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Structural and photoluminescence properties of $SrWO_4$ microcrystallites prepared by hydrothermal method

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Abstract

SrWO4 powder was synthesized by hydrothermal process at 90 0C for 12 h Teflon lined Stainless steel autoclave. The obtained powder was characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and photoluminescence (PL). XRD pattern of SrWO4 exhibits a scheelite-type tetragonal structure. SEM image shows flake like structure of SrWO4 microcrystallites. Photoluminescence emission spectra exhibits an intense peak around 365nm and a shoulder peak at 470nm.

Keywords: *Hydrothermal process, $SrWO_4$, Photoluminescence .*

1.0 INTRODUCTION

At room temperature, the tungstate presents a scheelite-type tetragonal structure with general formula ABO_4 (A = Ba, Ca, Sr, Pb; B = W) and space group *I*41*/a* [1, 2]. In this type of structure, the B ions are within tetrahedral O-ion cages and isolated from each other, while the A ions are surrounded by eight oxygen [3]. Presently, these materials have been widely employed in various industrial applications, like: optical fiber, catalysts, scintillation detector, humidity sensor, solid-state lasers, photo catalysts, photoluminescent devices and more [4–6]. In particular, $SrWO_4$ has attracted considerable attention to the development of new electro optics devices due to its blue or green luminescence emissions at room temperature [7].

2.0 EXPERIMENTAL

The sample was synthesized by hydrothermal method. Appropriate amount of 0.1M $SrCl_2.6H_2O$ (Strontium Chloride) with distilled water was put in a Teflon-lined stainless steel autoclave of 90 ml capacity. The solution was stirred for 1 h and 0.1 M $Na_2WO_4.2H_2O$ (Sodium Tungstate) solution was added drop wise with strong magnetic stirring. The autoclave was filled with distilled water up to 70% of the total volume. The autoclave was sealed and maintained at 90^0C for 12 h, then cooled to room temperature naturally. The obtained white precipitate was centrifuged and washed with distilled water and absolute ethanol to remove any impurities, then dried at room temperature.

3.0 CHARACTERIZATION

The morphologies were characterized using Scanning electron microscopy (SEM). Phase identification was conducted by the X-ray diffraction (XRD) technique, using Cu K_α radiation by Rigaku X-ray diffractrometer. SEM images were taken with Hitachi S-3000N Scanning electron microscope. The luminescence and excitation spectra of the sample were determined by a Fluorescence spectrometer with Xe lamp at R.T.

4.0 RESULTS AND DISCUSSIONS

4.1 X-ray diffraction (XRD)

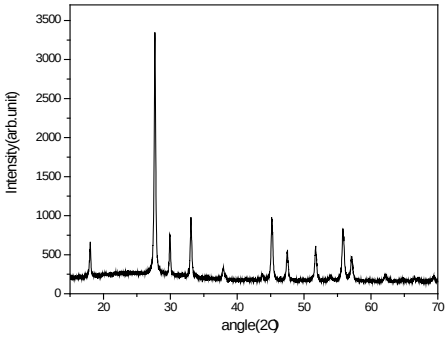

Fig.1: XRD patterns of $SrWO_4$ powder

Powder X-ray diffraction (XRD) patterns were recorded with a Japanese Rigaku D/max-RB diffractometer using Cu

Kα radiation (λ= 0.15406 nm) in the 2Θ range from 15^0 to 70^0. Fig. 1 shows the XRD pattern of $SrWO_4$ processed at 90 ^{0}C for 12 h. XRD patterns revealed that the SrWO4 powders can be indexed to the scheelite-type tetragonal structure with space group *I*41/*a*, in agreement with the respective JCPDS (Joint Committee on Powder Diffraction Standards) card No. 08-0490 [8]. According to the literature [9, 10], XRD patterns are able to estimate the degree of structural order–disorder at long-range in the materials. Therefore, the strong and sharp peaks indicate that the $SrWO_4$ is highly crystallized and structurally ordered at long-range.

4.2 Scanning Electron Microscopy (TEM)

Fig.2 shows the SEM micrograph of $SrWO_4$ processed at 90^0C for 12 hr. SEM micrograph revealed that the $SrWO_4$ exhibits a large quantity of particles with agglomerate and flake like structure of $SrWO_4$ microcrystallites .

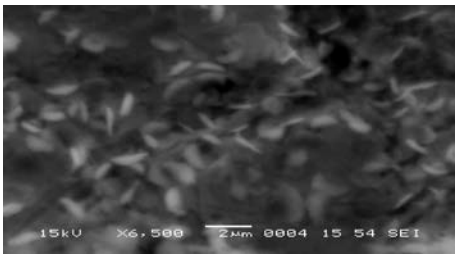

Fig.2: SEM images of $SrWO_4$

4.3 Photoluminescence (PL)

Blasse and Grabmaier [11] reported that the PL emission arises from the radiative return to the ground state, phenomenon that is in concurrence with the non-radiative return to the ground state. In the non-radiative process, the energy of the excited state is used to excite the vibrations of the host lattice, i.e., heat the lattice. The radiative emission process occurs more easily if there are trapped holes or trapped electrons within the band gap [12].

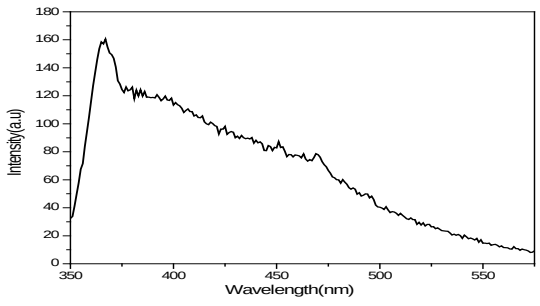

Fig. 3: PL spectra of $SrWO_4$

Fig.3 shows the photoluminescence (PL) spectrum at room temperature of $SrWO_4$ processed at 90^0C for 12 h. Excitation of $SrWO_4$ was done with 248 nm wavelength. Photoluminescence emission spectrum exhibits an intense peak around 365nm and a shoulder peak at 470 nm. PL emission of tungstates with scheelite-type tetragonal structure is not completely understood.

In particular, the literature has reported several hypotheses to explain the mechanisms responsible by the PL emission of $SrWO_4$.The existence of WO_3 and distorted WO_4 clusters in the $SrWO_4$ lattice, which are able to introduce the formation of intermediary energy levels are composed of oxygen 2p states and tungsten 5d states. In this case, the polarization induced by the symmetry breaks and the existence of these localized energy levels are favorable conditions for the formation of trapped holes and trapped electrons. PL emission of $SrWO_4$ with the transition of electrons within $[WO_4]$ tetrahedron groups can be treated as excitons. The presence of some shoulders on the PL spectrum are interpreted as extrinsic transitions caused by the defects and/or impurities in the material.

5.0 CONCLUSIONS

$SrWO_4$ was synthesized by hydrothermal process at 90 ^{0}C for 12 h. XRD patterns revealed that the SrWO4 can be indexed to the scheelite-type tetragonal structure with space group *I*41/*a*. The intense PL emission of $SrWO_4$ is responsible for the transition of electrons within $[WO_4]$ tetrahedron groups. SEM image shows flake like structure of $SrWO_4$ micro crystallites.

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