulfilled.

In a first possible application of the developed harvesting concept, the harvested energy is stored in a storage capacitor and used to power a commercial wireless RF transmitter.

A first device demonstrator of such a polymer energy harvester embedded in a shoe is now available (fig. 2). This is able to generate several microwatts of power in a second when subjected to mechanical deformation of pressure and frequency range specific to human walking (fig. 3).

This harvester circuit has been adjusted to power an RF transmitter module. Thus the system is able to generate mechanical power and, using that, to transmit RF signals ('telegrams') at intervals of seconds. Fig. 2 shows that 'telegrams' have been received via the USB receiver on a tablet.

Advantages

The newly developed energy harvesting device based on emergent electroactive polymers is small enough to be embedded in the sole of a shoe. As it is based on polymer layers, scalability and further miniaturization is possible.

With the new device design, Fraunhofer IPMS has demonstrated an efficient, low cost energy harvester system concept that works non-resonantly and in the low frequency range and can harvest enough energy from walking to power an RF transmitter.

The design of the harvester device and the corresponding circuit can be adjusted to meet the needs of various applications.

Usage

The harvester device and circuit can be adapted for other applications such as for powering wireless sensors (temperature, acceleration, pressure), for powering portable, wearable devices and monitoring various bio-data as well as various applications in medicine.

Key features

- Dielectric polymer energy harvester
- Low frequency vibrations of 1 – 10 Hz
- Low power harvester circuit
- Adapted for RF signal transmission
- Generated power of several microwatts
- Small footprint
- Shoe-embedded harvester

Applications

- Non-resonant energy harvester
- Powering wearable sensors
- Powering portable devices
- Bio-data monitoring

3 *Energy accumulated at a storage medium (excitation at 4 Hz and 1 bar).*