Supporting Information

Simultaneously enhance the energy storage, transparency, and hardness properties of $K_{0.5}Na_{0.5}NbO_3$-based ceramics via synergistic optimization strategy

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X-ray photoelectron spectroscopy (XPS) provides robust support for understanding material mechanisms and optimizing preparation processes by detecting information such as the elemental composition and electronic structure of ceramic surfaces.[1,2] Fig. 1 shows the XPS test results for (1-*x*)KNN-*x*BZN (*x*=0.1, 0.125, 0.15, 0.175) ceramics. The full spectrum in Fig. 1(a) confirmed the existence of elements of K, Na, Nb, O, Zn, and Bi. Fig. 1(b) shows the O 1s spectrum of KNN-*x*BZN ceramics measured by XPS. The O 1s spectrum can be resolved into three binding energy peaks, corresponding respectively to lattice oxygen (O_L, ~529 eV), oxygen vacancies (O_V, ~531 eV), and surface-adsorbed oxygen (O_A, ~532 eV). The relative area of the O_V peak permits semi-quantitative analysis of oxygen vacancy concentration. Fig. 1(b) indicates that the relative area of the O_V peak generally decreases with increasing

doping concentration, suggesting that BZN doping effectively suppresses oxygen vacancy formation. This is typically associated with enhanced microstructural density in ceramics. A low oxygen vacancy concentration favors reduced leakage conductance, thereby enhancing the material's breakdown field strength. However, the oxygen vacancy concentration reaches its maximum proportion at a doping concentration of x = 0.175. This may be attributed to excessive doping causing Bi element volatilization and exacerbating the non-equivalent substitution effect of B-site ions, thereby introducing additional charge-compensating oxygen vacancies.

The above content is included in the supporting information for the manuscript.

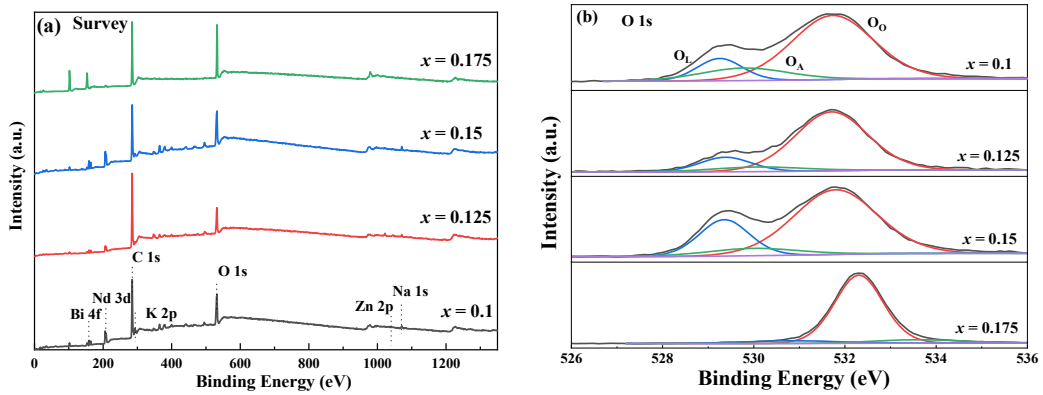

Fig. 1 (a) XPS survey of (1-x)KNN-xBZN (x=0.1, 0.125, 0.15, 0.175) ceramics. (b) XPS O 1s spectra of (1-x)KNN-xBZN (x=0.1, 0.125, 0.15, 0.175) ceramics.

REFERENCE

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