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Functional perovskite lead based and lead free ceramic/crystals for piezoelectric applications

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Functional materials possess typical properties like ferroelectricity, pyroelectricity, piezoelectricity, ferromagnetism, etc. which are sensitive to a change in the environment such as temperature, pressure, etc. and, therefore can be used in transducer, sensor and actuator applications. Piezoelectric binary $\text{Pb}(\text{B}'\text{B}'')\text{O}_3$ -PT perovskite, with proper substitution at B' and B'' sites, leads to high performance $\text{Pb}(\text{Zn}_{1/3}\text{Nb}_{2/3})_{0.91}\text{Ti}_{0.09}\text{O}_3$ (PZN-PT), PMN-PT, etc. systems which exhibit ultrahigh piezoelectric charge coefficient ($d_{33} > 2000$ pC/N) when properly poled (coeff d_{33} as 450 & 18 pC/N for PZT & LiNbO_3 , respectively). Crystals of these systems are extensively used in high end applications. However, due to high content of lead in these materials, the industry needs environment friendly ferroelectric materials suitable for devices, which do not contain lead and still have very good dielectric, ferroelectric and mechanical properties. Alkali based perovskite systems like (1-x) NBT-xKBT (BNKT) and NKLN are front runners of this category. Recently, single crystals of these materials are grown which exhibited excellent piezoelectric behavior. High piezoelectric coefficient (d_{33} more than 1500 pC/N), ferroelectric remnant polarization (P_r above $40 \mu\text{C}/\text{cm}^2$) and pyroelectric coefficient (P upto $3300 \mu\text{Cm}^{-2} \text{ } ^\circ\text{C}^{-1}$) properties have been achieved with reasonable high Curie temperature. These crystals were subjected to PUND test to extract true switchable polarization and shown that very small leakage current are present. Further, fatigue test established that these crystals can preserve the ferroelectric properties even after 107 cycles of field. Thus these crystals are suitable for high temperature devices for long duration. These ceramics and single crystals are used to demonstrate the piezoelectric energy harvesting and pressure sensor applications. It has been demonstrated how the performance of these devices are enhanced with the use of high performance materials.

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