SINGLE LAYER MULTI-COLOR LUMINESCENT DISPLAY AND METHOD OF MAKING

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Abstract

The invention is a multi-color luminescent display comprising an insulator substrate and a single layer of host material which may be a phosphor deposited thereon that hosts one or more different impurities therein forming a pattern of selected and distinctly colored phosphors such as blue, green and red phosphors in the single layer of host material. Transparent electrical conductor means may be provided for subjecting selected portions of the pattern of colored phosphors to an electric field thereby forming a multi-color, single layer electroluminescent display.

A method of forming a multi-color luminescent display includes the steps of depositing on an insulator substrate a single layer of host material which itself may be a phosphor with the properties to host varying quantities of different impurities; and introducing one or more of said different impurities into selected areas of said single layer of host material as by thermal diffusion or ion-implantation to form a pattern of phosphors of different colors in said single layer of host material.

23 Claims, 3 Drawing Sheets
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SINGLE LAYER MULTI-COLOR LUMINESCENT DISPLAY AND METHOD OF MAKING

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This is a continuation of application Ser. No. 07/337,768 filed Apr. 13, 1989, now abandoned, which is a divisional application of pending Ser. No. 07/140,185, filed Dec. 31, 1987, U.S. Pat. No. 4,903,193.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is a single layer multi-color luminescent display and method of making and more particularly to thin-film electroluminescent displays.

Typically, the three phosphors are applied to the substrate or substrates (in thickness of 2000 to 5000 Angstroms) by vacuum deposition. In conventional single layer TFEL devices alternating stripes of blue, green and red phosphors are grown on a glass substrate. In a two-layer TFEL device such as disclosed in U.S. Pat. No. 4,689,522, a single layer of blue phosphor is superimposed over a single layer of side-by-side alternating stripes of green and red phosphors.

The fabrication of a conventional multi-color TFEL device is generally as follows: After depositing a pattern of transparent electrodes on the surface of a glass substrate and covering it with a transparent layer of insulation, the following steps are performed: (1) a red phosphor is deposited as previously described over the insulated surface of the substrate; (2) the phosphor coated surface is masked with a striped pattern (commonly with photo-resist); (3) plasma etching of the red phosphor; (4) removal of the photo-resist; (5) deposition of a green phosphor; (6) the addition of an insulating layer; (7) the repetition of steps (2), (3), and (4), after the deposition of each additional colored phosphor; and (8) annealing of the phosphors. Variations in this process may be made by changing the order and repetition of the above steps or by ion-beam etching instead of plasma etching.

As is apparent, a disadvantage of the prior art is the necessity of the etching steps, the depths and locations of which must be precisely controlled. For instance, in the first etching step, the etching must continue through the full depth of the red phosphor layer but must be stopped before going into the insulating layer. In the second etching step, the etching must continue through the full depth of the green phosphor but stop before entering the red phosphor layer. The etching also leaves an uneven surface on the underlying phosphor layer that is believed to promote dielectric breakdown in the covering insulating layer applied after etching is completed.

OBJECTS AND SUMMARY OF THE INVENTION

An object of this invention is to provide a single-layer, multi-color luminescent display and method of making same.

Another object is to provide a multi-color luminescent display using a single-layer of a host material that may be a phosphor material with the properties to serve as a host to different impurities that form different colored phosphors in the single-layer of host material.

The above and numerous other objects are achieved by the invention which is a full colored, luminescent display that includes a single layer of a host material that itself may be a phosphor on an insulating substrate, the host layer, serving as host to different impurities that combine therewith in selected areas on said single host layer to form a pattern of phosphors of different colors. The impurities may be introduced into the host and single-layer of material, which also may be a phosphor, by thermal diffusion, ion implantation or the like. The number of phosphors of different colors that may be provided is determined by the number and quantity of different impurities to which the single-layer of host material can serve as a host.

BRIEF DESCRIPTION OF THE DRAWING

The above and numerous other objects and advantages of the invention will become apparent from the following detailed description when read in view of the appended drawing wherein:

FIG. 1 is a sectional view illustrating a preferred embodiment of a single layer, three-color electrolumi-
A pattern of exposed and unexposed surface areas on the host layer 13 of ZnS before the impurities TbF₃ and Mn are introduced into the newly exposed areas of the host layer 13 in sufficient quantity to form one or more stripes 16 or red phosphor ZnS: TbF₃:Mn. Again the metal mask is repositioned to form a third pattern of exposed areas on the surface of the host layer 13 of ZnS. Thereafter the impurity Mg is introduced into the newly exposed areas of the host layer 13 in sufficient quantity to form a single layer 13 of blue phosphor ZnS:Mg. Thus, a full-color luminescent display surface is achieved. The impurities may be introduced into the host layer 13 by thermal diffusion, ion-implantation or other suitable techniques.

After annealing the host layer 13 and the phosphor stripes 14, 16 and 17 therein, a pattern of individual, transparent row electrical conductors 19 embedded in a second transparent layer 18 of SiO₂ or other suitable dielectric material is applied over the host layer 13, the SiO₂ forming an insulator between the phosphor stripes 14, 16 and 17 and the row electrical conductors 19 which with the column electrical conductors 11 form a matrix for subjecting selected portions of the phosphor stripes 14, 16 and 17 to an electric field to provide an electroluminescent display.

As mentioned luminescent and electroluminescent displays can be made in accordance with the invention using any single layer 13 of host material into which impurities can be introduced to form phosphors of different colors in the single layer of host material. For example, the phosphors SrS:Ce₂S₄ (red) and SrS:CeF₃ (green) may be formed in a single host layer 13 of SrS to provide two distinct colors.

As shown in FIG. 3, luminescent and electroluminescent displays of two or more colors may be made in accordance with the invention using the green phosphor ZnS: TbF₃ as the single layer 13 of host material into which the impurity Mn is introduced as previously described to form stripes 16′ of the red phosphor ZnS: TbF₃:Mn. The number of phosphors of different colors that can be formed again is determined by the number of different impurities the single layer 13′ of phosphor is able to host as previously explained.

As shown in FIG. 3 an electroluminescent display may be fabricated as shown in FIGS. 1 and 2, like elements having the same reference numeral except for the prime (′) symbol—thus, 13 and 13′ identifying the different single layers of host material in the two embodiments. As is shown, the method of this invention eliminates the need for the difficult and costly steps of etching, thereby increasing the yield while reducing the cost of making full or multi-color thin film luminescent and electroluminescent displays.
single phosphor layer substrate for use in cathode ray tubes and other similar applications requiring a multi-color phosphor display surface.

While preferred embodiments of a multi-color, single phosphor layer electroluminescent display and methods of making same have been described in detail, numerous changes and modifications can be made within the principles of the inventions which are to be limited only by the appended claims.

What is claimed is:

1. A method of forming a multi-color luminescent surface on a substrate comprising the steps of:
   - depositing a single layer of host material formed of ZnS having a smooth top surface on said substrate;
   - and introducing sufficient quantities of Mg, TbF₃ and Mn within selected areas of said single layer of ZnS host material via an appropriately positioned mask to form a pattern of different colored phosphors namely ZnS:Mg (blue); ZnS:TbF₃ (green); and ZnS:Mn:TbF₃ (red), respectively, within said single layer of ZnS host material such that the top surface of said single layer of host material remains smooth.

2. The method as defined in claim 1 wherein the quantities of Mg, TbF₃ and Mn are introduced into said single layer of ZnS host material by means of thermal diffusion.

3. The method as defined in claim 1 wherein the quantities of Mg, TbF₃ and Mn are introduced into said single layer of ZnS host material by means of ion-implantation.

4. The method as defined in claim 1 including a third step of depositing an insulating layer over said smooth top surface of said single layer of ZnS host material.

5. A method of forming an electroluminescent display comprising the steps of:
   - forming a pattern of electrical conductor means on an insulator substrate;
   - depositing a single layer of host material formed of ZnS and having a smooth top surface on said substrate;
   - introducing sufficient quantities of Mg, TbF₃ and Mn within selected areas of said single layer of ZnS host material via an appropriately positioned mask to form a pattern of different colored phosphors namely ZnS:Mg (blue); ZnS:TbF₃ (green); and ZnS:Mn:TbF₃ (red), respectively, within said single layer of host material such that the top surface of said single layer of host material remains smooth;
   - depositing an insulating layer over said smooth top surface of said single layer of ZnS host material;
   - and energizing said electrical conductor means to subject selected areas of said insulator substrate to an electric field thereby forming an electroluminescent display.

6. The method as defined in claim 5 wherein the quantities of Mg, TbF₃ and Mn are introduced into said single layer of ZnS host material by means of thermal diffusion.

7. The method as defined in claim 5 wherein the quantities of Mg, TbF₃ and Mn are introduced into said single layer of ZnS host material by means of ion-implantation.

8. A method of forming a multi-color luminescent surface on a substrate comprising the steps of:
   - depositing a single layer of host material of SrS having a smooth top surface on said substrate; and
   - introducing sufficient quantities of Ce₂S₃ and CeF₃ within selected areas of said single layer of SrS host material via an appropriately positioned mask to form a pattern of different colored phosphors namely SrS:Ce₂S₃ (red) and SrS:CeF₃ (green), within said single layer of host material such that the top surface of said single layer of host material remains smooth.

9. The method as defined in claim 8 wherein the quantities of Ce₂S₃ and CeF₃ are introduced into said single layer of SrS host material by means of thermal diffusion.

10. The method as defined in claim 8 wherein the quantities of Ce₂S₃ and CeF₃ are introduced into said single layer of SrS host material by means of ion-implantation.

11. The method as defined in claim 8 including a third step of depositing an insulating layer over said smooth top surface of said single layer of SrS host material.

12. A method of forming an electroluminescent display comprising the steps of:
   - forming a pattern of electrical conductor means of an insulator substrate;
   - depositing a single layer of host material formed of SrS having a smooth top surface on said substrate;
   - introducing sufficient quantities of Ce₂S₃ and CeF₃ within selected areas of said single layer of SrS host material via an appropriately positioned mask to form a pattern of different colored phosphors namely SrS:Ce₂S₃ (red) and SrS:CeF₃ (green), within said single layer of host material such that the top surface of said single layer of host material remains smooth;
   - depositing an insulating layer over said smooth top surface of said single layer of SrS host material; and
   - energizing said electrical conductor means to subject selected areas of said insulator substrate to an electric field thereby forming an electroluminescent display.

13. The method as defined in claim 12 wherein the quantities of Ce₂S₃ and CeF₃ are introduced into said single layer of SrS host material by means of thermal diffusion.

14. The method as defined in claim 12 wherein the quantities of Ce₂S₃ and CeF₃ are introduced into said single layer of SrS host material by means of ion-implantation.

15. A method of forming a multi-color luminescent surface on a substrate comprising the steps of:
   - depositing a single layer of host material forming one color such that the top surface of said impurities within selected areas of said single layer of host material remains smooth;
   - and introducing sufficient quantities of one or more of said impurities within selected areas of said single layer of host material having the properties to host one or more different impurities therein; and
   - depositing a single layer of host material forming one color having a smooth top surface on said substrate; and
   - said single layer of host material having the single layer of host material of said phosphor ZnS:TbF₃ (green) and said one impurity host therein is Mn to form another, different colored phosphor therein, namely ZnS:TbF₃:Mn (red).
17. The method as defined in claim 15 wherein said different impurities are introduced into said single layer of host material by means of thermal diffusion.

18. The method as defined in claim 15 wherein said different impurities are introduced into said single layer of host material by means of ion-implantation.

19. The method as defined in claim 15 including a third step of depositing an insulating layer over said smooth top surface of said single layer of host material.

20. A method of forming an electroluminescent display comprising the steps of:
   - forming a pattern of electrical conductor means on an insulator substrate;
   - depositing a single layer of host material forming one color having a smooth top surface on said substrate, said single layer of host material having the properties to host one or more different impurities therein;
   - introducing sufficient quantities of one or more of said impurities within selected areas of said single layer of host material via an appropriately positioned mask to form a pattern of phosphors of different colors within said single layer of host material of one color such that the top surface of said single layer of host material remains smooth;
   - depositing an insulating layer over said smooth top surface of said single layer of host material; and
   - energizing said electrical conductor means to subject selected areas of said insulator substrate to an electric field thereby forming an electroluminescent display.

21. The method as defined in claim 20, wherein said single layer of host material is formed of the phosphor ZnS:TbF₃ (green) and said one impurity hosted therein is Mn to form another, different colored phosphor therein, namely ZnS:TbF₃:Mn (red).

22. The method as defined in claim 20 wherein said different impurities are introduced into said single layer of host material by means of thermal diffusion.

23. The method as defined in claim 20 wherein said different impurities are introduced into said single layer of host material by means of ion-implantation.

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