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Long Term Stability of Electrocaloric Response in Barium Zirconate Titanate

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Abstract

The stability of the electrocaloric effect under electric field cycling is an important consideration in the development of solid-state cooling devices. Here we report measurements carried out on $Ba(Zr_{0.2}Ti_{0.8})O_3$ ceramics which reveal that the adiabatic temperature change, polarization-electric field hysteresis loops and dielectric permittivity / loss show stable behavior up to 10^5 cycles. We further demonstrate that the loss in electrocaloric response observed after 10^5 cycles is associated with the migration of oxygen vacancies. As a result, the electrical properties of the material are changed leading to an increase in leakage current and Joule heating. Reversing the polarity of the electric field after every 10^5 cycles changes the migration direction of oxygen vacancies, thereby preventing charge accumulation at grain boundaries and electrodes. By doing so, the electrocaloric stability is improved and the adiabatic temperature remains constant even after 10^6 cycles, much higher than achieved in commercially available barium titanate ceramics.

Keywords: electrocaloric effect; ferroelectric; resistance degradation; fatigue; lead-free

1 Introduction

Cooling devices utilizing solid-state refrigerants have attracted interest as alternatives to conventional vapor compression technologies. In particular, electrocaloric (EC) materials hold potential for active miniature heat pumps with easy integration into electronic circuits, especially when used in mobile devices [1, 2]. As most of these devices operate at room temperature up to 350 K, material systems