PIEZOELECTRIC ENERGY HARVESTING SYSTEMS

Kenji Uchino
Int'l Ctr. for Actuators & Transducers, The Penn State Univ., University Park, PA 16802, USA

Email: kenjiuchino@psu.edu

Energy harvesting from wasted or unused power has been the topic of discussion for a long time. This paper focuses on harvesting energy from mechanical vibrations using piezoelectric transducers. We will consider comprehensively three major phases/steps associated with piezoelectric energy harvesting: (i) mechanical-mechanical energy transfer, including mechanical stability of the piezoelectric transducer under large stresses, and mechanical impedance matching, (ii) mechanical-electrical energy transduction, relating with the electromechanical coupling factor in the composite transducer structure, and (iii) electrical-electrical energy transfer, including electrical impedance matching, such as a DC/DC converter to accumulate the energy into a rechargeable battery. The problem found in the current research teams is on a narrow research area of each above phase. In order to provide comprehensive strategies on how to improve the efficiency of the harvesting system, I provide a general guideline for piezoelectric energy harvesting systems.

We dealt with detailed energy flow analysis in piezoelectric energy harvesting systems with stiff "Cymbals" (~100 mW) and flexible piezoelectric transducers (~1 mW) under cyclic mechanical load, in order to provide comprehensive strategies on how to improve the efficiency of the harvesting system. Energy transfer rates are practically evaluated for all three steps above. For your information, the former "Cymbal" is to be applied to the automobile engine vibration, while the latter flexible transducer is to the human-wearable energy-harvesting system.

We should also point out here that there is another research school of piezo-energy harvesting; that is, small energy harvesting (mW or lower) for signal transfer applications, where the efficiency is not a primary objective. This school usually treats a burst/pulse load to generate instantaneous electric energy for transmitting signals for a short period (100 ms ~ 10 s) without accumulating the electricity in a rechargeable battery. Successful piezoelectric products in the commercial market belong mostly to this category at present, including "Lightning Switch" [remote switch for room lights, with using a piezoelectric unimorph component], and the 25 mm caliber "Programmable Ammunition" [electricity generation with a multilayer piezo-actuator under shot impact], both of which were originally designed in our group (spin-off company, Micromechatronics Inc., State College, PA).

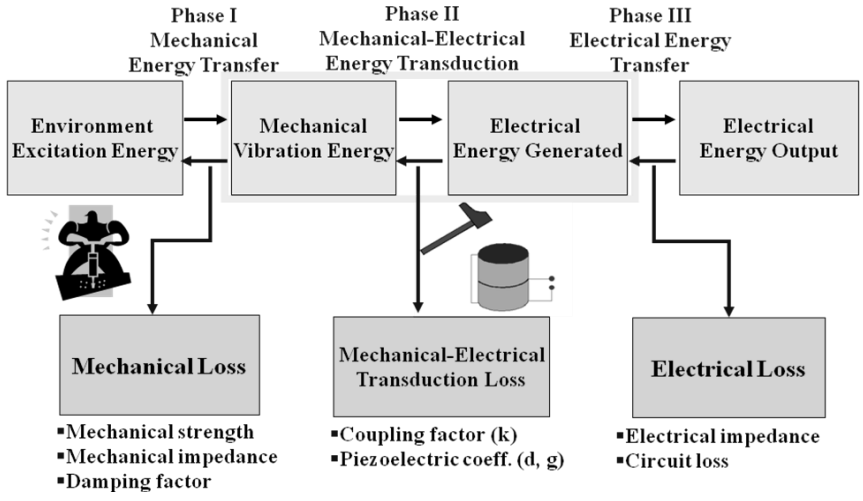

Fig. 1 Three major phases associated with piezoelectric energy harvesting): (i) mechanical-mechanical energy transfer, (ii) mechanical-electrical energy transduction, and (iii) electrical-electrical energy transfer.