SrS:Ce EL소자에 있어서 발광중심이 휘도에 미치는 영향에 관한 연구

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A study on the influence of luminecent center on luminance in SrS:Ce electroluminescent devices

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요 약

공 부활제로 KCl, Cl, S 및 P를 각각 첨가한 발광층을 전자 빔 방법에 의해 성장시킨 2중 절연구조의 SrS:Ce electroluminescent(EL) device를 제작하여, 공 부활제가 EL device의 휘도에 미치는 영향을 조사였다. 휘도 및 발광파장은 첨가되는 공 부활제 및 농도에 의하여 상당한 영향을 받고 있음을 알았다. 어느 공 부활제에서나 전체 휘도는 0.2 mol%에서 최고를 나타냈으며, $CeCl_3$+KCl를 첨가한 소자가 최고 850cd/m^2를 나타내었다. 또한 CeP를 첨가한 소자의 경우 전체 휘도는 낮았으나 청색 휘도의 비율은 가장 높았으며, 이 비율은 농도의 상승에 따라 증가했다.

ABSTRACT

The effect of codopants on the electroluminescent properties for SrS-Ce based thin films was studied. The active layer was deposited by electron beam with sulfur. The wavelength of electroluminecence shifted with codopants and their concentrations. The intensity ratio of blue to green were found in the CeP-doped device, but the highest total intensity of luminance showed about 850cd/m^2 in the $CeCl_3$+KCl-doped device, which indicates that codopants are playing an important role of luminance. At any device, the luminance was the strongest at 0.2 mol% concentration among the concentration studied, suggesting the existence of optimum concentration. By post-annealing, Luminance of most devices was improved, but the shift of wavelength was not observed.

Key words

SrS:Ce, Electroluminescence, Codopant, Electron Beam, Transferred Charge

Ⅰ. Introduction

Alternating-current thin film electroluminescence(ACTFEL) devices have been successfully applied in bright monochrome and multicolor flat panel displays for several years[1, 2]. However, full-color TFEL displays have not been put to practical use due to an insufficient luminance of blue color EL. The strontium sulfide(SrS) doped with rare earth or transition metal ions is highly promising phosphor for the blue emitting TFEL devices[3, 4], and especially, cerium-doped strontium sulfide (SrS:Ce) has been extensively studied[5]. It has been known that elemental Ce is not suitable for a doping of Ce in SrS since the presence of trivalent Ce on a divalent Sr site is expected to promote the introduction of Sr vacancies to maintain charge neutrality[6]. Therefore, cerium trichloride($CeCl_3$) is usually used as a dopant starting compound, in which Cl ions play a role of charge compensation to prevent vacancies. Thus, a series of codoping studies using trivalent Ce ions to substitute on the Sr site were investigated, but nothing is known about codopants influence on the emission characteristics of the Ce luminescent center.

Due to its distinct chemical properties, such as ionic radii and bond types, different halides and other codopants are expected to have decisive influence on the interatomic transitions and therefore on the emission properties of the Ce^{3+} ion.

To investigate these effects, in this paper, SrS:Ce-based TFEL devices with the several dopants($CeCl_3$+KCl, $CeCl_3$, CeP, Ce_2S_3) have been fabricated by electron beam(EB) evaporation and EL characteristics have been studied.

II. Experiments

The devices have been a conventional double insulating structure, as shown in Fig. 1.

The devices were prepared by sequential depositions of each layer on a Hoya NA-40 glass substrate. An indium-tin-oxide(ITO) transparent electrode , the Si_3N_4/SiO_2 first insulating layer and the SiO_2/Si_3N_4 second insulating layer were deposited by rf-sputtering, and an Al rear electrode was thermally prepared. The 1.3μm-thick SrS:X(X:$CeCl_3$+KCl, $CeCl_3$, CeP, Ce_2S_3) phosphor layer was deposited at the substrate temperature of 550℃ and vacuum pressure of 2.0×10^{-4}Torr by EB with sulfur(S) which is supplied from a S furnace placed on the outside of the growth chamber. The evaporation sources for the phosphor layer were prepared by pressing the mixed power of SrS(3N) with desired concentration of dopant power(3N) to form a pellet, and followed by firing this pellet at 1000℃ for an hour in a argon-sulfur(Ar-S) atmosphere. The dopant concentration was varied from 0.1 to 1.0 mol%. The concentrations of dopants shown in this paper are those of the evaporation sources. The concentrations for several evaporated thin films have been analyzed by electron dispersive analysis by x-ray(EDAX), and found that the concentrations in films are almost the same compared with those of the sources.

The post-annealing was performed for an hour at 600℃ in Ar-S atmosphere.

The luminance-applied voltage(L-V) characteristics were measured at 5kHz sinusoidal wave and the transferred charge-applied voltage(dQ-V) characteristics were measured using the Sawer-Tower circuit.

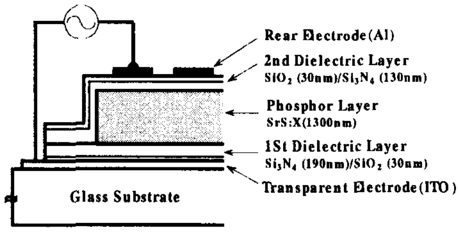

Fig. 1 The schematic structure of the TFEL devices.

III. Results and discussion

1. EL specta of SrS:Ce TFEL devices

Fig. 2 shows the EL specta of SrS:Ce TFEL devices doped with the concentration of 0.2 mol% of various codopants. Regardless of codopants, the two main emission bands are found at around 480nm and 540nm which are due to the parity allowed $^2D(5d)$-$^2F_{5/2}(4f)$ and $^2D(5d)$-$^2F_{7/2}(4f)$ transition for Ce^{3+} characteristic emissions in SrS[7]. The CeP-doped device shows the strong intensity of blue compared to that of green band, whereas the luminance of the Ce_2S_3-doped device are found at green band. That is, the wavelength of emission shifts with codopants, which implies that codopants are playing a decisively important role of electroluminescence.

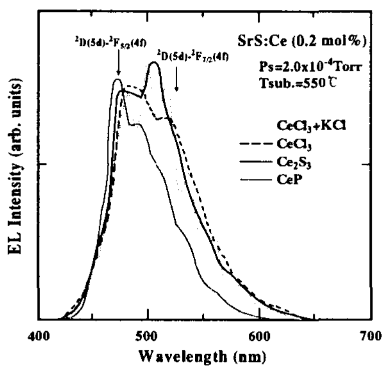

Fig. 2 The dependence of the EL specta of the SrS:Ce TFEL devices on the codopants.

The concentration dependence of EL spectra for the $CeCl_3$+KCl-doped SrS TFEL devices is shown in Fig. 3. The spectra show periodic oscillations caused by the interference effect due to multiple internal reflections in the devices. The variation of spectra with concentrations for the devices doped with other codopants were similar to Fig. 3. The luminance of most devices shifts to green with increasing the concentration, but in CeP-doped devices, a distinct blue-shift is found with increasing the concentration.

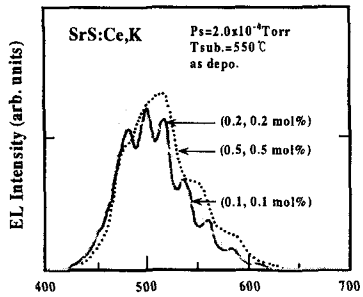

Fig. 3 The dependence of the EL specta of the SrS:Ce, K TFEL devices on the Ce, K concentration.

Fig. 4 shows the dependence of EL spectra on the post-annealing. A whole shape of spectra and the shift of wavelength between annealing and as-deposited TFEL devices was not observed except a change of luminance intensity.

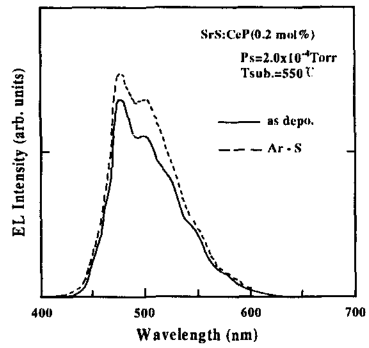

Fig. 4 The dependence of EL spectra on the post-annealing.

2. Luminance of SrS:Ce TFEL devices

Fig. 5 shows the typical L-V and dQ-V characteristics of SrS:Ce TFEL devices doped with the concentration of 0.2 mol% of various codopants. The luminance and transferred charge in all devices rise steeply at the voltage above the threshold of about 150V, which suggests that codopants contribute the luminescence by any means, probably a carrier magnification or an improvement of crystallinity. The $CeCl_3$+KCl-doped SrS TFEL device shows low threshold voltage of 145V and maximum luminance of about 850cd/m^2 compared with the other devices in this study, but its luminance is relatively low compared to the reported luminance of L_{max}=1100cd/m^2[8].

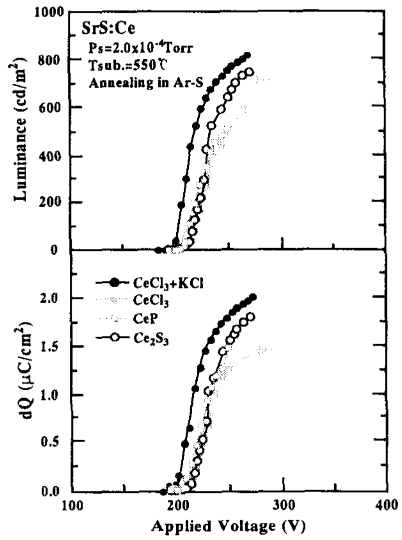

Fig. 5 The dependence of the L-V and the dQ-V characteristics of SrS:Ce TFEL devices doped with the concentration of 0.2 mol% of various codopants.

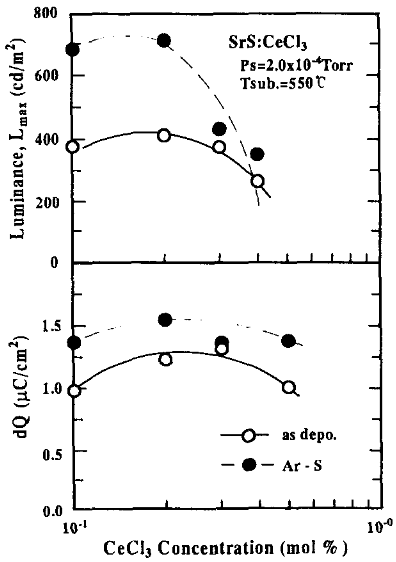

Fig. 6 The annealing effect on luminance and transferred charge in the SrS:$CeCl_3$ TFEL devices.

Fig. 6 shows the annealing effect on luminance in the SrS:Ce TFEL devices. At any concentration, luminances and transferred charge are improved by annealing, especially at low concentrations. The other devices also showed a similar trend.

Fig. 7 shows the concentration dependences of devices. At 0.2 mol% concentration, the luminance was very strong compared to those at the other concentration, suggesting the existence of optimum concentration. The decrease of luminance with the further increase of concentration may be due to the concentration quenching which increases in nonradiative transition due to Ce-Ce interactions.

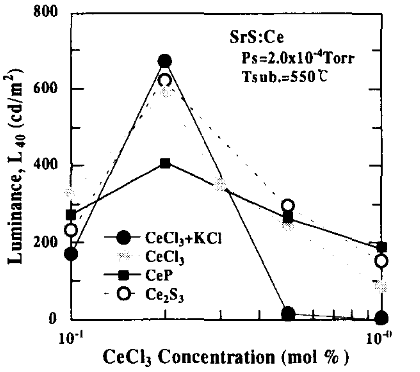

Fig. 7 The concentration dependences of luminance.

IV. Summary

SrS:Ce-based TFEL devices with the several dopants($CeCl_3$+KCl, $CeCl_3$, CeP, Ce_2S_3) have been fabricated by electron beam(EB) evaporation with sulfur and EL characteristics have been studied in order to investigate the effect of codopants on the electroluminescent properties of the SrS:Ce-based thin films.

The wavelength of electroluminecence shifted with codopants and their concentrations. The intensity ratio of blue to green were found in the CeP-doped device, but the highest total intensity of luminance showed about 850cd/m^2 in the $CeCl_3$+KCl-doped device, which indicates that codopants are playing an important role of electroluminecence.

At any device, the luminance was very strong at 0.2 mol% concentration compared to those at the other concentration, suggesting the existence of optimum concentration.

By post-annealing, Luminance of most devices was improved, *but the shift of* wavelength was not observed.

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