

Title : Effect of Heat Treatment on the Optical, Microstructural, and Mechanical Properties of Sm₂O₃-Doped KOH–Al₂O₃–SiO₂–B₂O₃ Glass-Ceramics

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ABSTRACT

This study examines the effect of heat treatment on the optical, microstructural, and mechanical properties of Sm₂O₃ doped KOH–Al₂O₃–SiO₂–B₂O₃ glass and derived glass-ceramics. Precursor glasses were prepared by conventional melt-quenching at 1550°C, and then glass-ceramic samples were prepared via traditional and modified glass-ceramic methods. Simultaneous thermal analysis (STA) revealed two crystallization peaks (T_p) at 632°C and 716°C, which guided the heat-treatment schedule.

X-ray diffraction (XRD) and scanning electron microscopy (SEM) confirmed the transformation from an amorphous structure to a highly crystalline Boromullite phase. The crystallized samples exhibited an interlocking network of rod-like and needle-like grains, indicating substantial microstructural reorganization during sintering.

Photoluminescence (PL) measurements under 403 nm excitation showed four characteristic Sm³⁺ emission bands at 562, 600, 645, and 706 nm, corresponding to the ⁴G_{5/2} → ⁶H_{5/2}, ⁶H_{7/2}, ⁶H_{9/2}, and ⁶F_{11/2} transitions, respectively. Luminescence intensity decreased with increasing heat-treatment temperature, mainly due to enhanced light scattering from grain boundaries in the crystalline matrix. In addition, the electric dipole to

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magnetic dipole (ED/MD) intensity ratio decreased from 0.91 to 0.70, suggesting increased local symmetry around Sm^{3+} ions as they became incorporated into the Boromullite lattice.

The glass-ceramic sintered at 900°C exhibited improved mechanical performance, with a Vickers hardness of 2.64 GPa and a Knoop hardness of 2.83 GPa. Overall, the results demonstrate that controlled crystallization effectively tailors the structural, optical, and mechanical properties of boromullite-based glass-ceramics, making them promising candidates for advanced optical applications.

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