(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 109 589**
A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 83110973.1

(51) Int. Cl.^{3}: H 05 B 33/22

(22) Date of filing: 03.11.83

(30) Priority: 15.11.82 US 441819

(43) Date of publication of application: 30.05.84 Bulletin 84/22

(84) Designated Contracting States: BE CH DE FR GB LI NL

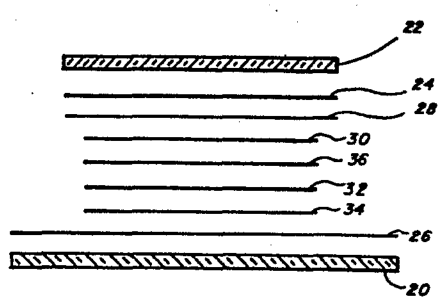
(71) Applicant: GTE Products Corporation
100 West 10th Street
Wilmington, DE 19801(US)

(72) Inventor: Plumb, John L.
27 Clark Street
Danvers, Mass. 01923(US)

(74) Representative: Reinländer & Bernhardt Patentanwälte
Orthstrasse 12
D-8000 München 60(DE)

(54) **Electroluminescent thin film display device.**

(57) An electroluminescent thin film display device for a lamp that has a pair of dielectric layers on either side of the device or lamp phosphor layer for providing improved electrical and chemical protection of the phosphor thin film layer. Both dielectric layers are of silicon nitride preferably deposited by sputtering either from a silicon target or silicon nitride target. The use of silicon nitride has been found to permit more electric charge to flow, each AC half cycle so as to achieve higher operating lamp brightness.



EP 0 109 589 A1

Croydon Printing Company Ltd.

ELECTROLUMINESCENT THIN FILM DISPLAY DEVICE

BACKGROUND OF THE INVENTION

The present invention relates in general to electroluminescent thin film display devices and the associated process of fabrication. More particularly, the present invention pertains to an electroluminescent thin film display device that has dielectric layers that provide for improved electrical and chemical protection of the phosphor thin film of the device.

The Government has rights in this invention pursuant to Contract No. DAAK20-81-C-0433 awarded by the Department of the Army.

In the fabrication of an electroluminescent thin film display device, there are a number of thin film layers that are deposited upon a base glass substrate. These layers include a transparent conductor, a rear electrode, phosphor layer, and dielectric layers. In the existing process, the deposition of the phosphor thin film is preceded by deposition of an yttria film, and is followed by subsequent deposition of a second yttria film. In other words, the phosphor film is sandwiched between two yttria dielectric films. FIG. 1, described in further detail hereinafter, shows the normal sequence of layers disposed between the glass substrate and a protective glass.

The purpose of the yttria dielectric films is to provide electrical protection for the phosphor film. The dielectric films make it possible to apply an AC voltage across the phosphor film of sufficient magnitude for electroluminescence. Electric breakdown at defects or thin areas of the phosphor is prevented because the dielectric films limit the electric charge that may flow each half cycle of the applied AC voltage. However, the limiting of electric charge is effective only when the yttria films are optimally of uniform thickness. The electric field in the yttria films is not uniform if the thickness of the films is not uniform. The limit on the electric charge that may flow is determined by the electric field that is impressed at thin points in the yttria film. The yttria film tends to be thin over edges of the electrode pattern on the substrate and also tends to be thin over any protruberances that may be present in the phosphor film. Because of non-uniformities of the yttria film thickness the electric field is likewise non-uniform resulting in a relatively low electric breakdown level which in turn limits operating lamp brightness.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an electroluminescent thin film display device that has thin film dielectric layers that provide for improved electrical and chemical protection of the phosphor thin film of the device.

Another object of the present invention is to provide an improved dielectric film used for protection of the phosphor layer in an electroluminescent display device and instrumental in achieving higher operating lamp brightness.

A further object of the present invention is to provide an improved thin film dielectic layer deposited on either side of the phosphor layer and which is characterized by providing improved chemical protection of the phosphor layer including protection against humidity conditions and protection against diffusion of halogen ions from the substrate.

Still another object of the present invention is to provide an electroluminescent thin film display device in which the dielectric layers that sandwich the phosphor thin film layer of the device are capable of being deposited to a more uniform thickness.

Still a further object of the present invention is to provide an electroluminescent thin film display device having protective dielectric layers for the phosphor thin film selected to enable greater charge flow levels before breakdown in comparison with existing dielectric layers.

To accomplish the foregoing and other objects of the present invention, there is provided a silicon nitride dielectric film which has been found to provide more electrical and chemical protection to the phosphor film than the previously used yttria dielectric films. Furthermore, this improved performance has been accomplished without sacrificing electroluminescent performance. In fact, the silicon nitride dielectric films permit more electric charge to flow each half cycle of the AC cycle so as to achieve higher operating lamp brightness in comparison with prior display devices employing the previously used yttria films. Silicon nitride is also more impervious to water or OH-ions, and thus provides protection to the phosphor layer from the adverse effects present in a humid atmosphere. The silicon nitride is more impervious to halogen ions, and is thus a barrier against diffusion of such halogen ions from the base substrate. It has also been found that the silicon nitride is deposited in a more uniform layer providing a more uniform thickness thereof which is particularly important in areas where the silicon nitride layer is over underlying surface irregularities.

BRIEF DESCRIPTION OF THE DRAWINGS

Numerous other objects, features and advantages of the invention should now become apparent upon a reading of the following detailed description taken in conjunction with the accompanying drawing showing one construction of thin film layers of a thin film electroluminescent display device constructed in accordance with the principles of this invention.

DESCRIPTION OF PREFERRED EMBODIMENT

As indicated hereinbefore, in accordance with the present invention, there is provided a silicon nitride dielectric film which is deposited on either side of the phosphor layer for providing both electrical and chemical protection thereof. The silicon nitride films have been found to provide more electrical and chemical protection than was previously provided with the use of yttria dielectric films. Moreover, the electrical and chemical protection is provided without sacrificing electroluminescent performance and in fact performance is enhanced with the use of the silicon nitride films.

Silicon nitride has a lower permittivity than yttria and as such one would expect that voltage breakdown would occur at a lower electric charge level than with the higher permittivity yttria. However, it has been found that the silicon nitride has a greater dielectric strength than the yttria and can sustain a higher electric field, and therefore greater electric charge, without breakdown, in comparison with the yttria films. It is theorized that the higher dielectric strength of the silicon nitride may be related to the band gap of the material. The "band gap" relates to the energy that is required to dislodge electrons from each ion. It is also theorized that the improved electrical protection and chemical protection is due at least in part to the fact that silicon nitride characteristically is deposited in a more uniform thickness which is particularly significant for depositions over underlying surface irregularities.

FIG. 1 shows a sequence of thin film layers that may be used in constructing a device in accordance with the present invention. In FIG. 1 there is provided a glass substrate 20. FIG. 1, for illustrative purposes, shows each of the layers essentially exploded off of the glass substrate 20. However, it is understood that each of these thin film layers are deposited, one on top of the other. The layers are then protected by a rear glass 22 and associated hermetic seal 24. Hereinafter, a more detailed description of the manner in which the layers are deposited is given.

The thin film layers schematically illustrated in FIG. 1 include a transparent conductor 26, a rear electrode 28, a dark field layer 30, and a phosphor layer 32. In the deposition process, the deposition of the phosphor thin film 32 is preceded by a deposition of a silicon nitride film layer 34, and is followed by the deposition of a second silicon nitride dielectric layer 36. Thus, the phosphor layer is essentially sandwiched between two silicon nitride thin film layers 34, 36.

The following is one example of a lamp fabricated with dielectric layers of silicon nitride. The lamp is fabricated by depositing successive films onto a tin oxide-coated soda lime float glass substrate. This deposition is carried out by sputtering. In addition to the use of tin oxide as a transparent conductor, one may also use indium tin oxide. The substrate is initially baked in an oven under vacuum and at a temperature higher than it is to be subjected to at any other time in the deposition process. Upon the tin oxide transparent conductor is deposited silicon nitride. This deposition is by sputtering a silicon target in a magnetron plasma in nitrogen at three micrometers pressure and 100 sccm flow at relatively low substrate temperature. The deposition temperature is carried out over a deposition period to provide a thickness of, for example, 150 nm (nanometers). The next step in the process is to reheat the substrate. Thereafter, zinc sulphide and manganese, for example, may be deposited by known sputtering techniques to provide a phosphor layer of a thickness of say 500 nm. After the phosphor layer is deposited then the second silicon nitride film is deposited in the same manner as the first, but without substrate heat. Also, the second layer is cooled in the presence of nitrogen. Finally, in the deposition process, as indicated by the sequence of FIG. 1, an aluminum electrode is deposited by vacuum evaporation to a thickness of say about 400 nm.

The deposition of the silicon nitride may be with the use of either a silicon target or a silicon nitride target. The sputtering gas may include argon if a higher deposition rate is desired. The deposition pressure used in the sputtering technique may be in the range of 1-20 micrometers, and the flow may be less than 100 standard cubic centimeters per minute (sccm) if residual gas flow is low.

The degree of electrical and chemical protection that is provided by the silicon nitride depends at least to some extent upon the thickness of the deposited films. Increased thickness, in general, provides increased protection, provided that the silicon nitride maintains structural integrity. Hereinbefore it was mentioned that the silicon nitride film thickness is on the order of 150 nm. Actually, it has been found that the thickness is preferably in the range of 100 nm-300 nm. Thicknesses below this range do not provide sufficient protection and thicknesses above this range tend to be characterized by degraded structural integrity of the silicon nitride.

In the example of the lamp just given, when the lamp is operated, it is possible to raise the charge flow level to a value on the order of 4.3 microcoulombs per square centimeter before electric breakdown occurs. This value compares with one of on the order of 3.4 microcoulombs per square centimeter for electric breakdown in connection with an yttria-protected lamp. In the measurements taken, both lamps are subjected to 24 hours of operation at brightness levels of about 100 ft-Lamberts.

Having described one embodiment of the present invention, it should now be apparent to those skilled in the art that numerous other embodiments are contemplated as falling within the scope of this invention.

CLAIMS

1. In an electroluminescent thin film display device having multiple thin film layers including a phosphor layer, the improvement comprising first and second dielectric protective layers deposited on either respective side of the phosphor layer for protection thereof, both said first and second dielectric layers being of silicon nitride to provide enhanced electrical and chemical protection of the phosphor layer and capable of deposition to a uniform layer thickness.

2. In an electroluminescent thin film display device as set forth in Claim 1 wherein said dielectric layers are deposited by sputtering from a silicon nitride target.

3. In an electroluminescent thin film display device as set forth in Claim 1 wherein said dielectric layers are deposited by sputtering from a silicon target.

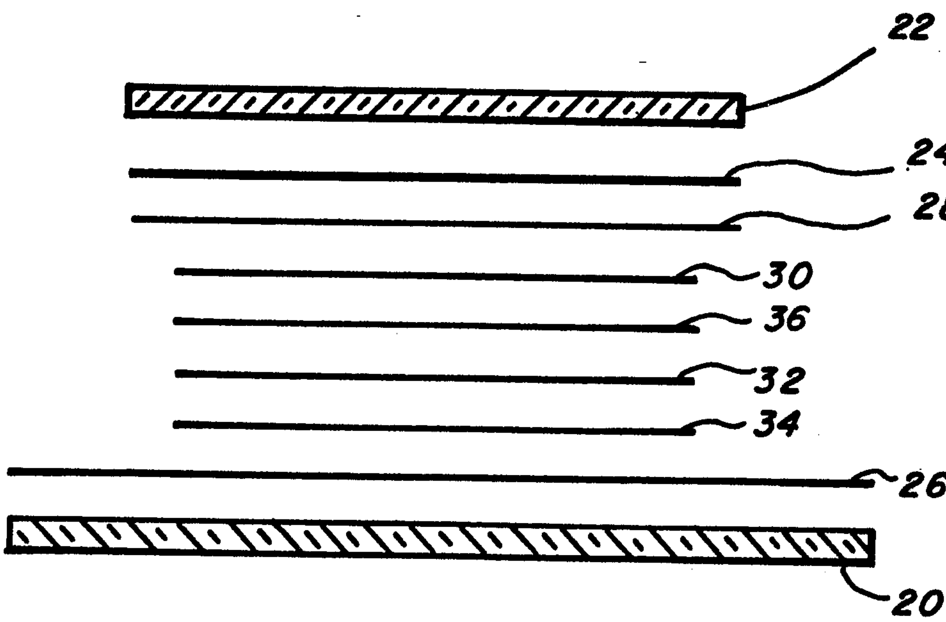
4. In an electroluminescent thin film display device as set forth in Claim 3 wherein the sputtering is carried out in a magnetron plasma in nitrogen at about 3 micrometers and 100 sccm flow at a relatively low substrate temperature.

5. In an electroluminescent thin film display device as set forth in Claim 1 wherein the silicon nitride is deposited to a thickness on the order of 150 nanometers.

6. In an electroluminescent thin film display device as set forth in Claim 1 wherein the silicon nitride is deposited to a thickness in the range of 100-300 nanometers.

7. In an electroluminescent thin film display device as set forth in Claim 1 wherein the sputtering is carried out at a pressure range of 1-20 micrometers.

8. In an electroluminescent thin film display device as set forth in Claim 1 wherein breakdown charge level is on the order of 4.3 microcoulombs per square centimeter.


22
24
28
30
36
32
34
26
20

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 83110973.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
A	GB - A - 1 602 895 (SHARP) * Totality * --	1-7	H 05 B 33/22
A	GB - A - 2 039 146 (GTE) * Abstract; fig. 1; claims 1-8 * --	1	
A	DE - B2 - 2 260 205 (INSTITUT POLUPROVODNIKOV AKADEMII NAUK UKRAINSKOJ SSR) * Totality * ----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

H 05 B 33/00
G 02 F 1/00
H 01 L 21/00
G 09 F 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	14-02-1984	VAKIL

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document