Transactions of the Materials Research Society of Japan 33[4] 1313-1316 (2008)

Evaluation of photoluminescence property of SrS:Cu films for blue EL elements

Masaaki Isai, Yuji Kurachi, and Tomoyoshi Horino

Faculty of Engineering, Shizuoka University Graduate School of Science & Engineering, Shizuoka University

Johoku 3-5-1, Nakaku, Hamamatsu, Japan 432-8561

E-mail: temisai@ipc.shizuoka.ac.jp

Abstract SrS:Cu films were prepared by an electron beam deposition method to improve the emission properties of blue EL elements. SrS:Cu pellets were used as an evaporant of SrS:Cu films. The correlation between sintering condition and PL properties of SrS:Cu films was investigated. As a result, it was found that an 1-hour sintering under 600℃ was best to prepare superior SrS:Cu films ,and the correlation between sintering condition and PL properties of SrS:Cu films was confirmed.

Keyword Blue EL elements, SrS:Cu films, photoluminescence property, sintering

1.Introduction

Flat-panel displays with thin, light-weight, and high resolution have been desired in the area of multi-media.[1] Up to now, displays of CRT (cathode-ray tube) and LCD (liquid crystal display) have been spread widely all over the world. Recently, many scientists have been actively studied flat panel displays, for example, LCD (liquid crystal display), PDP (plasma display panel), ELD (electro luminescent display). Particularly, EL elements have good characteristics, for example, self emitting, high-speed response, and wide viewing angle. Therefore, EL is expected as one of the candidates for large area flat-panel displays. To realize full color EL display, it's absolutely essential to develop blue EL elements with high brightness under low driving voltage. Fortunately, recently Miura et al. have discovered excellent blue EL elements that have emission layer of $BaAl_2S_4$:Eu.[2] This material facilitate a realization of full color EL display. In addition, the research for the blue EL elements with SrS:Cu as an emission layer have been succeeded.[3~14]

The purpose of this work is to improve the PL property of SrS:Cu films which are emission layer to make the blue EL elements of high-intensity. They were sintered SrS:Cu pellets. At first, PL properties of sintered pellets were investigated. And then, the effect of sintering conditions on film properties were investigated. Finally, the dependence of PL properties on substrate materials were investigated.

2.Experiment

Fig. 1 shows an sintering apparatus for sintering SrS:Cu pellets. These pellets involve 0.5 mol% Cu_2S as a blue-emission center. The powders of SrS and Cu_2S were mixed and pressed to be pellets. They were sintered from 1 to 3 hours under the temperature from 600 to 900℃. Sintering pellets, they were embedded in active carbon in a quartz boat.

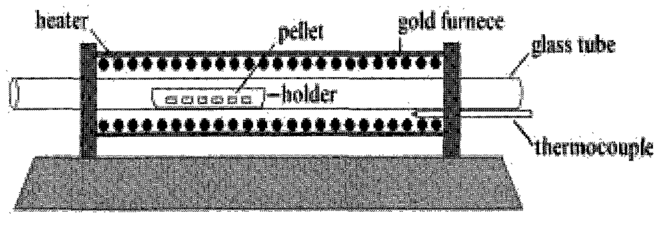

Fig. 1: Sintering apparatus for sintering of SrS:Cu pellets.

Fig. 2 shows an electron beam deposition apparatus. Sintered pellets were placed on deposition sources (hearth), and 3000Å-SrS:Cu thin films were deposited on glass and ITO substrates under accelerating voltage of 4kV, filament current of 10 mA for 10 min and followed by 20 mA for 25 min. The substrate temperature and vacuum pressure during deposition were 300℃ and 1×10^{-5} Torr, respectively.

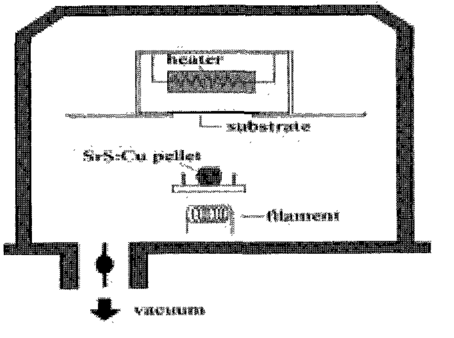

Fig. 2: Electron beam deposition apparatus.

The deposited films were annealed with a rapid annealing apparatus, as shown in Fig. 3. The annealing temperature and time were 450℃ and 2 min, respectively. The annealing of films were proceeded under Ar flow rate of 100 cc/min.

The annealing effect of films on the crystallinity of was evaluated by using PL and XRD (X-ray diffraction) measurements. Only the result of PL data was introduced in this paper.

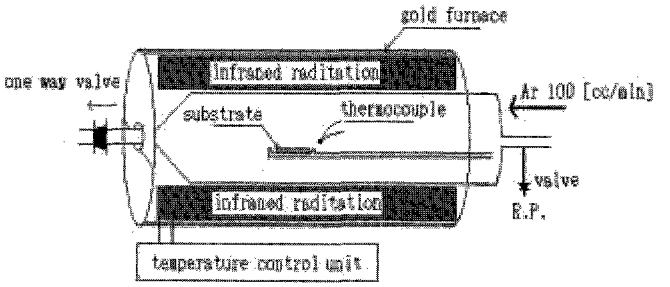

Fig. 3: Rapid thermal annealing apparatus.

3.Results and discussion

3-1 PL properties of SrS:Cu pellets

PL properties of SrS:Cu pellets sintered at 600℃ is shown in Fig. 4(a). The sintering process under 600℃ is very effective in this work. The sintering time was varied from 1 to 3 hours. PL properties of SrS:Cu pellets without sintering is also shown in Fig. 4(b).

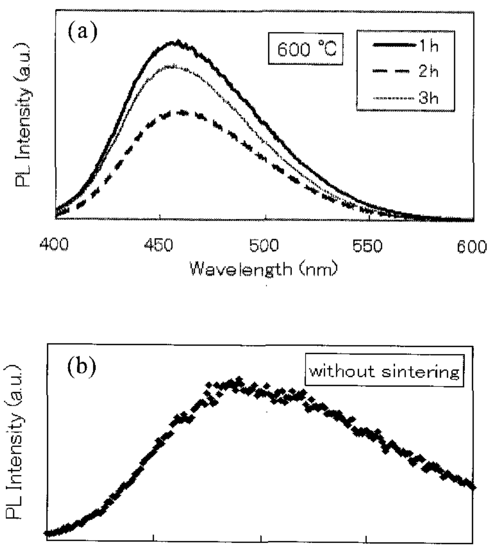

Fig. 4: PL properties of SrS:Cu pellets. (a) sintering temperature was 600℃ and (b) without sintering.

Fig. 5(a) and (b) show the comparison of the PL intensity of blue (high band) and green (low band) from PL properties of sintering pellets.

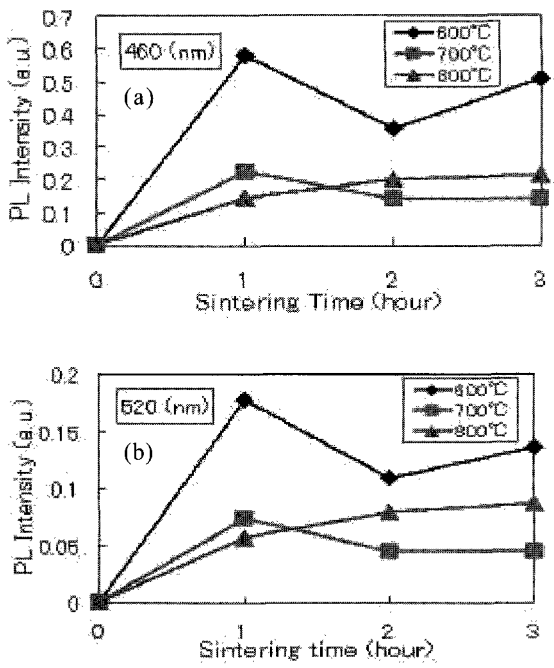

Fig. 5: The comparison of PL intensities of sintered pellets. (a) wavelength is 460nm and (b) wavelength is 520nm.

PL properties with and without sintering process were compared. It was found that the peak around 460 nm becomes sharp and smooth. This was seemed that Cu^{+} ions were doped actively as blue component (high band) elements and the crystal property of SrS was still maintained properly. The PL intensity has a maximum value under the sintering temperature of 600 ℃, and it was decreased at the higher sintering temperature. Color of pellets was also changed from pink to black under higher sintering temperature. This means that both Cu_2S and SrS crystallites coexist in these pellets. A comparison of sintering time showed that PL intensities was increased under the longer sintering time at sintering temperature of 800℃, though it was increased under the shorter sintering time at sintering temperature of 600℃ and 700℃. In the case of 800 °C, though PL intensities was increased under the longer sintering time, it will not increase greatly as increasing sintering time. Consequently, it was found that a short sintering time was effective.

PL intensities of blue component (high band) was two times longer than that of green one (low band). In the case of 600℃, it was 3 to 5 times larger than that of green one. The optimum sintering condition to obtain the highest PL intensity of blue was 1 hour under 600℃.

3-2 PL properties of SrS:Cu films

Fig. 6 shows PL intensities of as-deposited SrS:Cu films on glass substrates. Fig. 7 shows them after annealing. The annealing temperature and time were 450℃ and 2 min , respectively.

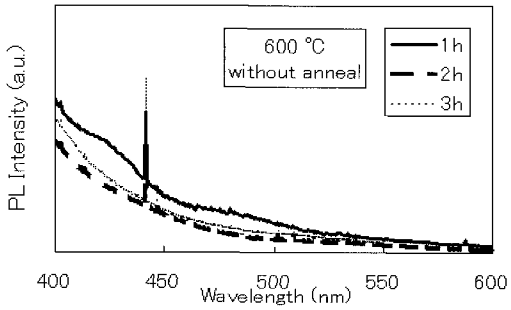

Fig. 6: PL properties of as-deposited SrS:Cu films (sintering temperature was 600℃, deposited on glass substrates)

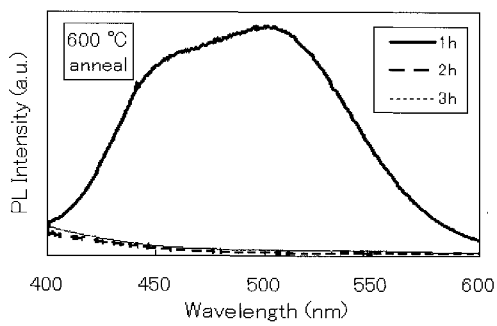

Fig. 7: PL properties of SrS:Cu films (sintering temperature was 600℃, after annealing, deposited on glass substrate)

Fig. 8 shows the PL properties of as-deposited SrS:Cu films on ITO substrates. Fig. 9 shows them after annealing.

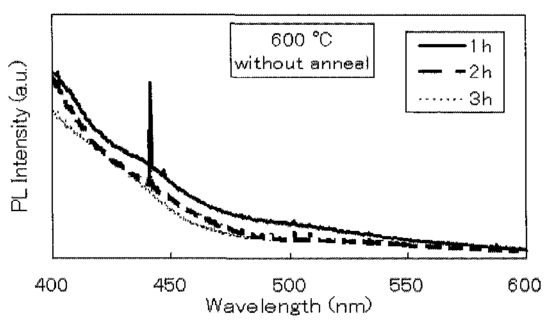

Fig. 8: PL properties of as-deposited SrS:Cu films (sintering temperature was 600℃, deposited on ITO substrates)

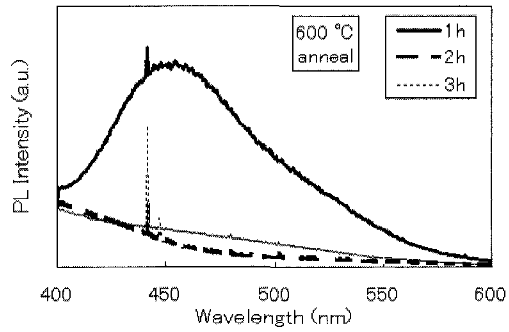

Fig. 9: PL properties of SrS:Cu films (sintering temperature was 600℃, after annealing, deposited on ITO substrates)

Comparing the annealing effect, PL intensities was increased in both substrates under sintering time of 1 hour. In the case of other conditions, the annealing effect was no effective. It was seemed that the annealing condition wasn't proper.

3-3 The comparison of PL intensities between the glass and ITO substrate s

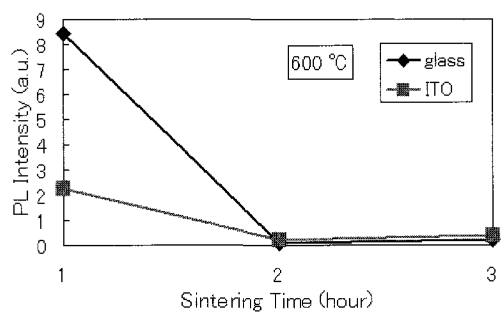

Fig. 10: The dependence of PL intensities on sintering time. Glass and ITO substrates were need (sintering temperature was 600℃, after annealing, wavelength is 460nm).

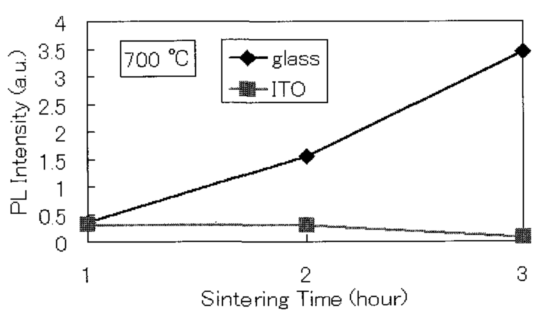

Fig. 11: The dependence of PL intensities on sintering time. Glass and ITO substrates were need (sintering temperature was 700℃, after annealing, wavelength is 460nm).

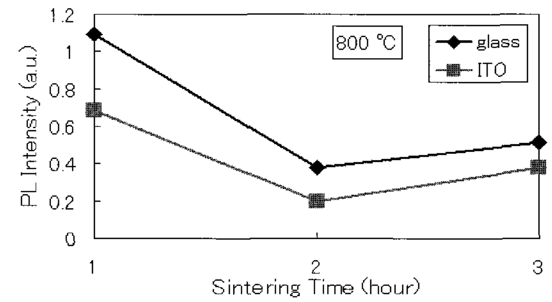

Fig. 12: The dependence of PL intensities on sintering time. Glass and ITO substrates were need (sintering temperature was 800℃, after annealing, wavelength is 460nm).

In the condition of all pellets, PL intensities of thin films on glass substrates were higher than them on ITO substrates.

4.Conclusion

The SrS:Cu films were prepared by using an electron beam deposition method. The relation between sintering condition of pellets for evaporat and the crystallinity of deposited films were investigated. As a result, it was found that an optimum condition of sintering temperature and time were 600℃ and 1 hours, respectively. Also, it was found that PL intensity of thin films on glass substrates was higher than that on ITO substrates.

• Acknowledgements

This work was supported in part by Shizuoka Research Institute and Hamamatsu Science and Technology Promotion Society. Several parts of vacuum apparatus have been made by K. Sahara, M. Iwasawa, A. Isogai, T. Matsuo, T. Okamoto and T. Kamio in the Manufacturing Center of Shizuoka University.

• Referrence

1. T. Inoguchi, M. Tanaka, Y. Kakihara Y. Nakata, and M. Yoshida, Digets of the 1974 SID International Symposium, p.84(1974).
2. N. Miura, M. Kawanishi, H. Matsumoto, and R. Nakano Jpn.J.Appl.Phys.38,L1291-1292(1999).
3. J. Kane, W. E. Harty, M. Ling and P. N. Yocom, SID '85 Digest,p.163,(1985).
4. S. Tanaka, V. Shanker, M.Shiiki, H. Deguchi and H. Kobayashi SID '85 Digest,218-221(1985).
5. S.-S. Sun, E. Dickey, J. Kane, and P. N. Yocom Conference Record of the Int. Display Con. Rec. Toronto,p.301(1974).
6. U. Troppenz, B. Huttl, U.Storz, P. Kratzert K-O. Velthaus, S.-S. Sun, and D. Tuenge 4th ICSTD pp.187-190 (1998).
7. W. M. Li, M. Ritala, M. Leskela, E.Soininen, and L. Niinisto, 5th Int.Cont.on Sci.&Tech of Display Phosphors,Sendai,Japan, pp.169-172(1999).
8. W.-M. Li, M. Ritala, M. Leskela L. Niinisto, E. Soininen, S.-S. Sun W. Tong, and C. J. Summers J.Appl.Phys.86,5017-5025(1999).
9. M. Isai, K. Fukui, K. Higo,and H. Fujiyasu Rev. Sci. Instrum.71, 1505-1508(2000).
10. K. Ohmi, K. Yamabe, H. Fukada, T . Fujiwara S. Tanaka, and H. Kobayashi Appl. Phys. Lett.73, 1889-1891(1998).
11. J. Ihanus, M. Ritala, M. Leslkela E. Soininen, W. Park, A. E. Kaloyeros, W. Harris, K. W. Barth, A. W. Topol, T. Sajarvaara, and J. Keinonen J.Appl.Phys. 94,3862-3868(2003).
12. N. Yamashita Jpn.J.Appl.Phys.30,No.12A, 3335-3340(1991).
13. N. Yamashita, K. Ebisumori, and K. Nakamura Jpn.J.Appl.Phys.32,3846-3850(1993).
14. Y. B.Xin, W. Tong, W. Park, M. Chaichimansour, and C. J. Summers, J. Appl. Phys., Vol.85, No.8, 15 April 1999.

(Recieved December 8, 2007 ; Accepted July 15, 2008)