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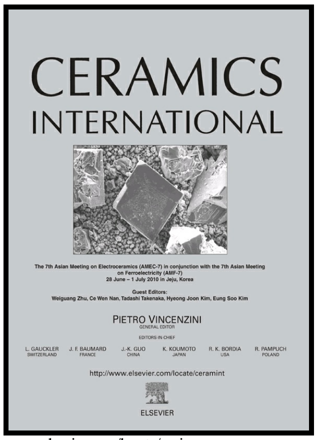

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A double-perovskite Sr_2ZnWO_6:Mn^{4+} deep red phosphor: synthesis and luminescence properties

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Abstract

Novel double-perovskite Sr_2ZnWO_6:Mn^{4+} (SZW:Mn^{4+}) phosphor is synthesized by high-temperature solid-state reaction method in air. SZW:Mn^{4+} phosphor with excitation at 325 and 526 nm emits deep-red light, the chromaticity coordinate is (0.7315, 0.2685), and the emission band peaking at ~ 702 nm within the range 640 - 760 nm is assigned to the $^2E \rightarrow {}^4A_2$ transition of Mn^{4+} ion. The influences of "Mn^{4+} - ligand" bonding and crystal field strength to emission properties of Mn^{4+} ion are analyzed. The optimal Mn^{4+} ion concentration in SZW:Mn^{4+} phosphor is ~ 0.8 mol%. Lifetime of SZW:Mn^{4+} phosphor decreases from 554.77 to 401.35 μs with increasing Mn^{4+} ion concentration in the range of 0.2 - 1.0 mol%. The lifetime data and decay curves indicate that there is only a single type of Mn^{4+} ion luminescent center in SZW:Mn^{4+} phosphor. The luminous mechanism of SZW:Mn^{4+} phosphor is analyzed by Tanabe-Sugano energy level diagram of Mn^{4+} in the octahedron together with the simple energy level diagram. The experimental results are helpful to research the influences of the neighboring coordination environment around Mn^{4+} and host crystal structure to the luminescence properties of Mn^{4+} ion and to deeply understand other Mn^{4+}-doped materials.

Keywords: Powders: solid state reaction; Perovskites; Optical properties; Functional applications

1 Introduction

Mn^{4+} as a non-rare-earth activator belongs to transition metal ion with outer $3d^3$ electron configuration [1]. Mn^{4+} ion can usually be stabilized in an octahedral environment by substituting Al^{3+}, Ti^{4+}, Zr^{4+}, Sn^{4+}, Si^{4+} or Ge^{4+} ion etc. in the host lattice, wherein the 3*d* state of Mn^{4+} ion tends to split into two- and three-fold degenerate T_{2g} and E_g states with a large gap between them by the crystal field strength [2,3]. Emission of Mn^{4+} ion is always dominated by the spin- and parity-forbidden ^2E_g - $^4A_{2g}$ transition whose energy is significantly influenced by the Mn^{4+} - ligand hybridization in host lattice according to Tanabe-Sugano diagram [4]. Mn^{4+}-doped materials have been extensively studied in many fields (e.g., holography, lighting, laser, and dosimetry), and can show red or deep red emission in the range of 620 - 760 nm under blue/UV light irradiation [5,6]. In Mn^{4+}-doped fluorides, such as K_2SiF_6, Na_2SnF_6, $BaSiF_6$, $BaTiF_6$, K_2TiF_6, $KNaSiF_6$, and K_3ZrF_7, the emission peak locates at ~ 630 nm owing to the weak hybridization effect [7-14]. In Mn^{4+}-doped oxides with high chemical stability and an