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“High Power Density Dual Phase Energy Harvesting”

Abstract

Novel material properties open the possibility of developing new components and systems. These new components and systems require sustainable power to operate. This synergy between the materials – energy – smart systems has provided the new paradigm for innovation driving the emergence of efficient and high performance architectures. Over the years, my research has been driven by this paradigm making contributions in visualization and creation of integrated architectures that lead towards energy efficient platforms. Some examples illustrating these platforms will be provided in this presentation. One such platform being the self-powered structural health monitoring and control nodes. The vast reduction in the size and power consumption of sensors and CMOS circuitry has opened the opportunity to develop on-board power sources that can replace or extend the life of the batteries. In some applications such as sensors for structural health monitoring in remote locations, geographically inaccessible temperature or humidity sensors, the battery charging or replacement operations can be tedious and expensive. Logically, the emphasis in such cases has been on developing the on-site generators that can transform any available form of energy at the location into electrical energy. Piezoelectric energy harvesting has emerged as one of the prime methods for transforming mechanical energy into electric energy. Various forms of piezoelectric transducer structures have been fabricated to capture the mechanical energy with high efficiency. At micro-to-nanoscale, the design of transducer becomes challenging as the size reduction is accompanied by enhancement in the resonance frequency. We will review the solution to the problem of low frequency resonant transducer structures. Next, we will utilize these novel transducers to develop dual phase harvesters, one that can capture mechanical energy and magnetic energy at the same time. The dual-phase harvester consisting of a magnetostrictive/piezoelectric/ magnetostrictive (M/P/M) laminate structure utilizing two mechanisms simultaneously: 1. *magnetolectric (ME) effect*, where external magnetic field H can excite longitudinal strain through magnetostrictive phase and transfer to piezoelectric phase; 2. *Piezoelectric effect*, where induced mechanical vibration can create strain and generate charge. The first step towards achieving the desired objective was to design and fabricate high ME coefficient self-biased structures. Ferromagnetic – ferroelectric composite resonant transducers with giant magnetolectric coefficient at ZERO bias were fabricated and utilized for the low frequency energy harvesting system. A fundamental understanding of elastic coupling in the thick film laminate structures was developed to identify the mechanisms controlling the self-biased magnetolectric response. Transition of these structures on the micro/nano scale will be discussed and experimental results in this direction will be provided. Implementation of these structures on the practical platforms will be demonstrated.

Biography

Dr. Shashank Priya is currently Professor in department of mechanical engineering. His research is focused in the areas related to multifunctional materials, energy and bio-inspired systems. He has published over 250 peer-reviewed journal papers and more than 50 conference proceedings covering these topics. Additionally, he has published more than four book chapters, five US patents, and five edited books. He is the founder and chair of the Annual Energy Harvesting Workshop series and Energy Summit. He is currently serving as the chief editor of journal “Energy Harvesting and Systems”, editorial board member of journal integrated ferroelectrics and advisory board member of journal of dielectrics. He is also serving as the member of the Honorary Chair Committee for the International Workshop on Piezoelectric Materials and Applications (IWPMA). Shashank has received several awards including: Alumni award for excellence in Research 2014, Fellow American Ceramic Society 2013, Turner Fellowship 2012, Dean’s Research Excellence Award 2011, and AFOSR Young Investigator Award.