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Effect of Rapid Thermal Annealing on the Crystal Structure of SrS:Cu Films

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SrS:Cu films were prepared for the blue EL elements. The compound SrS was evaporated by using an electron beam deposition. A rapid thermal annealing process was applied to the deposited films. The annealing condition was investigated as varying the parameter of annealing temperature and annealing time. The crystal properties were greatly improved at the annealing condition of 800℃ and 2 minutes. The PL properties were also improved after this annealing process.

Key words: electroluminescent elements, SrS:Cu, blue emission, vacuum deposition

I. INTRODUCTION

The inorganic electroluminescence (EL) display devices have many characteristics, for example, high durability, wide view angle, high speed response time, and self emitting. [1] They are one of the candidate devices for flat display panels which could be used in the wide temperature range. The biggest problem to overcome is the deficiency of blue emission strength.

The SrS films have been prepared by various methods to improve blue chromaticity as well as emission intensity.[2-12] It is difficult to evaporate compound SrS by resistive heating method because of it s high melting point. So these films were prepared by an electron beam deposition. The Cu_2S was used as a copper emission center which evolves blue emission color.

The purpose of this work is to investigate the relationship between a rapid thermal annealing condition and film properties.

II. EXPERIMENT

Figure 1 shows the deposition apparatus. The double insulating layer type electroluminescence elements were prepared. The EL phosphor was sandwiched between double insulating Y_2O_3 layers.[1,5] The SrS:Cu and Y_2O_3 layers have a thickness of about 0.5 μm. The first Y_2O_3 layer was deposited on an ITO coated alumino-silicate glass substrate (Hoya NA-40). These Y_2O_3 and SrS:Cu layers were subsequently deposited without breaking vacuum by using electron beam deposition.

The Cu_2S powder was involved in the SrS powder as a blue emission center. The concentration of Cu_2S and substrate temperature (T_{sub}) were fixed to 0.5 mol% and 400 ℃, respectively.

An optimum annealing condition was investigated by varying annealing temperature and annealing time. The Ar flow rate was fixed at 100 cc/min. through this study.

The photoluminescence (PL) spectra were measured by using a deutrium lamp, which excites the electrons in the luminescent centers. It contains a filter, which cuts off the visible radiation.

In order to obtain crystallographic information, X-ray Diffraction (XRD) measurements were carried out on a RIGAKU Rotaflex 12kW system with a CN2173D6 goniometer. The film thickness was measured mechanically by a DEKTAK-II surface profiler.

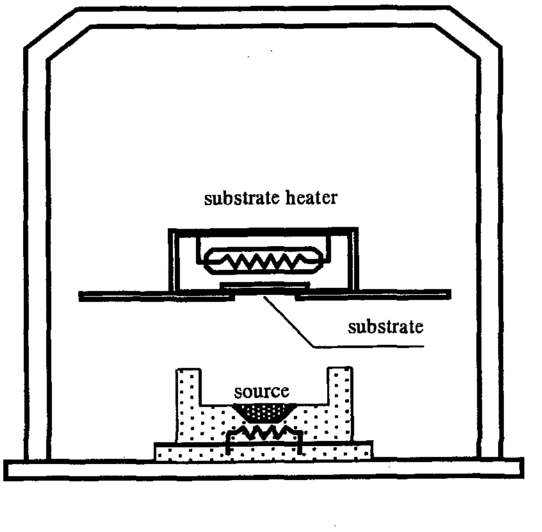

Fig. 1 Deposition apparatus.

III. RESULTS AND DISCUSSION

Figure 2 shows the variation of XRD intensity on the annealing temperature. The annealing time was fixed at 10 minutes. There is a peak at annealing temperature of 700 ℃.

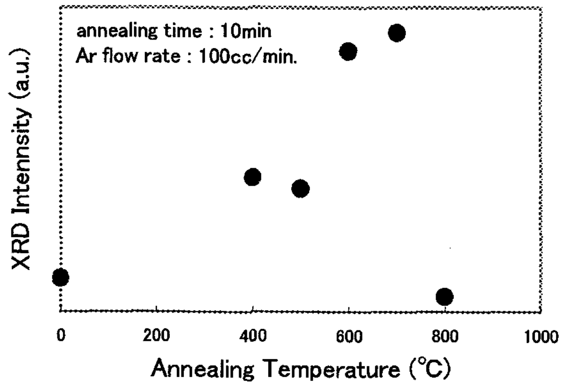

Fig. 2 The variation of XRD intensity on the annealing temperature.

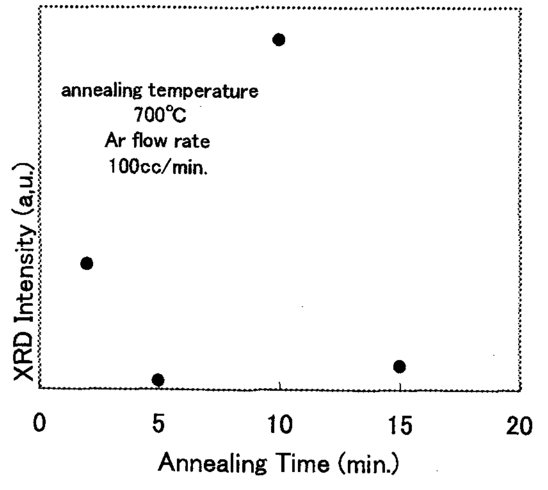

Fig. 3 Variation of XRD intensity on the annealing time.

Figure 3 shows the variation of XRD intensity on the annealing time. The annealing temperature was fixed at 700℃. There is a peak at annealing time of 10 minutes. The annealing time of 15 minutes softened the glass substrate during the annealing process. This problem could be overcome even under the annealing temperature of 800 ℃ provided that the annealing time had been shorten to 2 minutes.

Figure 4 shows a representative annealing property. The XRD peak is drastically improved after applying a 800℃ and 2 minute-annealing process.

Figure 5 shows the variation of PL spectrum of SrS:Cu film after applying a 800 ℃ and 2 minute-annealing process. The PL intensity is increased after the annealing process. Each PL spectrum has a broad peak. But, two shoulders are recognized after the annealing process. It is seemed that they could be correspond to the wavelength of 460 nm and that of 520 nm. These two peaks are observed in the PL spectrum of SrS:Cu.[7,8] They are denoted as H and L bands, respectively

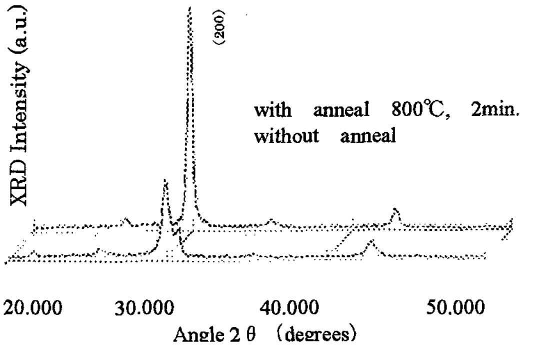

Fig. 4 A representative annealing properties after applying a 800℃ and 2 minute-annealing process.

The luminescence of the H band (460 nm) is originating from the paired or aggregated copper centers. The luminescence of the L band (520 nm) is originating from the off-center Cu^+ ions. Yamashita[9,10] examined PL spectrum of SrS:Cu powder samples. He deduced that these H and L bands come from Cu^+ monomer and dimmer centers, respectively. The exact explanation has not been done yet. It is found that the L band peak evolved after annealing process. This phenomenon could be explained that S atoms are easily re-evaporated during the annealing process and then Cu^+ ions land in these vacancy sites.

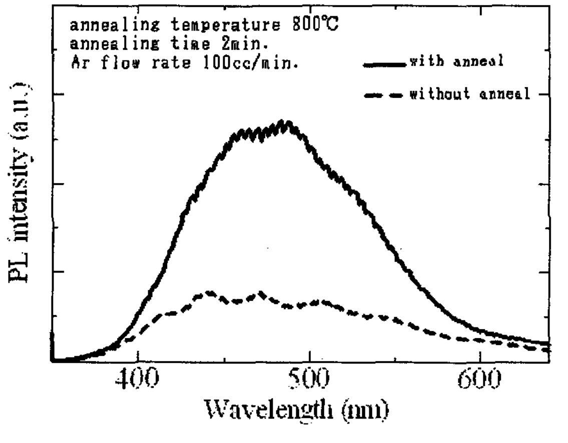

Fig. 5 The variation of PL spectrum of SrS:Cu films after applying a 800℃ and 2 minute-annealing process.

The EL emission characteristics depend on the properties of insulating layers as well as that of phosphor material. The performance of insulating layer depends on the thickness as well as the material of insulating layer. So, it is difficult to compare the properties of various insulating layers. The optimization of insulating layers will be the subject of a future study. The sulfur compensation is also one of the problems to be overcome. The improvement of EL characteristics will be conducted through investigating the correlation between structure of EL elements and EL emission mechanism.[9,10]

Ⅳ. CONCLUSION

A rapid thermal annealing treatment was applied to the SrS:Cu films. A good result was obtained under the annealing temperature and time of 800℃ and 2 minutes, respectively. The XRD data showed that crystal properties were drastically improved after the annealing process.

The PL intensity was also increased after the annealing process. The two shoulders were recognized after the annealing process. They correspond to the wavelength of 460 nm and that of 520 nm. They are denoted as H and L bands, respectively.

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