The novel perovskite lead-free ferroelectric relaxor system $\text{Bi}_{1-x}(\text{Zn}_{1/3}\text{Nb}_{2/3})_{x}\text{O}_3-\text{Ba}_y\text{Ti}_{1-x}\text{O}_3$ (BZN-xBT), has been investigated in a range of compositions from $x=0$ to $x=0.2$ using x-ray powder diffraction, SEM, dielectric and piezoelectric measurements. Studies of bulk-ceramic samples revealed a maximum in the piezoelectric coefficient $d_{33}$ of 120 pC N$^{-1}$ at $x = 0.038$ together with a coercive field of $E_c = 9.3$ kV cm$^{-1}$. Powder x-ray diffraction studies in the temperature range from 295K to 20K show this system having considerable polar phase coexistence with the highest $d_{33}$ correlating with dominance of the monoclinic phase at room temperature. The tetragonal perovskite structure characteristics of BT at room temperature disappears between $x=0.06-0.07$.

Low-temperature x-ray powder diffraction studies in the range 295-20K indicate a BT-like sequence of phase transitions from tetragonal-orthorhombic-rhombohedral for $x=0$ to $x=0.04$. Beyond $x=0.04$, the rhombohedral phase no longer appears. Appearance of a potential Morphotropic Phase Boundary (MPB) is signalled by the collapse of the tetragonal $c_T/a_T$ ratio near $x = 0.045$, which ratio then shows relative invariance with temperature over the whole interval. Above $x=0.07$, after the tetragonal phase has been eliminated at room temperature, BZN-BT appears as essentially an almost invariant mixture of monoclinic (Cm) and orthorhombic (Amm2) phases at all temperatures measured.

Piezoelectric coefficients showed a rapid decline for $x > 0.039$ at 295K. For $0.045 < x < 0.08$, the materials are lossy dielectrics ($T_m \sim 295K$) and potentially candidate electrocalorics.