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Contrasting strain mechanisms in lead-free piezoelectric ceramics

Piezoelectric ceramics find a wide range of applications in advanced technological fields. Most of the currently used electro-active ceramics contain lead (Pb). Environmental concerns and limitations in high temperature performances of lead based compositions have spurred the field of lead-free electroceramics research. Compositions based on bismuth sodium titanate (BNT), sodium potassium niobate (NKN), bismuth ferrite (BF) and barium titanate (BT) have long been considered as candidates to replace lead based electroceramics. Although lead-free compositions based on these systems exhibit piezoelectric properties for potential device application, further enhancement is required. To improve their properties, extensive knowledge of structure-property relationships, especially during the field-on condition is essential. Diffraction is a useful technique to highlight structure-property relationships. To understand the microscopic origin of strain in lead-free electroceramics several compositions based on BNT, NKN, BF and BT has been studied using in situ high energy x-ray diffraction. Their microscopic strain response has been elucidated under electric field. Both the intrinsic (lattice) and extrinsic (domain switching and/or phase transformation) strain contributions have been analysed for each system and have been correlated with their macroscopic properties. This comparative study of their strain responses will enable us to focus on some important aspects that are essential to improve electro-mechanical properties in future lead-free systems.

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