

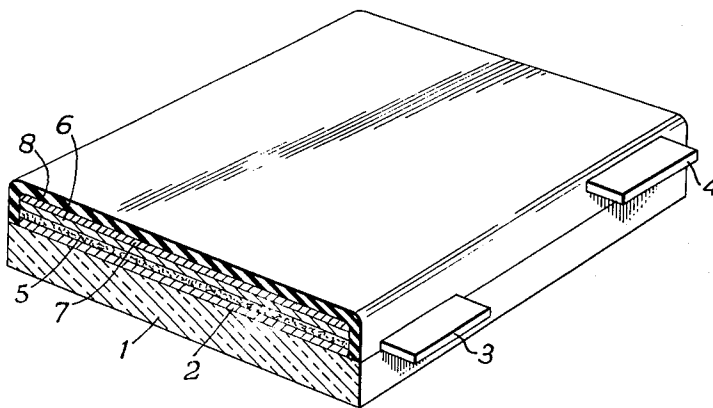
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ELECTROLUMINESCENT LAMP WITH A DIELECTRIC REFLECTIVE MATERIAL

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ELECTROLUMINESCENT LAMP WITH A DIELECTRIC REFLECTIVE MATERIAL

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This invention is concerned with improvements in and relating to electroluminescent lamps, that is to say lamps of the kind in which light is produced by the excitation of a material to luminescence by the application thereto of an electric field.

In one form of electroluminescent lamp that has already been proposed an electroluminescent material comprising silicon or other carbide crystals is mounted on a sheet of reflecting material, which may also serve as the anode of the lamp. A cathode formed of open mesh gauge is mounted over the crystal-faced anode sheet.

According to the present invention an electroluminescent lamp comprises a first conductive electrode which is capable of transmitting light, a second conductive electrode spaced from the first electrode, a light-producing layer disposed between the two electrodes and comprising an intimate mixture of electroluminescent and dielectric materials, and a light-reflecting layer comprising dielectric material disposed between the light-producing layer and the said second conductive electrode and capable of reflecting light from the light-producing layer toward the said first electrode. The second conductive electrode may be of graphite.

Preferably, the dielectric material of the light-reflecting layer includes one or more of magnesium oxide, the rutile and anatase forms of titanium dioxide, calcium titanate, barium titanate, strontium titanate and solid solutions of such titanates in one another, e.g. barium strontium titanate.

The second graphite electrode may readily be formed by painting or spraying on to the light-reflecting layer a suspension of graphite in a volatile suspending vehicle and then evaporating the suspending vehicle. An especially suitable material is a suspension of colloidal graphite in water. A substantially non-reflecting material such as graphite has the disadvantage that it absorbs a large proportion of the light emitted by the light-producing layer and directed toward the graphite electrode, and the presence of the light-reflecting layer enables greater use to be made of this light in the output of the lamp.

It is known that a relationship exists between the brightness of an electroluminescent lamp and the dielectric constant of the dielectric material in the light-producing layer, the brightness increasing as the dielectric constant increases, for a specific value of the applied voltage. The dielectric material must be of comparatively high resistivity if it is not to "short-circuit" the exciting electric field away from the crystals of electroluminescent material, and it must also be an efficient transmitter of light. Dielectric materials which have been used so far in the light-producing layer are fats, waxes, natural and synthetic resins and plastic the highest dielectric constant that has so far been achieved being not much higher than about 10.

A relationship also exists between the brightness of the electroluminescent lamp and the spacing of its electrodes from one another, the brightness decreasing as the spacing increases for a given value of the applied voltage. The presence of the light-transmitting layer increases the spacing between the lamp electrodes, and there is a consequent drop in the light output of the light-producing layer which offsets the increase in light output from the lamp due to

the extra light reflected through the first electrode by the light-reflecting layer. Thus the thicknesses of both the light-producing and light-reflecting layers should be kept as small as possible, and the dielectric constants of the materials used in both layers should be as high as possible.

In order to keep the thickness of the light-producing layer as small as possible the ratio of electroluminescent material to dielectric material should be high, e.g. between the values of 1:1 and 10:1, by weight.

For the purposes of this specification the said light reflecting layer is sufficiently light reflecting if the brightness of the lamp in which it is incorporated (as observed through the light-transmitting first electrode) is not less than the brightness of a similar lamp operated under like conditions and in which the light-reflecting layer is omitted.

Magnesium oxide, the anatase and rutile forms of titanium dioxide, barium titanate, calcium titanate, strontium titanate, and solid solutions of such titanates in one another, e.g. barium strontium titanate are suitable materials for use in the light-reflecting layer, being white solids which are efficient reflectors of light and have high dielectric constants. The dielectric constants of the two forms of titanium dioxide are higher than that of magnesium oxide, while the dielectric constants of the above-mentioned titanates are higher than those of the titanium dioxides, and for this reason the order of preference of the use of these materials is the titanates, titanium dioxides and magnesium oxide.

Electroluminescent lamps which are particular embodiments of the invention will now be described, together with methods of making them, by way of example, with reference to the accompanying diagrammatic perspective drawing showing a lamp with one end thereof in section.

Method 1

A square plate 1 of glass of 3 inches side is provided on one face with a transparent conductive coating 2 constituting a first electrode capable of transmitting light. The conductive coating may be applied for example, by exposing one face of the heated plate to stannic chloride vapour. Two metal contact strips 3 and 4 serving as terminals for connecting the lamp to an A.C. power source are mounted on the plate with one strip 3 in good electrical contact with the conductive coating 2 and the other strip 4 insulated therefrom.

8 cc. of a suspension of the following composition are then sprayed uniformly over the conductive coating 2 to form a light-producing layer 5, a spray gun of conventional form being used with a pressure of about 30 p.s.i.:

Castor-oil modified alkyd resin	gms.	12
Powdered electroluminescent material	gms.	40
Melamine-formaldehyde resin	gms.	2.4
Xylol	cc.	60
n-Butanol	cc.	15
Diacetone alcohol	cc.	1

The materials are ball-milled together until they are intimately mixed and a smooth suspension is obtained with the materials uniformly dispersed therein.

The light-producing layer 5 is allowed to dry in air for 5 minutes and then 8 cc. of a second suspension are sprayed uniformly over the light-producing layer to form a light-reflecting layer 6. The composition of the second suspension is the same as that of the first-described suspension, except that the electroluminescent material is replaced by 20 gms. of powdered anatase form of titanium dioxide. The light-reflecting layer is dried in air for ten minutes and the plate is then baked at between 100–150° C. for 30 minutes.

A second electrode 7 of graphite is formed by painting or spraying the exposed face of the light-reflecting layer

6 with a suspension of colloidal graphite in water, care being taken to ensure that the electrode 7 is in good electrical contact with its respective metal contact strip 4 and is insulated from the first electrode 2 and its respective strip 3. The second electrode is dried at 100° C. for 15 minutes and after allowing to cool the lamp is ready for use. A layer 8 of a moisture-impervious electrically-insulating material, e.g. a wax, may be applied over the electrode 7 to enable the lamp to be handled without danger of shock and to prevent entry of moisture to the lamp interior.

Method 2

A square glass plate 1 of 3 inches side is provided with a first electrode 2 and two metal contact strips 3 and 4, as in the first described method. 5 cc. of a first solution of the following composition are then sprayed uniformly over the first electrode:

Castor-oil modified alkyd resin	gms.	8
Melamine-formaldehyde resin	gms.	1.5
Xylol	cc.	92
n-Butanol	cc.	20

The resulting layer is tacky and after being allowed to dry in air for 1 minute dry electroluminescent material in the form of a fine, sieved powder is brushed on to the tacky layer, and the surplus that does not adhere brushed off. The layer of electroluminescent material is re-sprayed with another 5 cc. of the first solution and more powdered material brushed on, the procedure being repeated until the resulting light-producing layer 5 is of the required thickness.

The light-reflecting layer 6 is formed by spraying uniformly on to the light-producing layer 8 cc. of a suspension similar to the second suspension used in the first-described method, except that the 20 gms. of the anatase form of titanium dioxide are replaced by 20 gms. of the powdered rutile form. The plate is dried in air for 10 minutes, baked at 100–150° C. for 30 minutes and a layer of a graphite/water suspension then applied, as in the first-described method, to form the second electrode 7. After drying the graphite layer and cooling the lamp is ready for use. A coating 8 may be applied, as in the first-described method.

Method 3

A lamp is made according to the Method 2 described above, except that in the second suspension the 20 gms. of the rutile form of titanium dioxide are replaced by 40 gms. of powdered barium strontium titanate. The barium strontium titanate may be prepared by ball-milling a mixture of the following ingredients in distilled water for 18 hours:

Barium carbonate	gms.	78.8
Strontium carbonate	gms.	29.4
Titanium dioxide	gms.	48

The resulting suspension is filtered, dried, ground and heated in air at 1150° C. for 2 hours. It is then ground and reheated in air for 16 hours.

The effect of the light-reflecting layer on the brightness of lamps made by the methods described above is indicated by the following:

(A) Lamps made by the first-described method, using an electroluminescent material comprising zinc sulphide

activated with copper and lead, but omitting the light-reflecting layer gave a maximum brightness of 0.66 ft. lambert at 230 volts and 50 c.p.s., the current passed by each lamp averaging about 1.0 milliamperes.

(B) Lamps made according to the first-described method, except that the second suspension included 14.4 gms. of powdered magnesium oxide instead of the 20 gms. of the anatase form of titanium dioxide, gave a maximum brightness of 1.0 ft. lambert at 230 volts and 50 c.p.s., the current passed by each lamp averaging about 1.3 milliamperes.

(C) Lamps made according to the second-described method using the rutile form of titanium dioxide in the light-reflecting layer gave a maximum brightness of 3.0 ft. lamberts at 230 volts and 50 c.p.s., the current passed by each lamp averaging about 2.0 milliamperes.

(D) Lamps made according to the third-described method using barium strontium titanate in the light-reflecting layer gave a maximum brightness of 5.0 ft. lamberts at 230 volts and 50 c.p.s., the current passed by each lamp averaging about 4.0 milliamperes.

I claim:

1. An electroluminescent lamp comprising a first conductive electrode which is capable of transmitting light, a second conductive electrode spaced from the first electrode, a light-producing layer disposed between the two electrodes and comprising an intimate mixture of electroluminescent and dielectric materials, and a light-reflecting dielectric layer of high dielectric constant disposed between the light-producing layer and the said second conductive electrode and capable of reflecting light from the light-producing layer toward the said first electrode.

2. An electroluminescent lamp as claimed in claim 1, wherein the second conductive electrode is of graphite.

3. An electroluminescent lamp as in claim 1, wherein the dielectric material of the light-reflecting layer comprises magnesium oxide.

4. An electroluminescent lamp as in claim 1, wherein the dielectric material of the light-reflecting layer comprises a substance selected from the group consisting of the rutile form of titanium oxide and the anatase form of titanium oxide.

5. An electroluminescent lamp comprising a first conductive electrode which is capable of transmitting light, a second conductive electrode spaced from the first electrode, a light-producing layer disposed between the two electrodes and comprising electroluminescent material, and a light-reflecting layer comprising dielectric material disposed between the light-producing layer and the said second conductive electrode and capable of reflecting light from the light-producing layer toward the said first electrode.

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