CATHODOLUMINESCENCE CHARACTERISTICS OF $SrAl_2O_4$: Eu^{2+} NANOPHOSPHORS AT LOW TEMPERATURES

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This paper reports CL characteristics of nanosized $SrAl_2O_4$:Eu^{2+} phosphor. This sample was prepared by combustion method. X-ray diffraction (XRD), cathode luminescence (CL) were conducted to characterize the phosphor. The comparison between the emission spectra revealed that pure and Eu doped $SrAl_2O_4$ samples showed the same peaks at 375 nm. This peak is attributed to crystal defects.

Keywords: nanophosphor, combustion method.
PACS: 33.50.-j, 33.50. D

INTRODUCTION

Due to their excellent luminescence properties, high quantum efficiency in visible region, good stability, color purity, excellent physical and chemical properties and the easy preparation, green $SrAl_2O_4$:Eu^{2+} alkaline earth aluminates have the potential applications in fluorescent lamps, plasma display panels, pc LEDs and persistent luminescent materials [1-5].

In this paper, Eu^{2+} doped $SrAl_2O_4$ nanophosphor was synthesized by combustion method and their cathodoluminescence properties were studied. The results of the cathodoluminescence measurements of $SrAl_2O_4$:Eu^{2+} nanophosphors were compared and discussed. The emission of these materials is highly efficient, and their emission wavelength heavily depends on host lattice. In the $SrAl_2O_4$ host lattice, the main emission band of Eu^{2+} ions is centered near 520 nm, when another emission band at 444 nm is still the object of discuss. In this article, we have observed new peak at 375 nm and our experimental results proved that this peak is related to crystal defects which help to increase a number of traps and prolong afterglow duration. We have observed 2 minutes afterglow duration in $SrAl_2O_4$:Eu^{2+} phosphor [11]. If there is not any co activator ion, then the observed long afterglow duration showed that crystal defects played the role of traps.

2. EXPERIMENTAL SECTION

All reagents were commercially purchased and used without further purification. For the synthesis, stoichiometric amounts of $Sr(NO_3)_2$ (99,99%), $Al(NO_3)_3 \cdot 9H_2O$ (99,99%), $Eu(NO_3)_3 \cdot 6H_2O$ (99,99%), $CO(NH_2)_2$ (99,3%) and H_3BO_3 (99,9%) were dissolved together in 20ml of deionized water to obtain a transparent solution. Small amount of boric acid was used as flux and urea as fuel [6,7]. The components were mixed together and the solution was stirred using a magnetic bar at 70ºC for two hours. Every 15 minutes the temperature of the solution was raised by 10ºC up to 130ºC. We got white viscous gel. The gel was placed in a preheated muffle furnace at 600ºC. At this temperature the solution evaporated, generating large amounts of gases, e.g. oxides of carbon and nitrogen. The combustion process lasted for about 5 to 10 minutes and resulted in white ash.

Fig. 1. $SrAl_2O_4$:Eu^{2+} nanosized powder synthesized by combustion method.

At the next step, the precursor was annealed at 1000^0 C for 1 and 2 hours under Ar /H_2 reductive atmosphere for the purpose reducing Eu^{3+} to Eu^{2+}.

X-ray diffraction patterns were recorded using a Bruker 5000 diffractrometer in standard *θ-2θ* geometry using Cu Kα radiation.

The luminescence spectra were detected using the UV-VIS-NIR (200-1700 nm) monochromator ARC SpectraPro-2300i equipped with Hamamatsu photon counting head H6240. All measurements were carried out in a liquid helium vacuum cryostat (5-400K temperature range, vacuum $2*10^{-7}$Torr) equipped with LakeShore 331 Temperature Controller. The cathodoluminescence measurements were performed under irradiation with electrons (5 keV, 0.4µA, spot»$1mm^2$).

3. RESULTS AND DISCUSSION

3.1 XRD analysis

X-ray diffraction (XRD) analysis was used to identify the crystal structure and phase purity of the pure and Eu doped $SrAl_2O_4$ phosphors.

It is clear from the XRD results that the main peaks in the sample due to $SrAl_2O_4$ and showing good consistence to the data from the standard powder diffraction file, JCPDS-01-024-11-87 [11]. But one of the intensive peak (32º) and also other peaks which are not coincide with this ICDD data have shown that it is a

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cubic phase $Sr_3Al_2O_6$ (a=b=c=15,844Å). But there are not any lines of combination of other elements. It means that all nitrates, boric acid and urea were dissolved and during 5-10 minutes the combustion process absolutely has finished.

3.2. CL measurements of $SrAl_2O_4$:Eu^{2+}.

First of all, it is still unclear whether the traps are related to host defects, the trivalent codopant, or a combination of both [8-10]. If host defects can play the role of traps then it could be useful for increasing duration of afterglow even without codopant.

In this paper CL measurements were carried out to study all observed peaks in detail. As the result of impinging high energy electrons, we can get detail information about peaks on PL spectrums [11]. Because of high energy electrons, we have observed a peak at 375 nm which was not clearly visible at FL spectrums at low temperatures.

First, it should be noted that the results of CL confirms the results of the spectrum FL [11].

Under VUV emission maximum peak at 520 nm and blue emission band at 442 nm were observed. The observed emission wavelength of 520 nm attributed to the $4f^65d^1 \rightarrow 4f^7$ transition of Eu $^{2+}$ ion. The reason for the appearance of the blue band has been the subject of discuss for many years.

In addition were compared the results of CL of the Eu^{2+} doped and undoped $SrAl_2O_4$ and was determined that just two peaks (375, 250) nm were coincide (fig 3). It proves that these two peaks are not attributed to Eu^{2+} ion. This new peak at 375 nm can be attributed to crystal defects. The peak at 618 nm is presumably due to the emission of Eu^{3+} ions. The main reason to relate this peak to the second $Sr_3Al_2O_6$ phase is the observation of green band on the emission spectrum of $Sr_3Al_2O_6$ under UV excitation. Akiyama and coworkers [12-17] reported a green band on the emission spectra of $Sr_3Al_2O_6$: Eu under the excitation of 365 nm, which corresponds to our results. But XRD results [11] have shown that the concentration of this phase is low. So we can attribute this peak to the crystal defects within $SrAl_2O_4$.

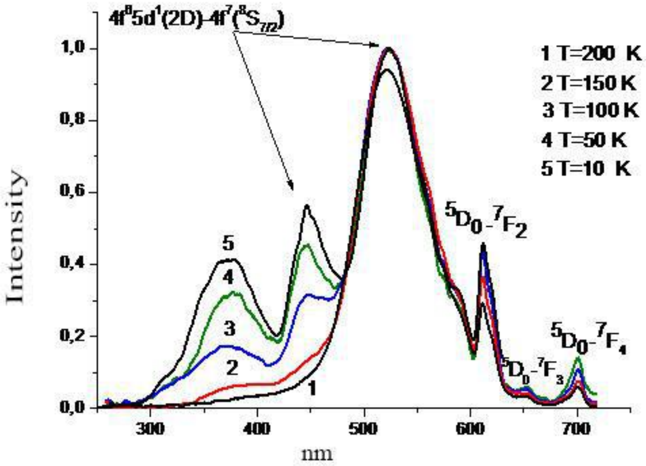

Fig.2. CL spectrums of $SrAl_2O_4$: Eu^{2+} nanophosphors at different temperatures

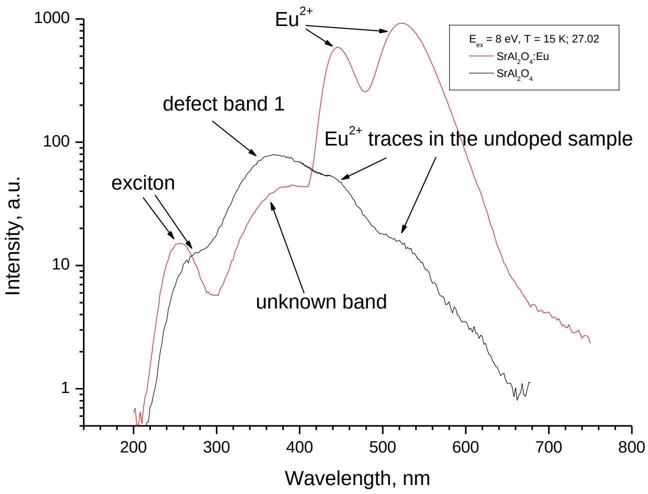

Fig 3. CL spectra of undoped and Eu doped $SrAl_2O_4$, E_{ex} = 8 eV, T = 15 K.

CONCLUSION

The nanosized green $SrAl_2O_4$:Eu^{2+} phosphor was successfully synthesized by combustion synthesis. Cathodoluminescence properties at low temperatures are reported. Broadband VUV excited luminescence around 520 nm is attributed to $4f^65d \rightarrow 4f^7$ transition of Eu^{2+} ions in $SrAl_2O_4$. Another band at 450 nm was observed only at low temperature less than 150 K, and its nature is under discussion. New peak at 375 nm was observed and attributed to crystal defects within $SrAl_2O_4$.

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Received: 21.06.2016