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Colour Characteristics of AC HEL Structures with Various Protective Layer*

L. Yourukova, **K. Kolentsov**, **A. Zheliaskova**

Institute of Solid State Physics, Bulgarian Academy of Sciences,
72 Tzarigradsko Chaussee Blvd., 1784 Sofia

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Abstract. The changes in the colour characteristics of Alternating Current Hybrid Electroluminescent structures with yellow emission, as a function of the type of the protective layer, are investigated. Conclusions for the possible applications of some of the investigated HEL structures in various systems for representation of colour sign information are given.

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1 Introduction

The intensive use of the electroluminescent display structures in various systems for representation of light information has emerged [1,2]. A reason for this is their advantages compared to liquid crystals and LED displays.

A marked interest for the application of the electroluminescent display structures represent the changes of the basic physical parameters of their colour emission vs the type of the protective layer and the conditions of the electroluminescent excitation. These parameters are connected with visual human sensation for the colour and in this sense one can speak of psychophysical characteristics of the colour of the emitting light from the electroluminescent display structures [2].

In the present work, the effect of the protective layer (which does not permit the appearance of an electrical breakdown) on Alternating Current Hybrid Electroluminescent (AC HEL) display structures with yellow emission upon their basic colour characteristics is investigated. Data for the changes in the colour characteristics are presented.

*This work is dedicated to Professor Alexander Derzhanski Dsci., Corresponding Member of the Bulgarian Academy of Sciences, on the occasion of his 70th anniversary.

2 Experimental Details

The investigated AC HEL display structures have been prepared by an original hybrid technology, representing a combination between binder and vacuum techniques [3,4]. A general view of these structures is shown in Figure 1. The emitting layer, of thickness 50 μm, is prepared based on the binder technique. This layer is a heterogeneous matrix containing industrial electroluminophors with yellow emission (Zn:Cu, Mn; type E 575) and a polyepoxy oligomer, in specific proportions. The protective layer is a vacuum evaporated thin film of thickness 1.2 μm, formed from chalcogenide semiconductors from the systems As-S and Ge-Sb-S [5,6].

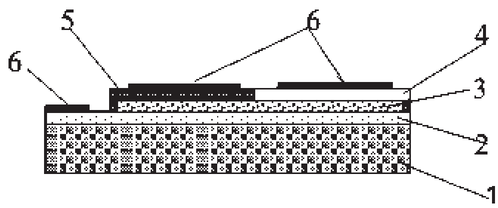

Figure 1. General appearance of an AC HEL display structure: 1 glass substrate; 2 transparent conductive SnO_2:F layer; 3 active layer with a yellow emission; 4 protective vacuum evaporated As_2S_5 layer; 5 protective vacuum evaporated $Ge_5Sb_{35}S_{60}$ layer; 6 Al electrodes.

Upon excitation of the electroluminescence in these HEL structures, the light emitted reaches the visual field of the observer. This light can be described by the brightness B in absolute units (cd/m^2), which characterizes its intensity, and by its colourity coordinates x and y, colour tone λ_D (predominant wavelength), colour purity p_e (colour saturation).

The above characteristics of the AC HEL structures are presented using a geometrical model in three-coordinate space (x, y, z) by the curves of the chromaticity diagram of CIE (Commission Internationale de L'Eclairage) 1931, where $x + y + z = 1$, and the third variable quantity $z = 1 - (x + y)$ [7].

The three-stimulus coordinates X, Y, Z of AC HEL display structures with yellow emission were measured with a Spectra Spotmeter, type UBD-10/4 (Photo Research, USA). The colourity coordinates x and y of the structures were determined by the formulas

$$y = \frac{Y}{X + Y + Z} \qquad x = \frac{X}{X + Y + Z}$$

For determination of the colour tone λ_D and the colour purity p_e, the chromaticity diagram of CIE 1931 for the standard light source D_{65} was used. This source corresponds to the middle phase of daylight, with a correlated colour temperature $T_c = 6500$ K. The phases of the total daylight lie mainly in the range of

$T_c = 6000$–7000 K, so that the source D_{65} is a good approximation to the mean value.

For determination of the colour purity p_e, the following formula was used:

$$p_e = \frac{\sqrt{(x - x_{D65})^2 + (y - y_{D65})^2}}{\sqrt{(x_\lambda - x_{D65})^2 + (y_\lambda - y_{D65})^2}},$$

where x and y are the colourity coordinates, x_{D65} and y_{D65} are the coordinates of the standard light source D_{65} and x_λ and y_λ are the coordinates of the colour tone λ_D (predominant wavelength).

3 Results and Discussion

The brightness of our AC HEL display structures with yellow emission and with protective As_2S_5 layers was always higher than in the case of structures with protective $Ge_5Sb_{35}S_{60}$ layers due to the higher transmission ($T_{\text{As–S}}$=88%, $T_{\text{Ge–Sb–S}}$=12%) the first one have.

The colour parameters of AC HEL display structures are weakly influenced by changes in the amplitude of the excitation voltage at a single frequency [8]. Therefore only the dependence of these parameters upon the frequency of the excitation voltage ($U = 120$ V) was investigated, as in Table 1.

For AC HEL display structures with yellow emission and a protective As_2S_5 layer, in range 400 Hz to 5 kHz one observes a change in the coordinates x and y. The same effect is observed for the colour tone λ_D, which remains in the interval 578 to 574 nm. The colour purity p_e, which is near from that of the spectroscopically pure yellow colour, decreases (96–92%). The behaviour of the structures with a protective $Ge_5Sb_{35}S_{60}$ layer is the same, but the colour purity p_e, which is more distant from that of spectroscopically pure yellow increases (81–88%). The colour tone λ_D remains in the interval 573.3 to 578 nm. This

Table 1. Change in the colour characteristics vs. frequency ν of the excitation voltage $U = 120$ V, for HEL structures with yellow emission

Prot.layer	ν(Hz)	x	y	λ_D(nm)	p_e(%)
	400	0.4905	0.4965	578.0	95.6
As_2S_5	1200	0.4804	0.5050	575.8	95.7
	3000	0.4690	0.5080	574.3	93.5
	5000	0.4595	0.5093	574.0	92.1
	400	0.4695	0.4705	578.0	81.0
$Ge_5Sb_{35}S_{60}$	1200	0.4658	0.4734	576.0	82.3
	3000	0.4585	0.4865	575.0	86.1
	5000	0.4497	0.5061	573.3	87.5

peculiarity is probably due to the higher degree of optical absorption for the $Ge_5Sb_{35}S_{60}$ layer (about 4 orders) in the range of the maximum of spectral emission of the built in electroluminofor [3,9].

4 Conclusions

AC HEL structures with yellow emission layer have a higher brightness when coated with a protective As_2S_5 layer than with a $Ge_5Sb_{35}S_{60}$ layer.

With an increase in the frequency of the excitation voltage, a change in the colour parameters x, y, λ_D, p_e of the structures with both types of protective layer is observed.

Despite the small changes in the colour parameters of the structures as a function of the frequency of the excitation voltage and the protective As_2S_5 layer, these structures can be successfully used for the representation of various colour sign information.

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