

Studying the SrTiO₃: Pr cathode-luminescence

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Abstract

The estimation of applicability SrTiO₃:Pr³⁺, Al to a class low-voltage flat-panel displays based on field emission effect, which have average value anode voltage $U_a = 300$ V and current density $j = 100$ mA/sm² at duty 240, has given positive result. In the same time observably for the most effective sample in similar conditions of excitation high brightness - more than 500 Kd/m² and linear brightness dependences from current density and voltage allows to decrease greatly the power which consumed by the device.

1. Objectives and Background

Implantation of full-color field emission displays is limited by insufficient efficiency of luminescent materials at excitation by low-energy electrons. As is known, the basic problem limiting quality of the color image always was the red phosphor. For many years this component conceded the blue and green phosphors on efficiency, than explains the numerous attempts of its upgrading and a heightened interest to new red-emitting phosphors. At present days, most effective of existing red-emitting phosphors is Y₂O₂S:Eu³⁺, however nonlinear dependence of brightness from current density, makes it inefficient at excitation by low energy electrons ($U = 50 - 700$ V). Application of a luminescent material in field emission displays demands a favorable combination of necessary properties, such as ability to cathode-luminescence and low specific resistance, which is available at very much limited number of substances. It's zinc and tin oxides, zinc - cadmium sulfides and some gallates of alkali-earths elements. In 1996 to number of such substances was referred SrTiO₃:Pr³⁺-phosphor, emitting in red area of a spectrum.

The aim of the present work is the studying of SrTiO₃:Pr³⁺, Al cathode-luminescence in a range of accelerating voltage and anode density current, characteristic for field emission displays.

2. Results

Studying the influence of technological and chemical-physical factors on radiation centers formation,

mechanisms of absorption and energy transfer in examined system [1-2] allowed to formulate technological recommendations of reception highly effective at low-voltage excitation phosphor SrTiO₃:Pr³⁺, Al.

Optimum size of Region of the Coherent Scattering (RCS) ~ 270 nm and statistical activator's distribution in volume of a basis are reached by synthesis temperature 1270 °C and by use of mineralization substance, which accelerating inner-grain re-crystallization processes allowing to reduce a heat treatment period from 12 till 6 hours. During synthesis process carried out the careful control of the gas environment which should provide favorable concentration of oxygen vacancies V_O^{**} . Finally was received phosphor, cathode-luminescence quantum output of which was achieved the maximal value predicted on standard [3] idealized equation (1) for radiating efficiency of cathode-luminescence:

$$\eta = (1 - \gamma)(N_{eh}/N_A)(h\nu_m/\beta E_g)SQ \quad (1)$$

It is necessary to note, that for all synthesized samples of phosphors observed the increasing of relative cathode-luminescence brightness at reduction of energy excitation electrons (fig. 1). This points on low-voltage character of given phosphor.

Volt - brightness dependence of phosphors on a basis strontium titanate greatly differ from those for Y₂O₂S:Eu³⁺ phosphor, which has a well defined low-voltage tail. That can be explained by presence at low voltage the Surface - Localized Electrons (SLE) which has not enough energy for formation $e - h$ (electron-hole) pairs. It is taken into account by multiplier N_{eh}/N_A in equation (1) where N_{eh} - number of bombarding electrons, which produce $e-h$ pairs, and N_A - the general number of electrons, which are absorbed by a basis lattice, formed from $N_{eh} + N_{SLE}$. For this reason, non-linear volt-brightness dependences for Y₂O₂S:Eu³⁺ is caused by presence of surface - localized electrons which number is increased with downturn of anode voltage. Phosphors based on strontium titanate do not have low-voltage tail, and their volt- brightness dependence is submitted by a direct line in all range of used voltages

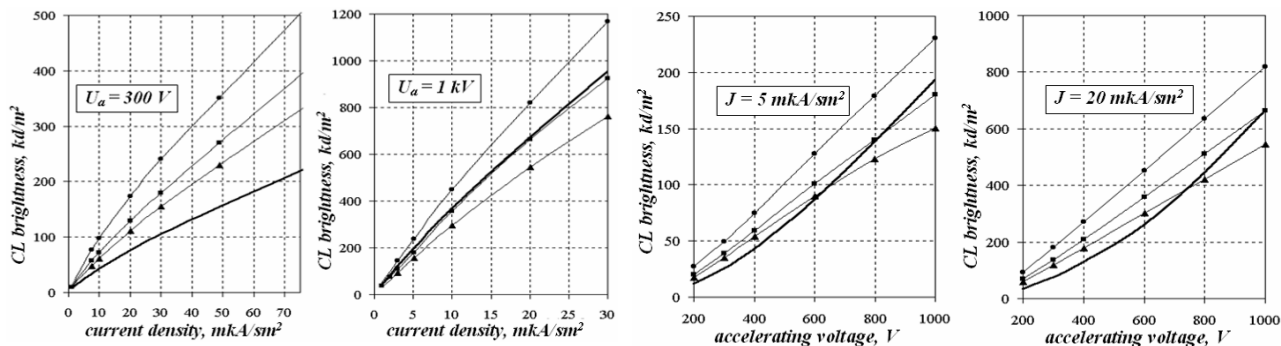


Figure 1 Ampere-brightness and volt - brightness dependences of cathode-luminescence for $SrTiO_3:Pr^{3+}, Al$ synthesized in various gas environments in comparison with $Y_2O_2S:Eu^{3+}$ (Table 1).

Table 1. Chromaticity of $Y_2O_2S:Eu^{3+}$ and $SrTiO_3:Pr^{3+}, Al$, synthesized in various gas environments

Designation (fig. 1)	composition	gas environments at synthesis	Chromaticity	
			X	Y
■	$SrTiO_3:Pr^{3+}_{0.002}, Al_{0.17}$	oxidizing	0.641	0.358
●		weak - regenerative	0.690	0.310
▲		regenerative	0.636	0.314
—	$Y_2O_2S:Eu^{3+}$		0.640	0.350

and current densities. These linear dependences point, that $N_{ch}/N_A=1$ in a measured range of voltages (200 - 1000 V). Very important that linear dependence of luminescence brightness $SrTiO_3:Pr^{3+}, Al$ from accelerating voltage is available also at the high current densities, because general current densities, applied in low-voltage displays are equal to 0,1 - 4 mA/sm².

Linear character of amperes-brightness dependence $SrTiO_3:Pr^{3+}, Al$, also has the big length in comparison with the similar dependence received for $Y_2O_2S:Eu^{3+}$.

3. Impact

Application of $SrTiO_3:Pr^{3+}, Al$ phosphor in displays devices, working in the region of accelerating voltages lower than 1000 V, has significant advantages in comparison with applied at present days $Y_2O_2S:Eu^{3+}$ phosphor.

Also it is necessary to pay attention to remarkable feature, that with increase of cathode-luminescence brightness by means of change the gas environment at heat treatment, color purity (table 1) is improved. Thus the samples synthesized in a weak- regenerative atmosphere, have excellent chromaticity $X = 0.690$ and $Y = 0.310$, the appropriate to 100 % cleanliness of the red color which till now have been not achieved on one of known us phosphors, including phosphor the same structure first suggested by the Japanese

group "Futaba" [4-6].

4. Acknowledgements

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5. References

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