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Investigation on optical band gap, photoluminescence properties and concentration quenching mechanism of $Pb_{1-x}Tb^{3+}{}_xWO_4$ green-emitting phosphors

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Abstract

A series of monophasic Tb^{3+}(2, 5, 7, 10 and 15 at%) doped $PbWO_4$ phosphors were successfully prepared via hydrothermal method. X-ray diffraction patterns revealed that the prepared samples possess a high crystallinity with tetragonal scheelite-type structure. FT-IR and Raman analysis exhibited a W–O stretching peak of WO_4^{2-} group, which is also related to the scheelite structure. UV-visible diffuse reflectance spectra indicated a reduction in the optical band gap with the replacement of Pb^{2+} by Tb^{3+} ions. The presence of strong and intense emission peaks characteristic of Tb^{3+} with the dominant peak at 545 nm (green, $^5D_4 \rightarrow {}^7F_5$ transition) under UV irradiation at 320 nm demonstrated an efficient energy transfer from the host to Tb^{3+} ions. Using Van Uitert's model, the concentration quenching mechanism between Tb^{3+} ions in $PbWO_4$:Tb^{3+} phosphor was attributed to a dipole–dipole interaction and the critical distance was determined to be ~12 Å. The decay lifetimes and CIE chromaticity co-ordinates of $PbWO_4$:Tb^{3+} phosphors were also investigated in detail. These prepared materials might serve as a potential phosphor for LED applications.

Keywords: $PbWO_4$:Tb^{3+}; photoluminescence; charge transfer; concentration quenching