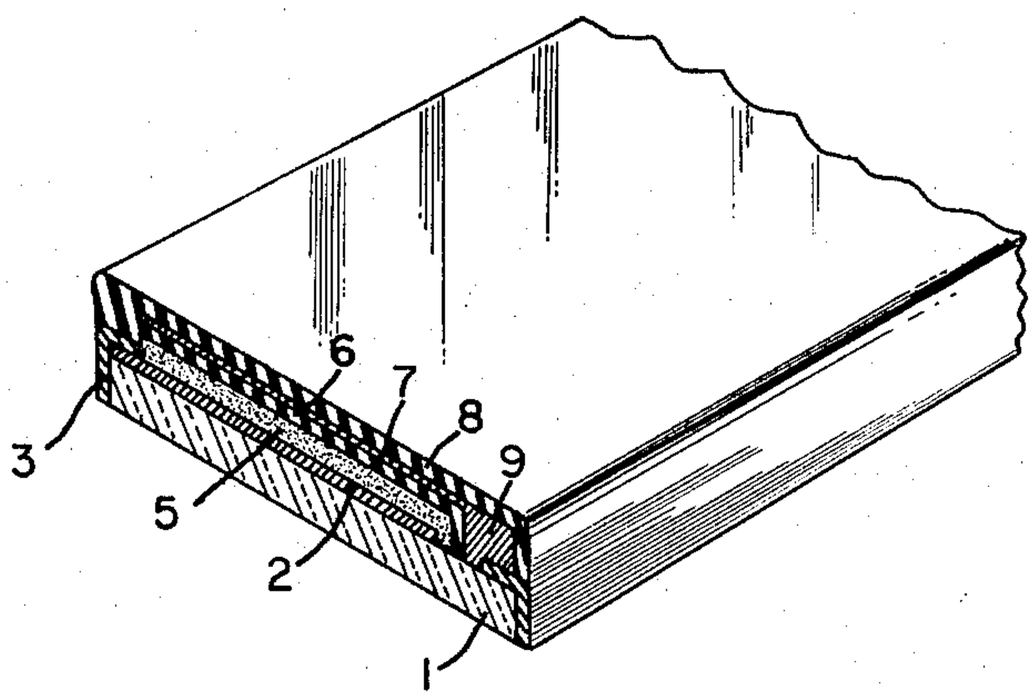
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ELECTROLUMINESCENT LAMP WITH HOMOGENEOUS PHOSPHOR-DIELECTRIC LAYER

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ELECTROLUMINESCENT LAMP WITH HOMOGENEOUS PHOSPHOR-DIELECTRIC LAYER

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Application Oct. 24, 1958, Ser. No. 769,511, now Patent No. 3,043,978, dated July 10, 1962, which is a continuation of application Ser. No. 230,738, June 9, 1951. Divided and this application Jan. 2, 1962, Ser. No. 163,758

2 Claims. (Cl. 313—108)

The invention relates to electroluminescent lamps and to the manufacture thereof.

This application is a division of my United States patent application 769,511, filed October 24, 1958, and issued as U.S. Patent 3,043,978, which is a continuation of Serial No. 230,738, filed June 9, 1951, and now abandoned.

Such lamps have a light-transmitting piece of material with a light-transmitting, electrically-conducting surface, a mixture of phosphor and dielectric substance coated thereover, and a conductive backing layer over the phosphor. Light is emitted from the device when a voltage is applied between the conductive backing layer and the conducting surface of the material.

I have found that the deterioration in light output of such lamps during life can be greatly reduced by the use of a thin dielectric coating over the phosphor-dielectric layer, that is between the latter layer and the conductive backing coating. The dielectric coating can be of lacquer, wax, plastic or other material of high resistivity, dielectric constant, and dielectric strength, and inactive chemically with the backing layer and the phosphor-dielectric layer. Such a coating would be expected to cause a diminution in light output from the lamp, because of the voltage drop in the coating, but I find that instead the light output is about the same as that without the coating, at least after a short aging period.

The maintenance of light output during life can be still further increased by the use of an alloy of aluminum and copper as the material of the conuctive backing layer.

One specific embodiment of the invention is shown partly in section and partly cut away in the accompanying figure.

The glass plate **1** in that embodiment carries on its surface the light-transmitting electrically-conductive layer or coating **2**, in contact with the metal strip **3** which preferably extends over the corresponding edge of the glass plate **1**, in the L-shape shown. A similar L-shaped metal strip **4** is affixed to the opposite edge of the glass plate **1** as shown, it being affixed to a portion thereof to which the conductive coating **2** does not extend. There is a non-conducting space between the edge of layer **2** and metal strip **4**. At least part of this non-conducting space is covered by the phosphor-dielectric layer **5**, which extends as a coating over the conductive layer **2**, or by the dielectric coating **6** on the phosphor layer **5**. The conductive backing layer **7** is applied over the dielectric layer **6**, at least in part, and extends into contact with the metal strip **4**, although it must not also extend into contact with the metal strip **3** which is connected electrically to the transparent conductive layer **2**, as that would simply short circuit the device.

The conducting surface or layer **2** should be durable, inactive chemically with respect to the other materials used in the lamp, and of good light-transmission. Such a durable, chemically-inactive conducting surface **2** of good light-transmission, either transparency or translucency, is difficult to obtain, because good electric conductors are generally good reflectors of light, rather than transmitters of it. However, although other coatings may be used, I find that a particularly effective conductive surface can be provided by heating the glass and exposing it while hot to vapors of the chlorides of silicon, tin, or titanium, and afterward placing the treated glass in a slightly reducing atmosphere. Where the application in the vapor state is not convenient, good results may be obtained by mixing stannic chloride with absolute alcohol and glacial acetic acid and dipping the heated glass plate into the boiling mixture.

The resultant conductive surface appears to be a layer **2** of stannic (or silicic or titanic) oxide, probably to some extent at least reduced to a form lower than the dioxide, although the exact composition is difficult to determine.

The resistance of the conductive surface **2** should be low enough to avoid excessive power loss therein at the current used. A surface having a resistance of several hundred ohms per square, that is a resistance of several hundred ohms taken between the entire opposite edges of a square of the material, has been found satisfactory, although the permissible resistance can be varied widely.

One side of the glass plate **1** can be completely coated with the conducting layer **2**, if desired, and then the portion of layer **2** in the vicinity of the position desired for the application of the metal strip **4**, which must be out of electrical contact with said conducting layer **2**, can be removed by applying to that portion a mixture of zinc dust and dilute acid, which can be applied with a spatula. The acid used can be one which is capable of emitting nascent hydrogen by reaction with the zinc dust. A solution of three parts water and one part sulfuric acid by volume, mixed with sufficient zinc dust to form a thick slurry has been found very effective.

Other methods can be used for removing a part of the conductive layer or the original application of the layer can be confined to the desired portions by shielding or other means, if desired.

The metal strips **3** and **4** are coatings painted onto the glass piece **1** (over the conducting layer **2** in the case of strip **3**) by using one of the conducting silver paints of the firing type know in the art and commonly on the market. After application, the paint is fired to the glass at about 1000° F.

Silver paints of the air-dried type can be used, but do not afford the permanent metal-to-glass bond that can be obtained with the fired paints. Spraying and other forms of metal deposition can be used instead of painting, if desired. A copper coating can be plated over the fired silver, for example from one of the usual acid plating baths, to provide a still more desirable surface and one to which electrical connecting wires can easily be soldered.

If desired both contact strips **3** and **4** may be placed along different portions of a single edge of the glass plate **1**, the conductive layer **2** being in contact with the first of said strips and out of contact with the other, and conversely, the backing layer **6** being out of contact with the first of said contacts but in contact with the second. The contact strips **3** and **4** need not extend all the way over the edge to the opposite face **8** unless desired.

The phosphor, in the form of fine particles, is suspended in a suitable dielectric medium to form the layer **5** of phosphor particles embedded in dielectric. For example, in one embodiment we have dissolved about 3½ grams of quarter-second nitrocellulose as a dielectric material in sufficient butyl acetate to make 17½ cc. of the resulting solution, with about 6½ grams of castor oil to act as the plasticizing component of plasticizer and as the dielectric, and about 9 cc. each of toluol, ethyl acetate and butyl acetate added to thin the solution, in which about 13 grams of phosphor are suspended. The suspension is sprayed or otherwise applied to the conductive glass layer **2**, to a thickness of a few thousandths of an inch.

The dielectric layer **6** can be applied in a similar

manner over the phosphor-dielectric layer **5**, that is by spraying, painting or the like. In the specific example described, the layer **6** was of clear lacquer applied by spraying to a thickness of about 15% that of the phosphor-dielectric layer, although other thicknesses can be used with good results. The layer **6** should, however, be as thin as possible consistent with a good maintenance, as an extremely large thickness might reduce the luminescent brightness of the lamp for a given voltage.

The lacquer used in the specific embodiment being described was made by mixing wet quarter-second viscosity nitrocellulose equivalent to about 50 grams of dry nitrocellulose, there being about 25 grams of ethanol present to wet the material, with enough butyl acetate to make up about 250 cc. of solution. 50 grams of castor oil was added, and the resultant liquid was then diluted with about 400 cc. of a solvent of equal parts of butyl acetate, ethyl acetate, and toluol.

Caster oil is available in a wide variety of acid numbers from about 20 down, but the best light maintenance from the lamp will be obtained with material of the very low acid numbers, less than 3 or 4.

The backing layer **7** is of a good conducting material, such as metal, and preferably of a good reflecting metal such as aluminum, which will not react appreciably with the phosphor or embedding material used. The backing layer **6** is preferably of low resistance and can be applied in any convenient manner, care being taken not to damage the phosphor-dielectric layer. Best results have been obtained by vacuum-deposition of the metal. The glass plate **1**, with its conductive surface **2** coated with the embedded phosphor layer **5**, is placed in a bell jar and coated over the phosphor layer **5** with an evaporated metal after a suitable vacuum has been obtained. The backing layer **7** can also be deposited effectively by spraying.

In the particular example described, the conductive backing layer **7** was an alloy of 87% aluminum and 13% copper by weight. The addition of copper to the aluminum improves the lumen maintenance of the lamp, that is, improves the maintenance of its light output during life. The addition of the copper also has the effect of greatly toughening the aluminum film and increasing its durability. Other proportions of copper and aluminum can be used than those given, but the amount of copper added should not be great enough to seriously reduce the reflectivity of the aluminum.

A transparent conductive plastic, or a transparent plastic coated with a transparent conductive layer, can be used as the piece **1**, if desired. Where the piece **1** is conductive of itself, the conduction coating **2** can be omitted, but in that case the metal contact piece **4** should be separated from the piece **1** by a layer of insulation.

Other materials than nitrocellulose can be used as the embedding dielectric material, for example, a wax or plastic of reasonably high dielectric constant, dielectric strength and resistivity.

The thickness of the various layers can be altered to suit various voltage conditions and the like. The voltage will depend on the phosphor used, the thickness and composition of the layers **5** and **6**, and the brightness desired, but voltages between 25 volts and 2500 volts and even higher have been used. A lamp operable from a 110-volt alternating current power line can be made with

the conducting surface **2** of a thickness of about a wavelength of light, with a phosphor layer **5** of about two one-thousandths of an inch, and a metal layer **4** of a fraction of a thousandth of an inch. The plate **1** can have any convenient thickness and must be light-transmissive.

The phosphor used must be one capable of electroluminescence, that is of emitting light or other desired radiation on excitation by a varying electric field when the phosphor is in a dielectric medium. Suitable phosphors are described, for example, in applications, filed concurrently herewith by Keith H. Butler and Horace H. Homer as joint inventors, and by Keith H. Butler as a sole inventor, although other electroluminescent phosphors can be used.

The portion **9** of the metal backing layer **7** is preferably reinforced where it passes over the edge of the phosphor-dielectric layer **5**, or the dielectric layer **6**, to prevent breakage of the layer along that edge. Painting a thin stripe of one of the well-known air-drying conductive silver paints over the backing layer **7** along the portion that is in register with said edge is a satisfactory strengthening means for that portion of the lamp.

The entire back of the unit is preferably coated with an insulating protective layer **8**, for example of lacquer.

What I claim is:

1. An electroluminescent lamp comprising two electrodes having therebetween a layer of an electroluminescent phosphor in a dielectric medium and a layer of dielectric material only, one of said electrodes being transparent, the other being of metal, the layer of dielectric material only being between the metal electrode and the layer containing electroluminescent phosphor, said layer of electroluminescent phosphor in a dielectric medium being homogeneous.

2. An electroluminescent lamp comprising two electrodes having therebetween a layer of an electroluminescent phosphor in a dielectric medium and a layer of dielectric material only, one of said electrodes being transparent, the other being of metal, the layer of dielectric material only being between the metal electrode and the layer containing electroluminescent phosphor, said layer of electroluminescent phosphor in a dielectric medium being homogeneous, and said layer of dielectric material only being different in composition from the dielectric in the layer of electroluminescent phosphor and dielectric medium.

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