Bio-compatible Lead-free Piezoelectric Thin Films for Small-scale Flexible Energy Harvesting and Storage Devices

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Modern power electronics play a critical role in transportation, energy distribution, space shuttle, medical defibrillators, military weapons, and other electronic applications. So far, rechargeable batteries have been most widely used in energy generation and storage systems for these applications. However, their characteristics, including lifetime, restricted usable temperature range, over-current and electrical shock, slow charging and discharging time and limited power densities require that they be complemented with capacitors for many systems which require high power density, i.e. rapid delivery of energy.

Therefore, continuous self-power harvesting and high-energy storage devices with fast discharging time are of critical importance for the successful deployment of alternative energy generation and storage systems for ideal power electronic applications. In addition to developing high performance energy materials and devices, it is also desirable to explore applications in flexible electronics. Currently flexible electronics have many potential uses, from consumer products, such as mobile phones, laptops and foldable keyboards, to biomedical devices, such as body-mounted sensors. In these applications, the devices are desired to reduce the size and the weight, and be compatible with flexible structures so that power conditioning modules of increasing capacity and functionality can be incorporated.

The objective of this research is to develop a new class of eco-friendly small-scale flexible energy devices using bio-compatible lead-free piezoelectric thin films, with the emphasis on self-power generation and high energy storage capabilities. Our research addresses the critical need for autonomous power to replace or recharge the batteries that power the current electronic devices. We demonstrate a new approach for improving the power generation and energy storage capacity of the devices via cost effective chemical solution-derived lead-free piezoelectric thin films coupled with medical grade flexible substrates. Several materials and process innovations are integrated to provide a robust platform to expand the performance of the important category of energy harvesting and storage systems, and the platform is also more broadly applicable to size-scaled and low cost flexible electronic systems.

Our new approach for bio-compatible and flexible energy device systems with the size and the weight of the smallest scale provides an advanced processing and design platforms to dramatically expand the capability of high power and high energy density devices, and also explores the addition of new functionality to current and future power electronic systems.