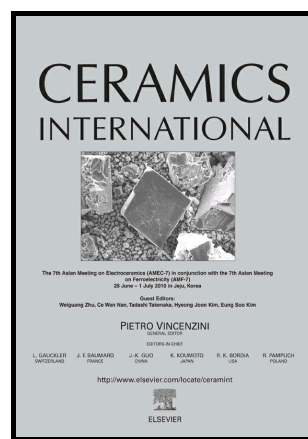


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# Enhanced electromechanical properties of $\text{CaZrO}_3$ -modified $(\text{K}_{0.5}\text{Na}_{0.5})\text{NbO}_3$ -based lead-free ceramics

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## Abstract

Pairing of large strain response and high  $d_{33}$  with high  $T_c$  in  $(\text{K}_{0.5}\text{Na}_{0.5})\text{NbO}_3$ -based materials is of high significance in practical applications for piezoelectric actuators. Here, we report remarkable enhancement in the electromechanical properties for  $(1-x)(\text{K}_{0.52}\text{Na}_{0.48})(\text{Nb}_{0.95}\text{Sb}_{0.05})\text{O}_3-x\text{CaZrO}_3$  (KNNS- $x\text{CZ}$ ) lead-free ceramics through the construction of a rhombohedral ( $R$ )-tetragonal ( $T$ ) phase boundary. We investigated the correlation between the composition-driven phase boundary and resulting ferroelectric, piezoelectric, and strain properties in KNNS- $x\text{CZ}$  ceramics. The KNNS- $x\text{CZ}$  ceramics with  $x=0.02$  exhibited a large strain response of 0.23% while keeping a relatively large  $d_{33}$  of 237 pC/N, which was mainly ascribed to the coexistence of  $R$  and  $T$  phases confirmed by the XRD and dielectric results. It was found that pairing of large strain response and high  $d_{33}$  in KNN-based materials was achieved. As a consequence, we believe that this study opens the possibility to achieve high-performance lead-free electromechanical compounds for piezoelectric actuators applications.

**Keywords:** Potassium-sodium niobate; Electromechanical properties; Multiphase coexistence; Lead-free ceramics; Strain response.

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