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INVESTIGATION OF EFFECTS OF DEPOSITION PARAMETERS ON COMPOSITION, MICROSTRUCTURE, AND EMISSION OF RF SPUTTERED SrS:Eu THIN FILM PHOSPHORS

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To date, there has been little systematic study of the cause of dead, or inactive layers in II-VI phosphor materials for use in thin film electroluminescent (TFEL) devices. Investigation of photoconductivity, cathodoluminescence, and photoluminescent (PL) efficiencies as functions of phosphor film thickness have provided insight into the existence and spatial extent of the dead layers[1,2,3]. In general, however, results have not always been consistent.

In this work, we discuss preparation and characterization of rf sputter deposited europium doped strontium sulfide (SrS:Eu) thin films for use in a subsequent systematic study to determine the cause of the dead layer. The behavior of the dead layer is likely influenced by thin film composition, crystallinity, and microstructure, properties that are determined by deposition conditions of the thin film phosphor material. We have deposited SrS:Eu thin films in a repeatable and consistent manner and have characterized properties such as composition, crystallinity, and microstructure as well as PL and electroluminescent (EL) behavior.

Composition, crystallinity and microstructure of the SrS:Eu thin films were characterized using a variety of analysis techniques. The composition was determined using Rutherford backscattering spectrometry and electron microprobe analysis. X-ray diffraction was used to assess crystalline orientation and grain size, while scanning electron microscopy was used to image thin film microstructure. Measurement of the decay of PL after subnanosecond laser excitation in the lowest absorption band of the dopant allowed for a direct measurement of the dopant luminescence efficiency.

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Experimental

For the preliminary PL studies, simple stack structures consisting of a borosilicate glass substrate/ 130 nm SiO_xN_y/500-1000 nm SrS:Eu/ 130 nm SiO_xN_y were fabricated. All thin films

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were deposited using reactive RF sputtering. In order to obtain similar microstructure for SrS:Eu in both PL and EL devices, all SrS:Eu thin films were deposited onto identical SiON films. In addition all SrS:Eu layers were capped with a thin film of SiO_xN_y to prevent atmospheric contamination which severely limits luminescent output from SrS-based phosphors. The deposition parameters used to rf sputter deposit the SrS:Eu and the SiO_xN_y (x=.61 and y= .93) thin films are listed in Table 1. Deposition parameters such as substrate temperature, chamber pressure, process gas composition, and power to the target affect thin film properties such as composition, stoichiometry, crystallite size, and microstructure which ultimately determine the luminescent behavior. Here, a suitable set of deposition parameters was determined for SrS:Eu thin film phosphors and then held constant for subsequent depositions. Only the substrate temperature was varied for the different samples.

Results

X-ray diffraction patterns indicate that the phosphor films are crystalline with preferential orientation in the 200 direction of the cubic crystal structure. The average crystallite size, calculated using the Scherrer equation, was similar for each of the samples deposited from 300 ^{0}C to 650 ^{0}C. The relatively large crystallite size (35 to 42 nm) reduces the number of boundaries which are potential sites for non-radiative recombination. It is interesting to note that the higher PL efficiencies were achieved for films deposited at lower temperatures where grain sizes were relatively larger.

The PL excitation and emission spectra indicate that for optimized samples no appreciable density of states below the SrS interband absorption edge exists. The Eu-emission can be excited by gap-excitation or by exciting the internal transitions of Eu. Measurements of the decay of PL after sub-nanosecond excitation in the lowest absorption band allowed for the direct measurement of the luminescent efficiency of Eu. The dependence of this efficiency on the preparation conditions was used as an optimization criteria. The EL behavior of the samples corresponded to that reported for RF-sputtered CaS:Eu, in that they did not show trailing edge current or emission as often reported for e-beam deposited CaS:Eu[4]. We attribute this to the good crystallinity and stoichiometry of the optimized samples.

Table 1 Recipe for PL stack layers

	SrS:Eu Layer	SiON Layer
Target	SrS:Eu	Si
Pressure (mTorr) O_2	--	8×10^{-3}
N_2	--	3.00
Ar	2.2	0.8
H_2S	0.8	--
Total Pressure	10.00	10.00
Power	150 Watts	150 Watts
Temperature (°C)	300, 400, 500, 650	300 °C
Time/Thickness	varied	35 min / 130 nm

Table 2 PL Results for initial samples

Thickness (nm)	Temperature (°C)	PL Efficiencies
1000	300	17 %
550	400	21 %
1000	400	35 %
500	500	17 %
1000	650	22 %

References

[1] R.H. Bube, Physical Chemistry, **10**, 515 (1970)
[2] N.L. Dmitruk et al., Surface Science **72**, 321 (1978)
[3] O. Geode, et al., Phys. Status. Solidi A **94**, 259 (1986)
[4] Y. A. Ono, J. Appl. Phys. **10**,69 (1991)