A PERFECTED TECHNOLOGY FOR ELECTROLUMINESCENT DISPLAY PREPARATION

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Abstract
The physical bases of a perfected technology for electroluminescent display are examined. The technology combines the advantages of the thick -layer (binder) and thin-film (vacuum) techniques. This technology presents a full and complete cycle for preparation of sandwich-like structures, which are the basis of electroluminescent displays. The basic technological contribution is connected with the original solution to include a thin layer from a widebandgap semiconductor. This layer leads to an increase of the brightness and the stability of the structures. The possible applications of the hybrid electroluminescent displays in various fields of informational representation are indicated.

The electroluminescent technology is one of the alternatives to plasma, liquid crystal and LED technologies for the preparation of indicator electroluminescent devices that can be of various sizes, configuration and purpose. The electroluminescent displays are multilayer sandwich-like structures, which emit light of various spectral compositions, i.e.,color emission upon application of excitation sinusoidal or impulse voltage of fixed amplitude and frequency [1-3].

In the present work the physical bases of the developed by the authors perfected hybrid technology are examined. This technology includes both the uses of thick-layer (binder) and thin-film (vacuum) techniques, and their combining insures advantages for the prepared hybrid electroluminescent structures compared to the conventional ones. The basic operations of this technology and the steps of constructional designing of digital electroluminescent displays are revealed.

THE HYBRID TECHNOLOGY BASES

The developed hybrid technology for electroluminescent display preparation includes the use of optical, chemical, spray pyrolisys, binder, screen printing and vacuum technologies [4-6]. The basic operations used for the preparation of the display structure are presented in Table 1.

The hybrid display structure, shown in Fig. 1,is the basic part of any electroluminescent display -- letter, digital and sign. On a plane-parallel glass substrate 1 the lower transparent electrode 2 is formed. The active emitting layer 3 is a heterogeneous matrix of ZnS-luminophor powder of definite spectral composition and one-component transparent polyepoxy oligomer. The used oligomer has a high molecular weight (4000-6000 mole. un.), dielectric constant $\varepsilon \approx 4{,}6$ and small dielectric losses $tg\delta \approx 10^{-2}$,besides, it changes its dielectric properties and capacitance in wide limits from 400 Hz to 20 kHz.

The layer emission is realized by means of prebreakdown electroluminescence [7, 8.] On the active layer 3 a protective layer of wide-bandgap A_5B_6 system semiconductor is deposited, which besides protection, leads to an increase of structure brightness and stability [9, 10]. The reasons for this improvement are the electronic processes, going on at the interface “active layer-protective layer," at which an increase of primary electrons occurs, responsible for the setting-in of the electroluminescent emission [11-13]. Aluminum electrodes 5 are deposited on the structures. The hybrid electroluminescent

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structure emits definite color emission depending on the luminophor composition of the emitting layer matrix 3 at application of excitation voltage $U_{\sim}$.

Table 1

Consistency of the basic technological operation, used for preparation of electroluminescent display structures

1 glass substrate	**2** chemical treatment and refreshment of the substrate
3 deposition of a transparent conductive SnO_2 layer	**4** deposition of protective lacquer
5 etching of the nonprotected sections of the SnO_2 layers	**6** removal of the protective lacquer
7 deposition of the active electroluminescent layer	**8** deposition of the protective chalcogenide layer
9 deposition of aluminum electrodes	**10** fixing of the metallic leads with conductive paste
11 soldering of electrical conductors	**12** testing of the prepared electroluminescent display structure

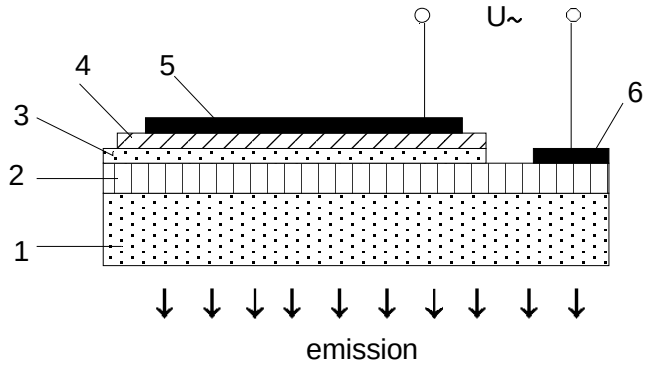


Fig. 1. General view of a hybrid display structure.

DEVELOPMENT AND PREPARATION OF DIGITAL ELECTROLUMINESCENT DISPLAYS

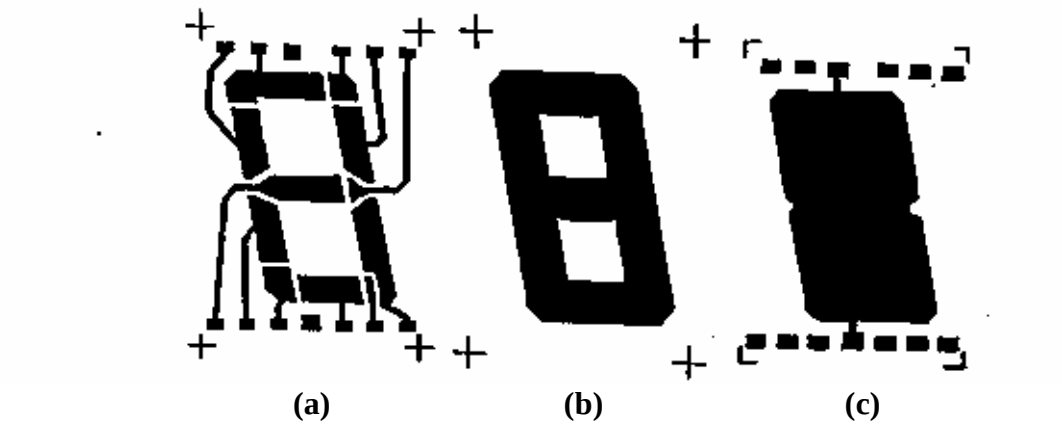
The preparation of the digital and dispatching display panels is connected with the preliminary development of the display structure construction as well as of the basic and additional appliances necessary for its designing on the glass substrate:

- design of the corresponding glass substrate size;
- design of the form, size and configuration of the emitting area of the display structure;
- design and development of appearance and configuration of the screen printing and metal mask originals, used for the display structure separate layer deposition;
- design and development of the metal holders for the display structure, used at the protective chalcogenide layer and the upper aluminum electrodes deposition and on the contact platforms;
- choice of a manner the metal leads on the contact platforms to be fixed.

The digital display structure is shaped on a glass substrate of sizes 150/100/2 mm. This structure contains eleven segments that allow the digital sign's presentation from 0 to 9 with a good design. The segments are inclined at an angle of degrees, so the digital sign takes an area of 110/60 mm^2 at a width of 12 mm for each electroluminescent segment.

In Fig. 2 a, b, c, photopatterns are shown for the preparation of screen printing masks (Fig. 2 a, b), by which the lower electrodes and the contact platforms (Fig 2 a) are sharped and the heterogeneous electroluminescent layer (Fig. 2 b) as well. The metal masks (Fig. 2 c) are presented too, by which the upper aluminum electrodes and the filled with aluminum contact platforms are deposited. Two contact platforms are used for deposition of the upper general electrode aiming the uniform electric field distribution over the display structure.

The dispatching display structure is shaped on a glass substrate of sizes 150/80/2 mm. This structure contains two segments that are inclined at an angle of degrees, so the dispatching electroluminescent panel takes an area of 135/35 mm^2 at a width of 12 mm for a separate segment.

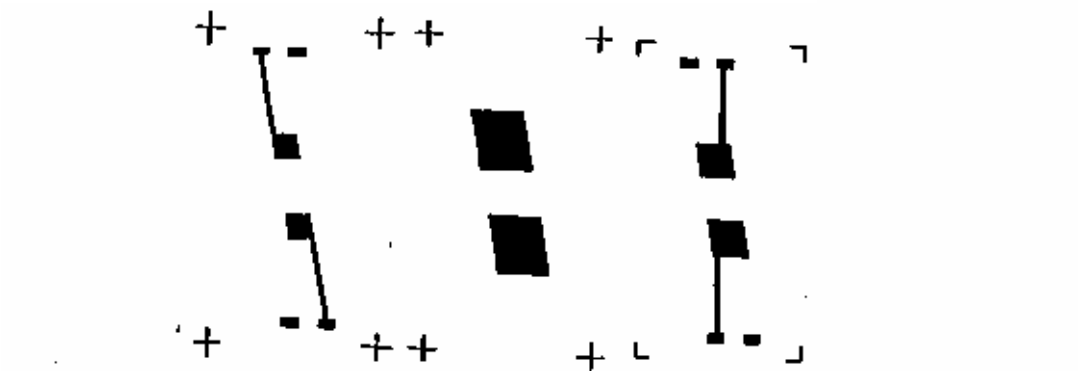


(a) **(b)** **(c)**

Fig. 2. A photopatterns of screen printing masks (a, b) and a metal mask (c), used for preparation of the digital display panel hybrid structures.

In Fig. 3 a, b, c are presented the photopatterns for preparation of the screen printing masks (Fig. 3 a, b) by which the lower electrodes, the contact platforms (Fig. 3 a) and the heterogeneous emitting layer (Fig. 3 b) are shaped, as well as the metal mask (Fig. 3 c), by which the upper aluminum electrodes and the filled with aluminum contact platforms are deposited, of the dispatching electroluminescent panel separating hours from minutes in the four-discharge digital display set-up.

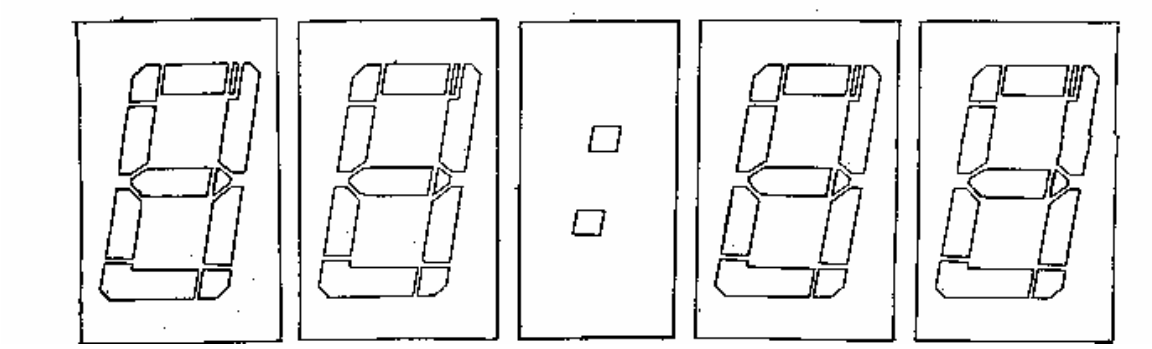
The digital display structure is used for preparation of a double-digital display set-up allowing the representation of digital signs from 00 to 99 using a feeding set-up with a regulated impulse generator and segment decoder 14.



(a) (b) (c)

Fig. 3. A photopatterns of screen printing masks (a, b) and a metal mask (c), used for preparation of the dispatching electroluminescent panel hybrid structure.

The digital display and the dispatching panels serve for design and preparation of the display set-up which by a feeding set-up with a timer realizes the representation of hours and minutes in a four-discharge hybrid electroluminescent display set-up for an electronic clock (Fig.4).



hx10 **hx1** **s:** **min x10** **minx1**

Fig. 4 A general view of a four -discharge digital hybrid electroluminescent display set-up, allowing the representation of hours and minutes with a blinking indication for the seconds.

POSSIBLE APPLICATION FIELDS FOR THE PRODUCTS OF THE PERFECTED HYBRID ELECTROLUMINESCENT TECHNOLOGY

The developed wide-format hybrid digital electroluminescent displays can be used in electronic clocks and digital boards in the Metropolitan, airfield complex, auto-and railway stations, dispatch points, commodity and currency exchanges, banks, hospitals, hotels and technological and production lines.

Besides, the hybrid technology products can find appropriate applications in other fields like:

- indicatory and explanarly signs in instrument -building ,transport automation and household;
- various indicators in modern car dashboards;
- lighting letters and digital signs for the vehicles of town transport-street-cars, trolley buses, buses;
- light sources of various color emission, applicable for anti-fire protection;
- lighting of the scales for elevators and hotels;

- special illuminating techniques-advertising boards, interior, attracting, night, dutiful and artistic lighting, light panels et al.;
- balance in metallurgical production;
- masking illumination and marking lines in cinema and theater halls:
- matrix elements of various purpose, as well as all the places where representation of light sign information is necessary;

The used electroluminescent hybrid displays are bright, stable in working regime (see Table 2), environment friendly, energy efficient, radiation-resistant and creating social comfort at their operation.

Table 2 Technical data of the electroluminescent display structures

•Brightness (depending on the emission)	5-70 cd/m^2
•Brightness non-uniformity no more than	20%
•Excitation voltage	100-140V
•Operating frequency	400-1200 Hz
•Capacitance	150-2pF/cm^2
•Power consumption	0,035 W/cm^2
•Life time (the time-span during which the brightness should not fall under 50% of the inital value	no less than 10000 h
•Ambient temperature range -	30 to +50^{0}C

CONCLUSION

The developed hybrid electroluminescent technology is a full and complete cycle of constructional and technological activities, connected with the design, development and preparation of the electroluminescent displays for various applications. This technology is a result of scientific investigations and application of results, use of inventions and know-how. The basic contribution in this technology is connected with the original solution to include a thin layer of a wide-bandgap semiconductor, deposited over the active emitting layer of the display structure[*/].

Because of its technical accessibility, economic advantageousness and recapitulation, the hybrid technology gives an opportunity for preparation and fabrication of various in sizes, configuration and color emission letter, digital and sign electroluminescent displays. [**/]

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[**]/ Letter and digital hybrid electroluminescent displays, prepared by the perfected hybrid technology were honored with two Silver (1996, 1997) and two Gold (1997, 1998) medals from an authorized International Jury of the International Exhibitions in Sofia, Bulgaria and in Manila, Philippines. The Gold medal from Manila is with a special Mention of the Jury.

ACKNOWLEDGMENTS

The presented examination of the perfected hybrid technology for digital and sign electroluminescent displays preparation is realized with the financial support of the National Foundation “Scientific Investigations” at the Ministry of Education and Science under Contract N Ph 649/99, while the finishing of the four-discharge digital display set-up is sponsored by “TRAFEL” Ltd-Sofia.

_[*]/ The author team suggests to companies and organizations interested in and using display techniques, contracts for realization of demonstration projects for design, development and preparation of hybrid electroluminescent products of various purposes.

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