Porous PZT with Aligned Porosity and Improved Pyroelectric and Piezoelectric Properties for Energy Harvesting Applications

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Energy scavenging, or energy harvesting, from ambient energy sources and converting it into useful electrical power continues to receive increasing amounts of industrial and academic interests since it provides a route for the realization of autonomous and self-powered low-power electronic devices [1]. This research demonstrates the significant benefits of using highly aligned porosity in energy harvesting piezoelectric and pyroelectric materials. Porous lead zirconate (PZT) ceramics with highly aligned pore channels (Figure A) and varying porosity were manufactured via a unidirectional freezing method, termed 'freeze casting' [2]. It was observed that on increasing the porosity level from 20 to 60 vol.%, the compressive strengths of the parallel and the series porous PZT were ~200% and 320%-580% higher than the conventional randomly distributed porous materials, respectively. Due to the introduction of porosity and air into the ceramic, the permittivity in the porous freeze-cast PZT decreased significantly, which is beneficial to achieving a high piezoelectric and pyroelectric performance figures of merit, compared with the dense PZT. A complete thermal energy harvesting system, composed of aparallel-aligned PZT harvester unit and an AC/DC converter unit was constructed to successfully demonstrate the real-time operation of charging a storage capacitor (Figure B). These results indicated that the porous materials generated significantly more energy than the dense material when subjected to thermal oscillations. The results are of benefit for the further design and selection of promising porous pyroelectric and piezoelectric materials in devices for the energy harvesting applications. The maximum voltage of 14.7 V can be obtained in the capacitor utilising the porosity of 60 vol.% PZT with the fastest charging speed. The correspondingly generated 115 μJ electrical energy stored in the capacitor was reported to be sufficient to power a commercial temperature and humidity sensor generated from PTFE film [3].

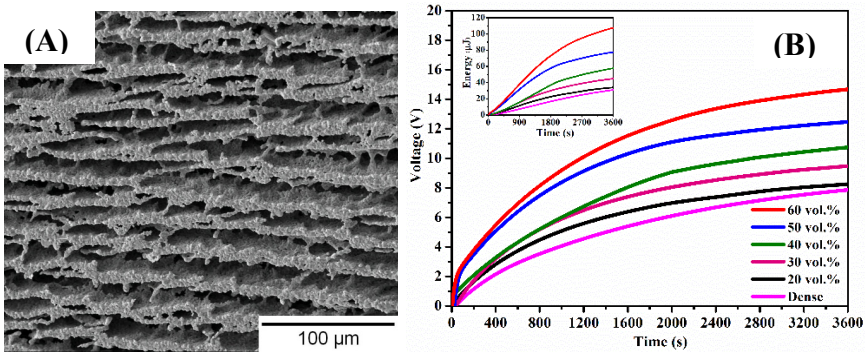

Fig. (A) SEM images of porous PZT. (B) Charging voltage vs time plots of the dense and porous PZT.

References

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