Lead-free KN-NBZ Piezoelectric Ceramics

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Lead-based piezoelectric materials with high piezoelectric and electromechanical coupling properties, such as $PbZrO_3$– $PbTiO_3$ (PZT) and Pb(Nb,Mg)–$PbTiO_3$ (PMN–PT) solid solution systems, are the primary piezoelectric materials used today [1].

In recent times, there has been a drive to develop new piezoelectric materials for a wide range of applications with properties comparable with PZT. One main driver has been the growing awareness of the environmental impact and health concerns due to the toxicity of lead [2] which has led to existing environmental legislations and restrictions both in the EU and across the globe under the auspices of Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) directives which concern the reduction of the use of hazardous substances in electrical equipment and the management of the ensuing waste [2].

A number of lead-free piezoelectric materials to replace PZT have been developed or considered. Select but not exhaustive examples of such materials include: lithium niobate ($LiNbO_3$); barium titanate ($BaTiO_3$), lead-free substitutes based on the tungsten–bronze structured (e.g. $KBa_2Nb_5O_{15}$, $(Sr_{0.7}Ba_{0.3})_2$- $NaNb_5O_{15}$), perovskite-like compounds based on bismuth layer structures, and bismuth sodium titanate (BNT) and potassium sodium niobate, $(K,Na)NbO_3$ (KNN)-based compositions [2]. Many of these lead-free materials exhibit technical challenges including relatively weak piezoelectric effect; and low-phase transition temperature [2].

We investigated the use of zirconium to modify the stability of potassium niobate. Using the mixed oxide route a series of $(1\text{-}x)KNbO_3$. x $(Li_{0.5}Bi_{0.5})ZrO_3$ ((1-x) KNN-xNBZ) ceramics with x varying from 0.0 to 0.2 was successfully grown. The XRD of each showed single phase periovskite structure, with the peak at 2 theta = ~45° and 56 changing indicating that the boundary region between tetragonal and rhombohedral phases had been crossed.

References

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