Next-generation Electrocaloric and Pyroelectric Materials for Solid-state Electrothermal Energy Interconversion

S. Pamir Alpay , Joseph Mantese , Susan Trolier-McKinstry ,
Qiming Zhang , and Roger W. Whatmore
S. Pamir Alpay, Department of Materials Science and Engineering, University of Connecticut, Storrs, CT, USA ; p.alpay@ims.uconn.edu
Joseph Mantese, United Technologies Research Center, East Hartford, CT, USA; mantese@utrc.utc.com
Susan Trolier-McKinstry, The Pennsylvania State University, University Park, PA, USA; STMcKinstry@psu.edu
Qiming Zhang, The Pennsylvania State University, University Park, PA, USA; qxz1@psu.edu
Roger W. Whatmore, Department of Materials, Faculty of Engineering, Imperial College London, UK; r.whatmore@imperial.ac.uk

Thin-fi lm electrocaloric and pyroelectric sources for electrothermal energy interconversion have recently emerged as viable means for primary and auxiliary solid-state cooling and power generation. Two significant advances have facilitated this development: (1) the formation of high-quality polymeric and ceramic thin films with figures of merit that project system-level performance as a large percentage of Carnot efficiency and (2) the ability of these newer materials to support larger electric fields, thereby permitting operation at higher voltages. This makes the power electronic architectures more favorable for thermal to electric energy interconversion. Current research targets to adequately address commercial device needs including reduction of parasitic losses, increases in mechanical robustness, and the ability to form nearly freestanding elements with thicknesses in the range of 1–10 μ m. This article describes the current state-of-the-art materials, thermodynamic cycles, and device losses and points toward potential lines of research that would lead to substantially better figures of merit for electrothermal energy interconversion.