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Effects of composition and misfit strain on multicaloric effects in  $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$  thin films

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**Effects of composition and misfit strain on multicaloric effects in  $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$  thin films**F. Wang<sup>1,3</sup>, B. Li<sup>2,\*</sup>, Y. Ou<sup>1,3</sup>, L. F. Liu<sup>1,3,\*</sup>, W. Wang<sup>4</sup><sup>1</sup>*Hunan Provincial Key Laboratory of Health Maintenance for Mechanical Equipment, Hunan**University of Science and Technology, Hunan Xiangtan 411201, China*<sup>2</sup>*School of Materials Science and Engineering, Xiangtan University, Hunan Xiangtan 411105, China*<sup>3</sup>*School of Materials and Engineering, Hunan University of Science and Technology, Hunan Xiangtan 411201, China*<sup>4</sup>*China Three Gorges Corporation, Chengdu, Sichuan 610041, China*

In this study, multicaloric effects in  $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$  thin films were investigated using phase field simulations and thermodynamic analyses. The results indicate that multicaloric temperature changes depend significantly on the composition and misfit strain in  $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$  thin films. The maximum multicaloric temperature change was found to be 11.8 K in a  $\text{PbZr}_{0.25}\text{Ti}_{0.75}\text{O}_3$  thin film with tensile misfit strain at room temperature. Understanding the domain evolutions with different material compositions and misfit strains is of key importance for tuning the multicaloric effects in  $\text{PbZr}_{1-x}\text{Ti}_x\text{O}_3$  thin films. These results provide an effective way of controlling the multicaloric effects in ferroelectric thin films.

**Keywords:** Ferroelectrics; Thin films; Multicaloric effect; Domain structure; Phase field simulation**1. Introduction**

The lead zirconate titanate ( $\text{Pb}(\text{Zr}_{1-x}\text{Ti}_x)\text{O}_3$ , PZT) system has been intensively studied because of its excellent piezoelectric and ferroelectric properties[1-4]. In particular, a wide-reaching investigation of the caloric effects in PZT was triggered after a large electrocaloric effect was reported in a

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