

Synchrotron VUV Study of Luminescent Properties in Mn-Doped ZnO–ZrO₂ Ceramics

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The luminescent behaviour of transition-metal ions strongly depends on the host lattice structure, defect concentration, and cation site occupancy. Owing to their ability to adopt multiple oxidation states, Mn ions can serve as sensitive optical probes in wide-bandgap oxide ceramics. In this work, we investigated the light-emitting properties of Mn-doped ZnO–ZrO₂ ceramics using synchrotron-based vacuum ultraviolet (VUV) excitation at the P66 beamline of PETRA III (DESY, Hamburg). The samples were prepared by solid-state reaction of the corresponding oxides at 1100–1500 °C for 3 h in air, with Mn concentrations of 0.01 and 0.1 at.%. Their structural and optical properties were also studied using FTIR spectroscopy, UV–Vis diffuse reflectance, SEM, and EDS analyses.

The emission–excitation maps revealed distinct luminescence behaviour depending on sintering temperature and excitation energy. Ceramics sintered at 1100–1200 °C exhibited two main components: a broad green emission excited by 250–300 nm radiation associated with ZnO-related defects, and a narrower green band excited at 150–200 nm, characteristic of ZrO₂-based regions. Upon Mn incorporation, a broad orange photoluminescence band emerged, becoming more pronounced at sintering temperatures above 1300 °C, where strong densification and partial stabilization of the tetragonal ZrO₂ phase occur. The observed luminescence evolution is attributed to competition between Mn dopants and intrinsic defects coexisting within multiple structural phases. These findings highlight the sensitivity of Mn-related emission to local structure and demonstrate the potential of VUV excitation for probing defect- and dopant-related luminescence in complex oxide ceramics.

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