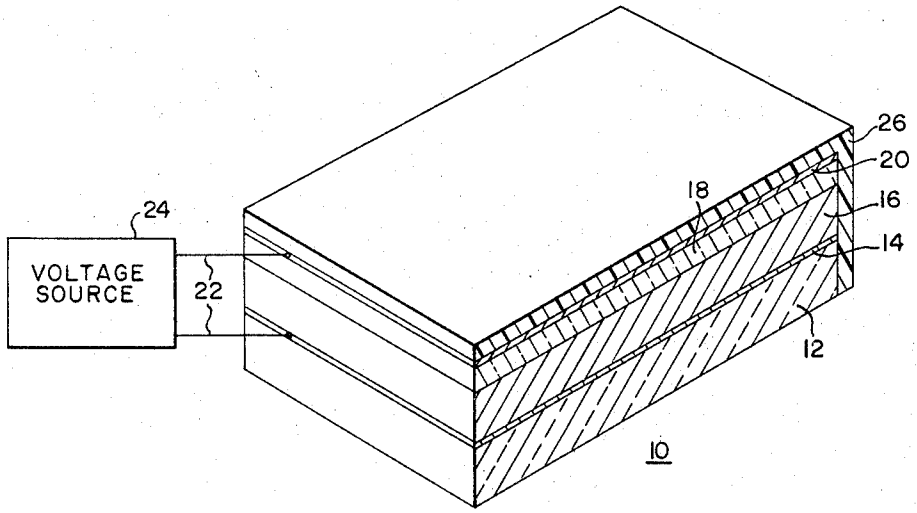
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ELECTROLUMINESCENT DEVICE WHICH INCORPORATES BARIUM OXIDE FILMS AS BREAKDOWN PROTECTION

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WITNESSES

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ELECTROLUMINESCENT DEVICE WHICH INCORPORATES BARIUM OXIDE FILMS AS BREAKDOWN PROTECTION

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This invention relates generally to electroluminescent devices and, more particularly, to such devices which incorporate barium oxide dielectric films as a breakdown protection layer.

As is known, the higher the dielectric constant of the breakdown layer of a two-layer electroluminescent device, the higher will be the luminescence efficiency of the phosphor layer, and hence of the device as a whole. Less of the applied voltage is lost across a high dielectric protective film than across a low dielectric film of comparable thickness. A higher portion of the applied voltage is available to energize the phosphor. Also, the thinner the dielectric film, the less applied voltage is lost thereacross. A minimum thickness, however, is required to prevent electrical breakdown or puncture.

It is also known that electroluminescent devices are susceptible to damage by contact with moisture, and to prevent such damage it is known to operate electroluminescent devices in conjunction with a desiccant. As an example, if an electroluminescent device which incorporates an aluminum oxide breakdown protection layer were to be protected against damage through contact with moisture, it would be necessary to encapsulate the device for such protection. Even then, the degree of protection from moisture is not always as good as desired.

It is an object of this invention to provide a simple electroluminescent device having an improved maintenance and efficiency of light emission.

It is an additional object of this invention to provide an electroluminescent device in which a single additional dielectric layer therein provides both "desiccant action" to protect the device against the deleterious effects of moisture as well as improving the light emission obtainable from the device.

Briefly, these and other objects, which will become apparent as the description proceeds, are achieved by providing a barium oxide dielectric film and an electroluminescent phosphor layer disposed between spaced electrodes. One of the electrodes is carried on a substrate means. The electrodes are adapted to have an operating voltage applied thereacross which causes the phosphor layer to electroluminesce. The barium oxide has a very high dielectric constant and may be formed in very thin films. These two properties significantly affect the brightness of the device. Further, the barium oxide film is a desiccant and prevents moisture from contacting the phosphor. Thus, the deleterious effects of moisture on the phosphor are avoided and both the operation and maintenance of light emission of the device are improved. In addition to having a high dielectric constant, the barium oxide film also has a high electrical breakdown strength or puncture strength so that an increased electrical potential can be applied across the device electrodes without incurring an electrical breakdown.

For a better understanding of this invention, reference should be made to the sole figure of the accompanying drawing which is a perspective view, partly in section, of the present electroluminescent device.

Referring to the figure, the electroluminescent device **10** has a substrate **12** which carries a first or base electrode **14**. The substrate **12** may be any substance which can withstand the firing temperatures discussed below, such as

glass or ceramics, for example. The base electrode **14** is made of an electrically conductive material, tin oxide, for example. If desired, the substrate **12** and the electrode **14** may be light transmitting. A substantially continuous phosphor film or layer **16** is disposed over the base electrode **14**. The phosphor layer **16** may be any electroluminescent substance such as copper-activated zinc sulphide, and is preferably formed by vacuum deposition, although other methods may be used. If zinc sulphide is used for phosphor layer **16**, typical thicknesses range from about 0.5 micron to about 5 microns, 2 microns being preferred. The phosphor layer **16** may be prepared by first vacuum depositing a zinc sulphide layer on the electrode-carrying substrate **12**. The zinc sulphide layer is then activated by heating while it is exposed to suitable activators, which for zinc sulphide are copper, copper plus manganese, and a suitable coactivator such as chlorine. Other known activators can also be used. The firing temperature may vary from 600° C. to 1200° C., 750° C. being preferred. The firing duration may vary from five minutes to two hours, thirty minutes being preferred. The above described activation technique is well known and is described in more detail in U.S. Patent No. 3,044,902, dated July 17, 1962.

Referring again to the sole figure, a thin continuous barium oxide dielectric film **18** is formed over the phosphor layer **16**, preferably by a conventional vacuum deposition which is discussed briefly here. The barium oxide material which is to be evaporated is placed in a boat-type container which is made of an inert, refractory material such as tungsten, molybdenum, or tantalum. This boat and the substrate **12** (carrying the electrode **14** and phosphor layer **16**) are placed in a vacuum chamber. The chamber then is pumped down to a hard vacuum of about 10^{-4} torr or less. The boat and the barium oxide are heated to a temperature sufficient to evaporate the barium oxide, from about 1200° C. to about 1600° C., for example. The thickness of the evaporated barium oxide film **18** may vary over a wide range and still be suitable for purposes of the invention. As an example, a film **18** thickness of from about 10 nm. to about 5 microns is operable operable in this invention, 0.4 micron being preferred. The thinner barium oxide films may be used advantageously in conjunction with thin phosphor films. As mentioned hereinbefore, the voltage lost across the dielectric film is in part determined by the relative thicknesses of the dielectric film and the phosphor film. A second or cover electrode **20** is then formed over the dielectric film **18**. The cover electrode may be of any conductive material; however, an opaque layer of aluminum is preferred because of the reflective properties of aluminum. The electrode **20** is preferably also formed by vacuum deposition. Vacuum deposition has the advantage of placing the layer being formed in closely contiguous, tightly adhered relationship with the adjacent surface. This minimizes the energizing voltage lost across the interfaces of the layers, and enhances the desiccant action of the barium oxide film **18**. The electrodes **14** and **20** are provided with leads **22** which are connected to voltage source **24** for applying an operating voltage between the electrodes which energize the phosphor film **16**.

As a specific example, the phosphor layer **16** is formed of copper- and manganese-activated zinc sulphide, having a yellow emission, and a thickness of 1.8 microns. Over this phosphor layer **16** is coated a barium oxide film **18** having a thickness of 0.4 micron and a dielectric constant of 30–40, the resulting device operated with a breakdown brightness of 24 foot-lamberts with an applied potential of 76 volts. A device which was otherwise identical, but which did not incorporate the barium oxide film, displayed a breakdown brightness of 2 foot-lambers, with

an applied potential of 18 volts. Because of the desiccating action of the barium oxide film during operation, the maintenance of initial light emission of the present device is improved.

For prolonged operation, the device **10** will normally be encapsulated by coating a protecting layer or cover **26**, such as a layer of epoxy resin, over the sides of the substrate **12** and over the cover electrode **20**. With such a construction the barium oxide film **18** provides a supplemental barrier against ingress of moisture.

It will be apparent to those skilled in the art that the objects of this invention have been achieved by providing a high dielectric constant barium oxide film in an electroluminescent device. The desiccating action of the barium oxide prevents moisture that might enter the electroluminescent device from contacting the phosphor, thereby protecting the phosphor from the deleterious effects of the moisture. Because the barium oxide may be deposited in very thin films, it may be used with very thin phosphor films, where thicker dielectric films would be impractical because of the high voltage lost thereacross.

While a preferred embodiment of the invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

What is claimed is:

1. An electroluminescent device which is energizable to a high brightness with a low applied potential, said device comprising:

a substrate means;

a first electrode carried on said substrate means;

a substantially continuous phosphor layer disposed over said first electrode;

a thin continuous barium oxide dielectric film tightly tightly adhered to said phosphor layer, said barium oxide film having a high electrical breakdown strength and a high dielectric constant, and said barium oxide film constituting a desiccant for moisture; and

a second electrode over said barium oxide layer, said first and second electrodes adapted to have a potential applied thereacross for energizing said device; whereby said barium oxide film serves the plural functions of protecting said device from electrical breakdown across said electrodes, permitting a more intense electric field to be applied across said phosphor layer to increase the brightness of said device, and also protecting said phosphor layer from the deleterious effects of moisture through the desiccant properties of barium oxide.

2. The device as specified in claim **1**, wherein said substrate means is light transmitting, said first electrode is a thin light-transmitting tin oxide film, and said second electrode is a thin opaque layer of aluminum.

3. The device as specified in claim **1**, wherein the thickness of said barium oxide film is from about 10 nm. to about 5 microns.

4. The device as specified in claim **1**, wherein the thickness of said barium oxide film is about 0.4 micron.

5. The device as specified in claim **1**, wherein said phosphor layer comprises zinc sulphide and has a thickness of from about 0.5 micron to about 5 microns.

6. The device as specified in claim **1**, wherein said phosphor layer comprises zinc sulphide and has a thickness of about 2 microns.

7. The device as specified in claim **1**, wherein said device is provided with an encapsulating means over said second electrode and the sides of said device.

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