Energy Harvesting from Mechanical Strain of Electrostrictive Polymeric Nanocomposites

Michele Zanoletti,[1] Paolo Vitulo,[1] Riccardo Morina,[3] Daniele Callegari,[2] Eliana Quartarone,[2] Riccardo Viola,[4] Davide Comoretto,[5] Sergio Dulio,[4] Piercarlo Mustarelli,[3] and Maddalena Patrini[1,*]

[1] *Dipartimento di Fisica, Università di Pavia, Via A. Bassi 6, I 27100 Pavia*
[2]*Dipartimento di Chimica, Università di Pavia, Via T. Taramelli 12, I 27100 Pavia*
[3]*Dipartimento di Scienza dei Materiali, Università di Milano Bicocca, Via R. Cozzi 55, I 20125 Milano*
[4]*Atom S.p.A. Via Morosini 6, I 27029 Vigevano*
[5]*Dipartimento di Chimica e Chimica Industriale, Università di Genova, Via Dodecaneso 31, I 16146 Genova*
*corresponding author: maddalena.patrini@unipv.it

Harvesting systems capable of transforming mechanical vibration into electrical energy have attracted considerable interest throughout the last decade. Most of the research activities refer to classical piezoelectric ceramics, but triboelectric and polymer materials are now increasingly considered. They are basic components of harvester platforms that are needed for powering wearable electronics in the IoT world. The goal of this work is to develop harvester systems compatible to a shoe sole structure and capable of recovering energy from human gait, then sustaining the energy consumption of a sensor platform to monitor biophysical parameters. Herein a stretchable and stable polymer composite of polyurethane and a high-*k* ceramic filler is fabricated by doctor blade coating [1]. The composite (in strips of tens cm^2 area and tens of micron thickness) serves as electrostrictive material with high resistivity and variable capacitance as due to an elongation-release cycle at about 1 Hz. Multilayers of strips were electrically assembled in parallel configuration as to obtain an overall flexible structure to be inserted in the shoe sole; the necessary bias voltage is provided from a rechargeable battery or an electret supply. Due to the constraint for wearable electronics, we were forced to adopt battery voltage values lower than 50 V obtaining energy density output of about 5 $\mu J/cm^3$. In view of different applications, we developed custom electrets, with surface voltages as high as 1 kV, and measured energy density output a factor 3 to 10 higher. Finally, during motion time the harvested energy should be accumulated in a supercapacitor, supplying the sensor platform or low-bit-rate bluetooth data transmission. The real system must be engineered to be robust, to endure mechanical deformations without performance degradation, and to maintain stable electrical output demonstrating their potential for use as smart textiles and wearable power sources.

[1] Invernizzi, F. et al. *Journal of Physical Chemistry C* 122 (2018) 21115.