

X-ray Induced Luminescence Spectroscopy of Samarium Doped Barium Sulfate Prepared by Sintering Method

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Abstract

- X-ray induced luminescence (XL) properties of phosphor materials made of samarium doped barium sulfate have been investigated.
- The XL observed Sm^{2+} and Sm^{3+} ions.
- The XL intensity increased with Sm concentration up to 1 at.%. The intensity was almost constant larger than 1 at.% Sm.
- Sm doped BaSO_4 is found a host for XL phosphor materials.

1-1. Introduction

- X-ray imaging techniques are used in such as medical fields and non-destructive testing.
 - Various materials such as BaSO_4 and SrSO_4 have been developed for X-ray detection materials^[1]
- Indirect imaging method for obtaining X-ray images using fluorescent materials is required high sensitivity phosphor and, large area and high resolution
- An observation of X-ray induced luminescence has a merit of real-time measurement.
- Sm^{3+} , Sm^{2+} : red light emitting rare earth
 - The wavelength is a good match to Si detectors.

1-2. Purpose

Previous our study

X-ray phosphor of Sm -doped BaS^{[2], [3]}

- • Sm³⁺ ions were presented in the material.
- Sm²⁺ ions were not presented in the material.

This study

The optical and X-ray luminescence properties of Sm -doped BaSO₄.

BaSO₄ : the PL emission from Sm²⁺ ions has been reported^[4]

[2] Maeda K, Tsudome R, and Ido M 2011 *Phys. Status Solidi C* **8** pp 2692-2695

[3] Maeda K, Kawaida N, and Tsudome R 2012 *Phys. Status Solidi C* **9** pp 2271-2274

[4] Stefani R, Maia A D, Teotonio E E S, Monteiro M A F, Felinto M C F C and Brito H F 2006 *J. Solid Status Chem.* **179** pp 1086-1092

2-1. Sample preparation

- **Sample**

The mixture of BaSO₄, Sm₂O₃

- **Dopant**

Sm0.01-6 at.%

- **Reaction condition**

Hold 3h at 900~1250°C

2-2. Measurements

- **X-ray diffraction (XRD)**
- **X-ray luminescence (XL)**

Excited at Cu $K\alpha$

(1.54 Å, 45kV, 40mA)

- **Photoluminescence (PL)**

Excited at 405nm (24mW) diode
operating laser

PL was measured before X-ray irradiation

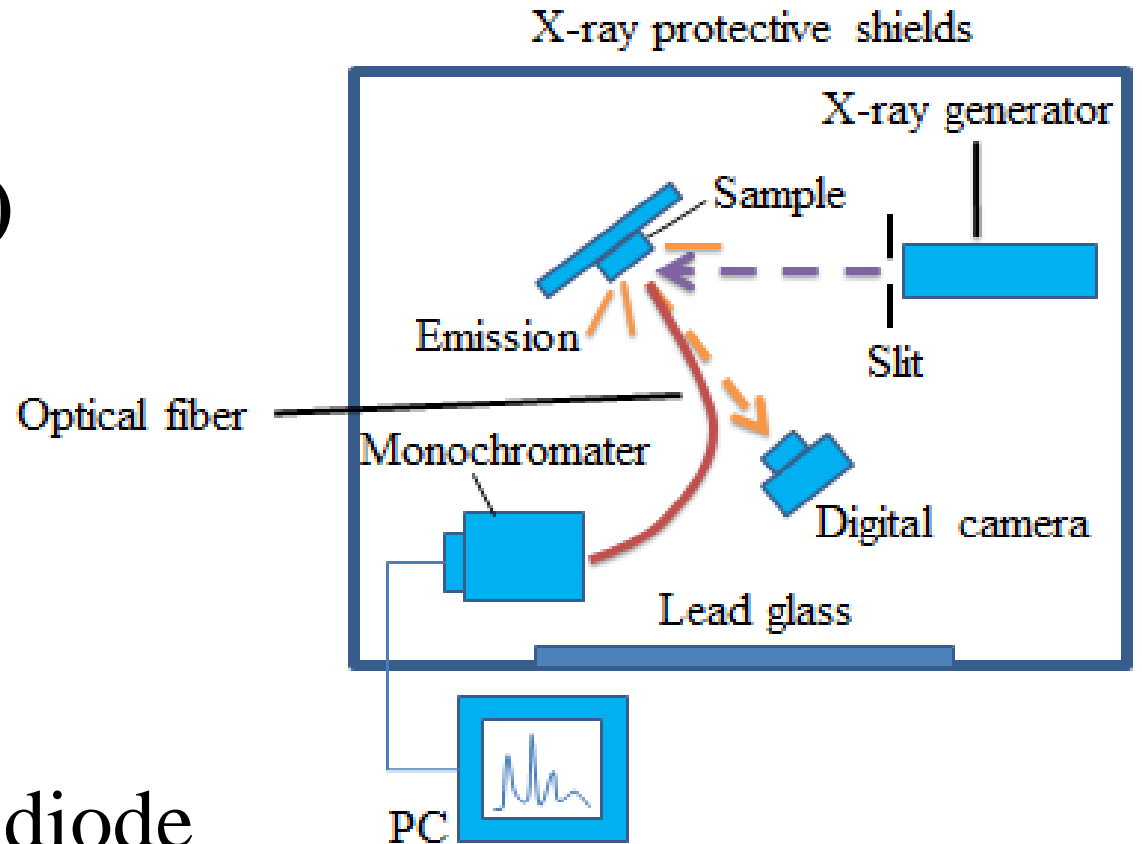


Fig. 1. XL measurement schematic system.

3.Result

3-1.XRD

Sm doped BaSO₄ compound



Single phase of BaSO₄

(ICDD card number
→ 01-080-0512)

Sm : 0.01 ~ 6 at.%

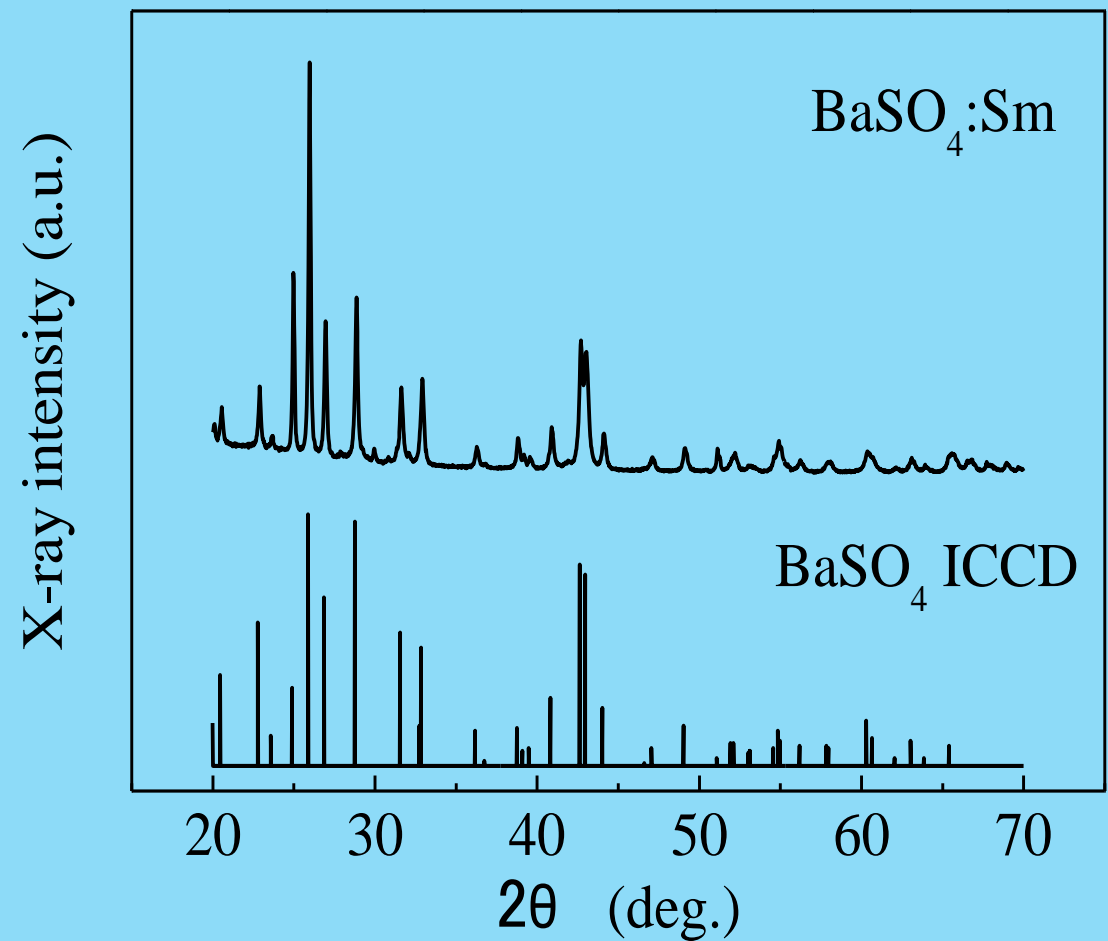


Fig. 2. X-ray diffraction patterns of BaSO₄ ceramics samples doped (upper curve) 2 at.% of Sm and (lower curve) ICDD data base of card number 01-080-0512 .

3-2. XL, PL Spectrum

PL

- 557, 593, 639, 698 nm bands
→ Sm^{3+} ions emitted

XL

- Sm^{3+} ions emitted
- 680, 694, 721 nm bands
→ Sm^{2+} ions emitted



Some Sm^{3+} ions are reduced into Sm^{2+} ions by X-ray irradiation^[4]

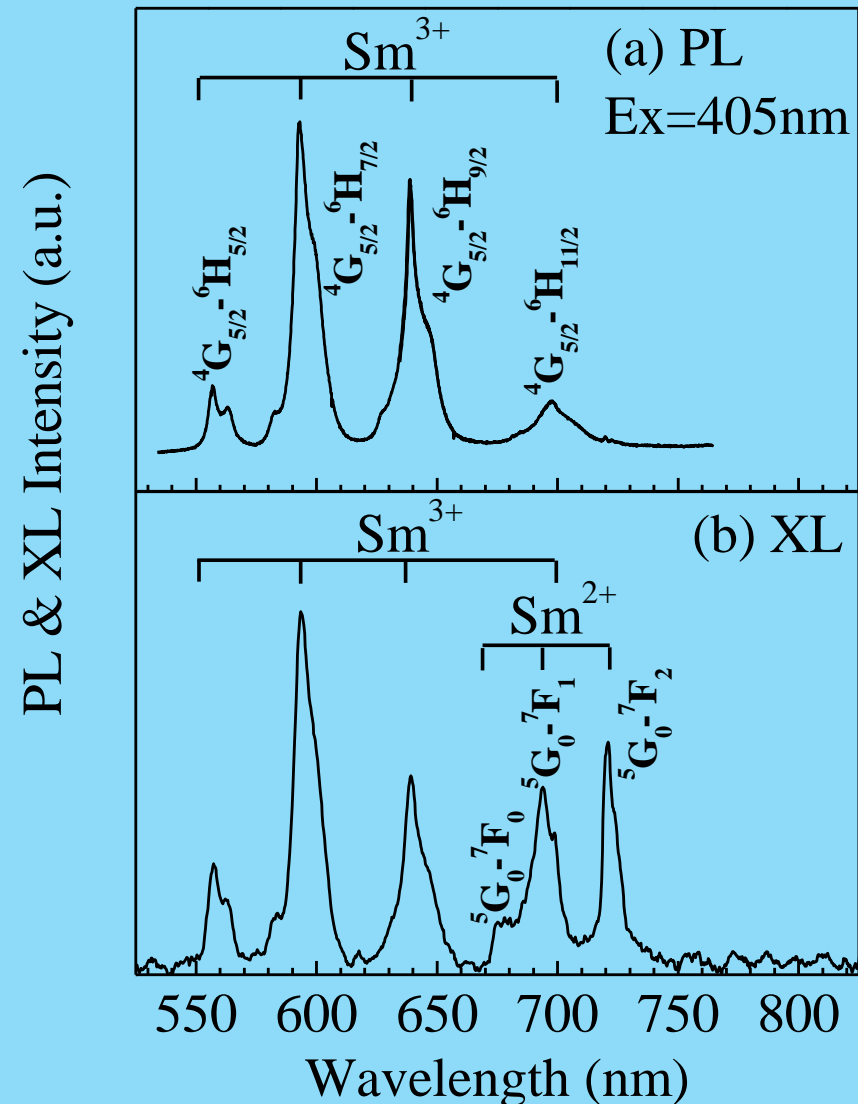


Fig. 3. PL spectra excited at 405 nm light is shown in (a), and XL spectra is shown in (b).

3-3. XL, PL Intensity

PL (Fig. 4(a))

Decreasing with Sm **Concentration quenching**

XL (Fig. 4(b) : Sm^{3+} , (c) : Sm^{2+})

Sm concentration dependence

No concentration quenching

- Smaller than 1 at.% . \rightarrow Increasing with Sm
- Larger than 1 at.% . \rightarrow Constant

Intensity ratio of Sm^{3+} and $\text{Sm}^{2+} \rightarrow$ Constant
(The figure is not shown)

X-ray irradiate time dependence (Inserted figure)

XL intensity \rightarrow constant

PL & XL Intensity (a.u.)

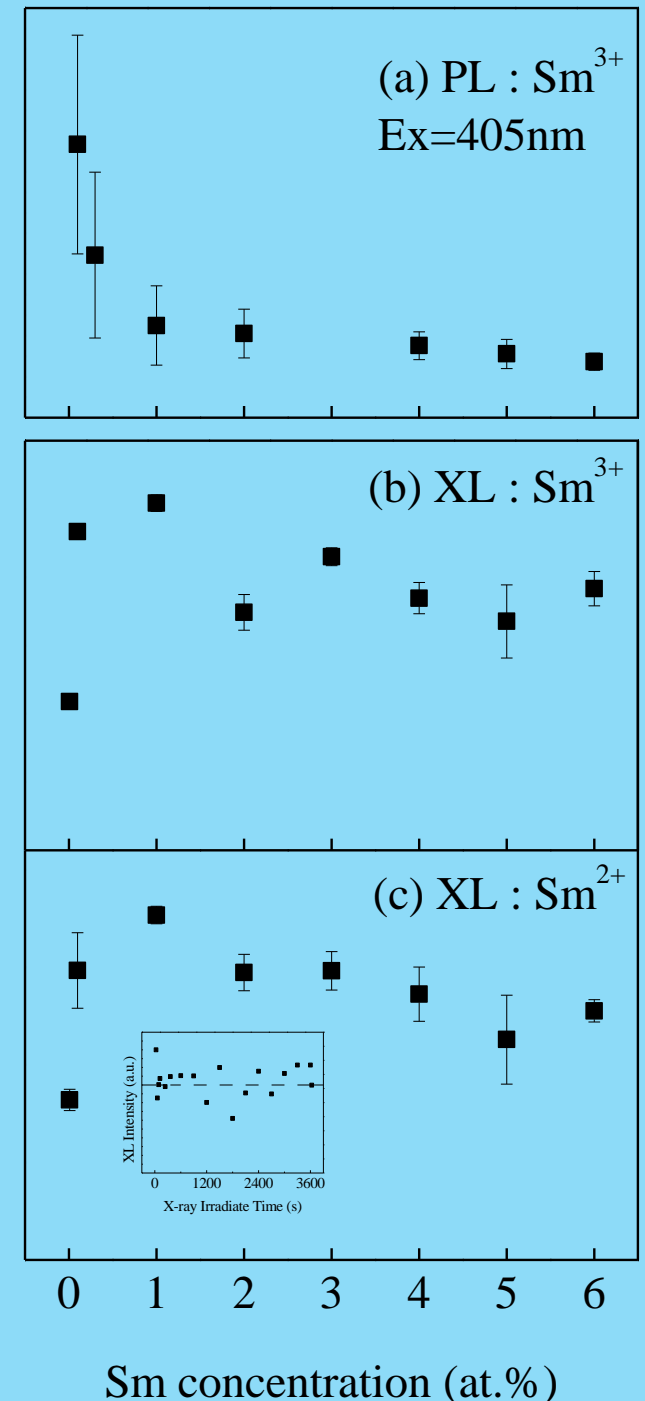


Fig. 4. PL and XL intensity of $\text{BaSO}_4:\text{Sm}$ ceramics as function of Sm concentration.

3-4. Emission Mechanism

PL

Sm³⁺ ions were directly excited by 405nm laser.



Sm³⁺ ions emit.

XL

X-ray irradiation



Some Sm³⁺ ions are reduced into Sm²⁺ ions^[4]

X-ray energy absorbed to the host material.



The energy transferred to both Sm³⁺ and Sm²⁺ ions.



Sm³⁺ and Sm²⁺ ions emit.

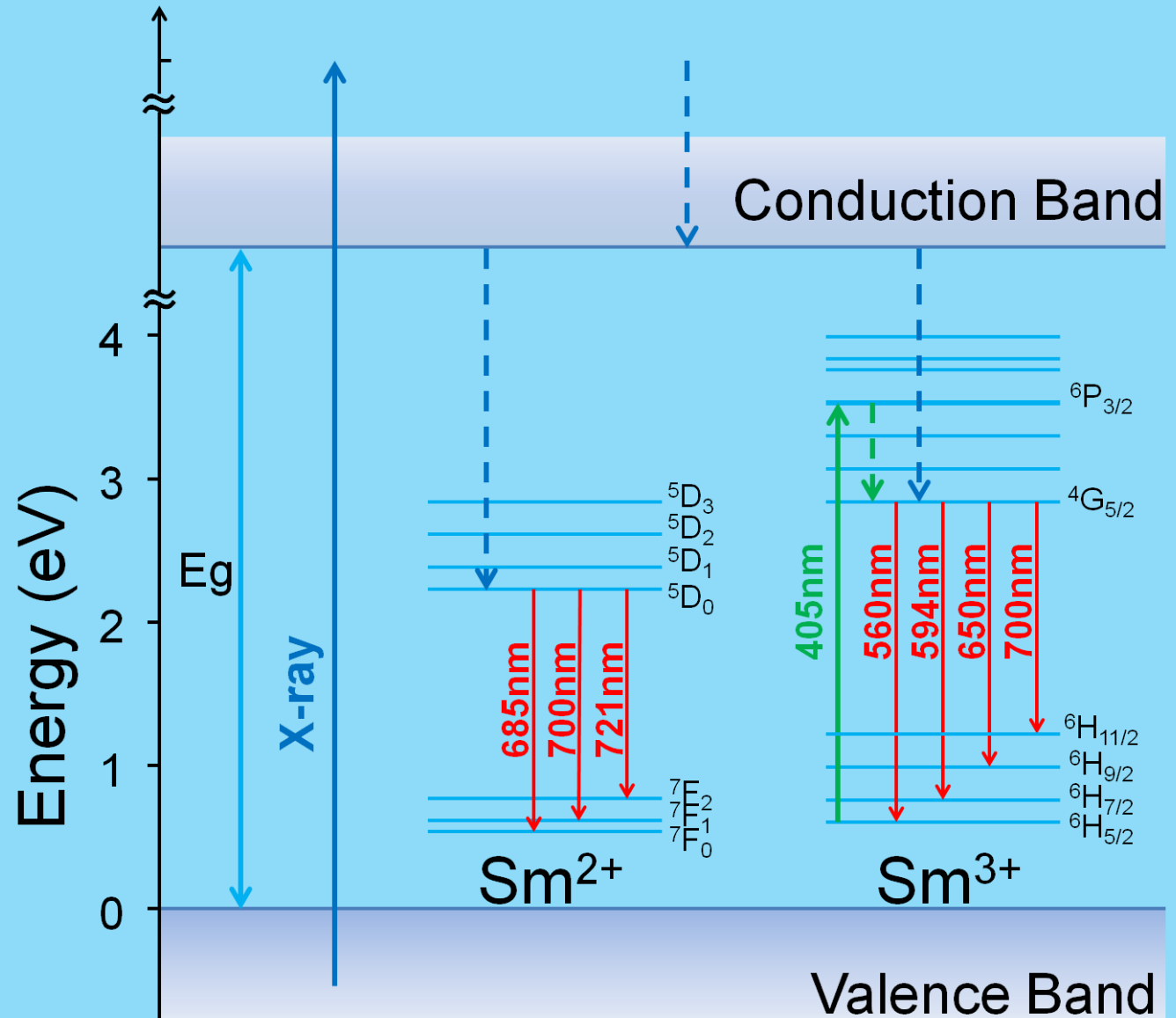


Fig. 5. Energy level diagram^[4]

[4] Stefani R, Maia A D, Teotonio E E S, Monteiro M A F, Felinto M C F C and Brito H F 2006 *J. Solid Status Chem.* **179** pp 1086-1092

4. Conclusion

- We have investigated the optical properties and X-ray luminescence of BaSO₄ ceramics doped Sm.
- The XL spectral bands were identified to the transitions in Sm³⁺ and Sm²⁺ ions.
- The XL intensity is independent of Sm concentration. (larger than 1 at.%)
- Sm doped BaSO₄ is found a host for XL phosphor materials.