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Structural, Microstructural, and Dielectric Properties of $Ba(2-x)Sr(x)GdFeNb_4O_{15}$ Ceramics with Tetragonal Tungsten Bronze Structure

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Lead-free ferroelectric materials with a tetragonal tungsten bronze (TTB) structure have attracted increasing attention due to their multifunctional potential in microelectronics and energy applications. In this study, $Ba(2-x)Sr(x)GdFeNb_4O_{15}$ (x = 0, 1, 2) ceramics were synthesized via the solid-state reaction route to investigate the influence of Sr substitution on structural and dielectric behaviors. X-ray diffraction combined with Rietveld refinement confirmed the formation of a single TTB phase with space group P4/mbm, showing a systematic decrease in lattice parameters with increasing Sr content, attributed to the smaller ionic radius of Sr^{2+} compared to Ba^{2+}. Raman and FTIR spectroscopies evidenced characteristic vibrational modes of the MO_6 octahedra, reflecting subtle structural distortions upon substitution. SEM analysis revealed dense microstructures with grain sizes varying from 2 to 14 µm, depending on the Sr concentration. Dielectric measurements demonstrated a high dielectric constant, low losses, and a sharp permittivity peak near the Curie temperature (≈310–330 °C), typical of classical ferroelectric behavior. The Curie–Weiss analysis indicated a second-order phase transition with large Curie constants ($C > 10^4$), confirming the displacive nature of the transition. These findings highlight the significant tunability of TTB-type Ba–Sr–Gd–Fe–Nb oxides for potential applications in capacitors, sensors, and multifunctional electronic devices.

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