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(73) Proprietor: **KABUSHIKI KAISHA KOMATSU SEISAKUSHO**
3-6, Akasaka 2-chome
Minato-ku Tokyo 107(JP)

(72) Inventor: **NIRE, Takashi**
3-18-11, Nakahara
Hiratsuka-shi Kanagawa-ken 254(JP)
Inventor: **WATANABE, Takehito**
920, Itado
Isehara-shi Kanagawa-ken 259-11(JP)
Inventor: **TANDA, Satoshi**
8-2, Kokufuhongo
Ooiso-cho
Naka-gun Kanagawa-ken 259-01(JP)

(74) Representative: **Newstead, Michael John et al**
Page Hargrave
Temple Gate House
Temple Gate
Bristol BS1 6PL (GB)

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EP 0 313 656 B1

Description

The present invention relates to a thin-film electroluminescent (EL) element.

In the field of colour display apparatus, there is an increasing tendency for small, thin low-power consuming ones to be demanded, and pocket-size television sets using liquid crystals as a shutter have become available to the public.

As shown in Fig. 18, a thin full-colour display apparatus used in a conventional pocket-size television set includes shutter means 100 in the form of a matrix of liquid crystal cells 6, a light source 101 disposed behind the shutter means and filter means 102 disposed before the shutter means and including a repeat of a red transparent filter R, a green transparent filter G and a blue transparent filter B arranged in order in correspondence to the liquid crystal cells. By controlling voltages applied to the respective liquid crystal cells in accordance with image information, quantities of light from the light source and passing through the liquid crystal cells are adjusted to thereby adjust the luminance and chromaticity of the respective pixels.

However, in such thin full-colour display apparatus, there is the problem that contrast is not excellent due to the characteristics of the liquid crystal itself and the angle of visual field being very narrow. In such apparatus, a light source as backlight is needed, so that there is the problem that the entire apparatus would be thick although the liquid crystal section itself is thin.

The thin-film EL elements each includes a thin transparent luminous layer which has no granularity. Therefore, external incident light and light emitted within the luminous layers not scattered, so that they cause no halation or oozing, the display is clear and provides high contrast. Therefore, they are highlighted as being used for a display or illumination unit.

The basic structure of a thin-film EL element includes a double dielectric structure which in turn includes, on a transparent substrate, a transparent electrode layer of tin oxide (SnO_2), etc., a first dielectric layer of tantalum pentoxide, etc., a thin luminous layer of zinc sulfide (ZnS), etc., and containing manganese (Mn), etc., a second dielectric layer of tantalum pentoxide, etc., and a rear electrode layer of aluminium (Al), etc., laminated in order.

The process of luminescence is as follows. If a voltage is applied across the transparent electrode and the rear electrode, the electrons trapped at the interface level are pulled out and accelerated by an electric field induced within the luminous layer so that they have energy enough to strike orbital electrons in manganese (the luminescent centres) to thereby excite same.

When an excited luminescent centre returns to its ground state, it emits light.

Researches in which a multicolour display panel is fabricated using thin-film EL elements have recently become popular and various researches have been made on making full colour panels.

A thin-film EL element emitting white light uses a luminous layer of zinc sulfide containing praseodymium fluoride (PrF_3), as disclosed in Yoshihiro Hamakawa et al, The Institute of Electronics and Communication Engineers of Japan Technical Research Report, CPM 82-10, 1982.

As shown in Fig. 19 a thin-film EL element using a luminous layer of zinc sulfide containing praseodymium fluoride has peaks at about 500 and 650 nm in the emission spectrum. The rays of light at 500 and 650 nm are in complementary-colour relationship to each other and show as if they were white light. However, the light does not contain three primary colours, so that it cannot be used for full colour display.

A thin-film EL element having such structure is all transparent except for its rear electrode. Thus external incident light is reflected by the rear electrode and the reflection interferes with the light from the luminous layer so that it does not provide a satisfactory contrast ratio and thus only display devices having low display quality would be provided.

As prior art there may also be mentioned JP-A-59-56391, which discloses apparatus in which the light absorption coefficient of a light absorption layer increases from a luminous layer side to a rear electrode side.

According to the present invention, there is provided a thin-film EL element comprising a luminous layer, a rear electrode and a dielectric layer therebetween, in which the luminous layer is caused to emit light by an electric field applied thereto, characterised in that the dielectric layer includes an insulating film of insulating oxide or nitride whose composition ratio is graded continuously from black to transparent in the direction towards the rear electrode.

Said insulating film may be a tantalum oxide (TaO_x where $x < 2.5$), an yttrium oxide (YO_x where $x < 3/2$), a silicon oxide (SiO_x where $x < 2$) or a silicon nitride (SiN_x where $x < 4/3$).

The thin-film EL element may comprise, on a baseplate, a transparent electrode, a further dielectric layer, said luminous layer, said dielectric layer which includes an insulating film of oxide or nitride and said rear electrode, laminated in order.

The voltage applied to the luminous layer may be controlled by the detection output from a photosensor disposed in the vicinity of the luminous layer.

By way of example, when said dielectric layer which includes an insulating film of oxide or nitride is formed in a reactive chamber by sputtering, using as a target tantalum pentoxide (Ta_2O_5) and feeding a mixed gas of argon (Ar) + oxygen (O_2), it is gradually changed from a black tantalum oxide (TaO_x where $x < 2.5$) film to a transparent tantalum oxide (Ta_2O_5) film by gradually increasing the partial pressure of oxygen.

Since the stoichiometric ratio changes continuously, substantially no dielectric breakdown occurs at the interface and substantially no reduction of contrast due to reflection at the interface occurs, so that a thin-film EL element is provided having high contrast and high dielectric strength.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figs. 1(a) and (b) are a cross-section view and a plan view, respectively, of colour display apparatus including thin-film elements not according to the present invention;

Figs. 2(a) and (b) illustrate the principle of luminescence at the luminous layer of the apparatus of Figs. 1(a) and 1(b) and a spectrum obtained from the luminous layer, respectively;

Fig. 3 is a diagram showing a contrast ratio in the apparatus;

Fig. 4 is a diagram showing the comparison in angle of visual field between the apparatus of Figs. 1(a) and 1(b) and a conventional apparatus;

Fig. 5 illustrates the emission spectrum of light from a luminous layer of another example of apparatus including thin-film elements not according to the present invention;

Fig. 6 illustrates the structure of a thin-film EL element not according to the present invention;

Fig. 7 is a diagram showing the emission spectrum of a thin-film EL element according to Fig. 6;

Fig. 8 illustrates another thin-film EL element not according to the present invention;

Fig. 9 illustrates the transmittance of a second dielectric layer used in the EL element of Fig. 8;

Fig. 10 is a diagram showing a comparison in contrast ratio between a thin-film EL element according to Fig. 8 and using a conventional insulating film;

Fig. 11 illustrates another thin-film EL element not according to the present invention;

Fig. 12 is a diagram showing the relationship between the partial pressure of oxygen and transmittance in the formation of an insulating layer of the element of Fig. 11;

Fig. 13 illustrates a thin-film EL element according to an example of the present invention;

Figs. 14 (a) and (b) illustrate curves showing the relationship between oxygen quantity and transmittance and the relationship between oxygen quantity and resistivity in the formation of a tantalum oxide film;

Fig. 15 is a diagram showing a comparison in voltage-luminance characteristics between the thin-film EL element of Fig. 13 and a conventional one;

Fig. 16 illustrates a modification of the element according to Fig. 13;

Fig. 17 shows curves relating to control of the luminance for environmental illumination to maintain within a predetermined range the contrast of the thin-film EL element shown in Fig. 16;

Fig. 18 shows a conventional colour display apparatus; and

Fig. 19 illustrates the emission spectrum of a conventional thin-film EL element which emits white light.

Figs. 1(a) and (b) show a thin film colour display apparatus, Fig. 1(a) being a cross-section view taken along the line A-A of Fig. 1(b).

The apparatus includes an EL element section 1 which in turn includes a multiplicity of thin-film EL elements or cells arranged in a matrix and corresponding to pixels, and a colour filter section 2 disposed integrally on a surface of the EL element section such that the rays of light from the respective cells are output through the colour filter section.

The EL element section 1 includes, on a glass baseplate 3, a transparent electrode 4 of indium tin oxide (ITO) disposed so as to form a like number of first stripe lines $\ell_1, \dots, \ell_n$ at predetermined intervals, a first dielectric layer 5 of tantalum pentoxide (Ta_2O_5), a luminous layer 6 having a single layer structure comprising a strontium sulphide (SrS) layer containing cerium (Ce) and europium (Eu) as an activator and potassium (K) as a coactivator, a second dielectric layer 7 of tantalum pentoxide, and a rear electrode 8 in the form of an aluminium (Al) layer comprising a plurality of second stripe lines $V_1, \dots, V_n$ disposed orthogonal to the first stripe lines $\ell_1, \dots, \ell_n$ such that by applying a voltage corresponding to information across any particular one of the stripe lines of the transparent electrode 4 and any particular one of the stripe lines of the rear electrode 8, the luminous layer portion located at the intersection of those particular stripe lines is caused to emit light. The principle of luminescence is as shown in Fig. 2(a) and thus rays of light having respective wavelengths are emitted. Fig. 2(b) shows the emission spectrum of the rays of light emitted from this luminous layer. One of the intersections constitutes a cell here.

The colour filter section 2 is disposed on the glass baseplate side of the EL element section and includes a repeat of a red transparent filter R, a green transparent filter G and a blue transparent filter B arranged in order, each filter including a dyeable polymer layer and corresponding to a respective cell, as shown in plan view in Fig. 1(b).

The contrast characteristic of this colour display apparatus is shown in Fig. 3. As will be clear from Fig. 3, the contrast ratio is about 1:100 for less than 1000 1x so that the characteristic is extremely satisfactory and greatly improved compared to the conventional one with a ratio of 1:10.

Fig. 4 shows a visual angle-dependent luminance characteristic. The characteristic of colour display apparatus according to Figs. 1(a) and 1(b) is shown by the solid line, which exhibits that the luminance does not lower significantly up to more than 60 degrees. It is understood that the apparatus is of high visual angle compared to the conventional apparatus whose characteristic is shown by a broken line.

This display apparatus does not need backlight and is very thin, i.e. at most about 1 mm thick, even inclusive of the glass baseplate.

While in the particular example the respective cells are formed integrally, the luminous layer as well as the respective layers may be provided separately for each cell. This applies to the electrodes.

The luminous layer is not limited to a strontium sulphide (SrS) layer containing cerium (Ce), europium (Eu) and potassium (K). The use of a single luminous layer of zinc sulphide containing nitrogen (N); CaSrS containing cerium (Ce), europium (Eu) and potassium (K); BaSe; ZnS; ZnCdS; ZnF₂; SrTiO₃; or BaTiO₃ would result in the emission of white light. Fig. 5 shows the emission spectrum of SrS containing Ce, Eu and K. The contents of impurities which are the luminescent centres of each luminous layer in the example may be changed as needed. The kind of impurities used may be changed as needed.

For the colour filter section, a dyeable polymer layer directly coated on the glass baseplate may be used as in the particular example. Alternatively, colour filters formed separately may be attached, namely, a different colour filter structure may be used as needed.

A protective film or the like may be provided as needed.

Another example of a thin-film EL element for use in colour display apparatus will now be described.

The thin-film EL element includes a single luminous layer which can emit white light. As shown in Fig. 6, a luminous layer 11 of thin-film EL elements having a double dielectric structure is

composed of a 5000 Å-thick thin-film layer of zinc sulphide containing nitrogen.

It is formed by laminating in order on a transparent glass baseplate 12, a transparent electrode 13 in the form of a tin oxide (SnO₂) layer, etc., a first dielectric layer 14, a luminous layer 11 of zinc sulphide containing nitrogen as mentioned above, a second dielectric layer 15, and a rear electrode 16 in the form of a thin aluminium (Al) film.

For the formation of the luminous layer, a process is employed in which a zinc sulphide layer is formed by sputtering and nitrogen is then implanted in the zinc sulphide layer by ion implantation.

The emission spectrum of the luminescence obtained by applying an alternating electric field across the thin-film EL element has a wide range of luminescent wavelengths covering three primary colours as shown in Fig. 7.

As just described above, according to the thin-film EL element, true white light is provided and a full-colour display panel can be fabricated.

While for the formation of the luminous layer the process including the implantation of nitrogen ions after the formation of the zinc sulphide film has been used, this is not essential. A process for forming the luminous layer by sputtering or CVD in an atmosphere of nitrogen may be used. Namely, it may be selected as needed.

A further example of a thin-film EL element for use in colour display apparatus will be described.

As shown in Fig. 8, the thin-film EL element has a double dielectric layer structure which includes on a transparent glass baseplate 21 a transparent electrode 22 in the form of a tin oxide layer (SnO₂), etc., a first dielectric layer 23, a luminous layer 24 of ZnS: Mn, a second, black dielectric layer 25 of tantalum oxide (TaO_x where x<2.5) and a rear electrode 26 in the form of a thin aluminium (Al) film laminated in order.

The second dielectric layer has the relationship between wavelength and transmittance as shown in Fig. 9, which shows that the transmittance is less than 10% in a visual light area.

A curve a in Fig. 10 shows the relationship between luminance and contrast ratio of the thin-film element (cd/m²).

For comparison purposes, a curve b in Fig. 10 shows the relationship between luminance (cd/m²) and contrast ratio of a conventional thin-film EL element using tantalum pentoxide (Ta₂O₅) as a material constituting the second dielectric layer.

It will be clear from comparison that in order to obtain a contrast ratio of 1:10 (at an illumination of 1000 1x), the conventional thin-film EL element requires a luminance of 200 cd/m² while the element of Fig. 8 only requires 20 cd/m², which illustrates that the contrast is greatly improved.

The black tantalum oxide film can be easily obtained by only changing partial conditions of a process for forming a transparent tantalum pentoxide layer used conventionally - for example, by lowering only the partial pressure of oxygen under the same conditions as those in the sputtering process. Thus, manufacturing work is performed efficiently.

While in the particular example a black tantalum oxide film is used instead of the conventional transparent tantalum pentoxide film, a composite film 25' of a black tantalum oxide layer 25a and a different dielectric layer 25b may be formed as the second dielectric layer as shown in Fig. 11. It may be applicable to other oxides and nitrides such as yttrium oxides, silicon oxides, silicon nitrides, etc., as in a thin-film transistor.

The materials constituting the luminous layer, transparent electrode and rear electrode are not limited to those of the particular example, and other materials are effective, of course.

The tantalum oxide film may be selected as needed among ones having transmittance of 30% or less in a visual area. If a film having a transmittance of more than 30% is used, it would reduce the contrast ratio.

The relationship between partial pressure of oxygen and transmittance is also ascertained from experiments such as those shown below.

A TaO_x film was formed on a glass baseplate by using Ta_2O_5 as the target and changing the partial pressure of oxygen in a high frequency (RF) sputtering process.

Fig. 12 shows the results of measurement of the relationship between the partial pressure of oxygen at the film formation and transmittance of the formed TaO_x film when the partial pressure of argon (Ar) was 5×10^{-3} (Torr). (In Fig. 12, the axis of abscissae represents the partial pressure of oxygen $\times 10^{-5}$ (Torr) and the axis of ordinates the transmittance (%)).

It will be clear from Fig. 12 that by reducing the partial pressure of oxygen and the proportion in composition of oxygen the transmittance is reduced. The transmittance of the TaO_x film formed at a partial pressure of oxygen = 0 was about 2%.

According to the above, the proportion in composition of oxygen or nitrogen in insulating oxides or nitrides is reduced stoichiometrically, so that the manufacturing process is not substantially changed and a black insulating film can be very easily provided.

An example of a thin-film EL element according to the present invention for use in colour display apparatus will now be described with reference to Fig. 13.

The EL element includes on a transparent glass baseplate, 31 a transparent electrode 32 in

the form of a tin oxide (SnO_2) layer, etc., a first dielectric layer 33 of yttrium oxide (Y_2O_3), a luminous layer 34 of zinc sulphide (ZnS): manganese (Mn), a second dielectric layer 35, whose composition ratio is graded continuously from black to transparent, and a rear electrode 36 in the form of an aluminium layer, laminated in order.

The second dielectric layer has a composition ratio continuously changing stoichiometrically in a direction towards the rear electrode from a black tantalum oxide film (TaO_x where $x < 2.5$) 3000 Å thick to a transparent tantalum pentoxide (Ta_2O_5) film and has a thickness of 5000 Å in total.

The second dielectric layer is formed by RF sputtering. Tantalum pentoxide is used as the target. Initially, a tantalum oxide (TaO_x where $x < 2.5$) film 3000 Å thick is deposited under reduced partial pressure of oxygen, and the partial pressure of oxygen is then gradually increased to thereby deposit continuously a tantalum oxide ($TaO_{x'}$ where $x' = x - 2.5$) film 2000 Å thick.

Figs. 14(a) and Fig. 14(b) show the relationship between oxide content of a tantalum oxide film and its transmittance (%) to light having wavelength $\lambda = 600$ nm and the relationship between oxygen content and resistivity (Ω cm), respectively, when the tantalum oxide film is formed using tantalum pentoxide as the target by RF sputtering and when the oxygen content is changed. As will be clear from these Figures, as the oxygen content decreases, the transmittance as well as resistivity is reduced whereas as the oxygen content increases, the resistivity also increases.

A curve a in Fig. 15 shows the luminance-voltage characteristic of the thin-film EL element thus formed. For comparison purposes, curves b and c in Fig. 15 show the luminance-voltage characteristics of a thin-film EL element having the same structure as the present example except for the second dielectric layer which consists of a single (black) tantalum oxide (TaO_x where $x < 2.5$) film 5000 Å thick and another thin-film EL element having the same structure as the present example except for the second dielectric layer having a two-layered structure which consists of a black tantalum oxide (TaO_x where $x < 2.5$) film 4000 Å thick and a transparent tantalum pentoxide film (Ta_2O_5) 1000 Å thick. Curves a and b are substantially equal in contrast and the curve c is somewhat lower. (In Fig. 15, the axis of ordinates represents luminance and the axis of abscissae applied voltage). It will be understood that the voltages which the elements can withstand for a long time (dielectric strength) are 165 V for a, 125 V for b and 150 V for c and that the thin-film EL element of the inventive example in which the second dielectric layer is continuously changed has a greatly improved dielectric strength.

As just described above, the thin-film EL element according to the inventive example exhibits high contrast and high breakdown voltage.

The above described thin-film EL elements may be used as light sources for writing signals into, reading signals out of and erasing signals in recording media for illuminating purposes in addition to the display apparatus applications.

With thin-film EL elements used in display apparatus under environmental conditions in which the environmental brightness changes, there is the problem that contrast is lowered and the display becomes difficult to view when the environmental brightness-illumination increases whereas the display is excessively bright if the luminance is constant when the illumination is extremely low. In order to cope with this problem, for example as shown in Fig. 16, a photosensor 37 may be provided. The voltage applied to the thin-film EL element is controlled in accordance with a signal from the photosensor to change the luminance to thereby maintain the contrast constant and improve the display effect.

As shown in Fig. 17, control of the applied voltage is easy if it is provided so as to change the applied voltage stepwise to thereby maintain the contrast within a predetermined range (a - b) when the signal from the photosensor exceeds a predetermined value.

For example, assume that the thin-film EL element is emitting light at a certain luminance of A. The luminance is changed stepwise as shown by A, B, C, D. If the environmental illumination or the detection output from the photosensor 37 becomes 1000 lx, the applied voltage is increased such that the luminance becomes B; if the illumination further increases to about 5000 lx, the luminance changes to C; and so on. In this way, the contrast can be maintained within a substantially constant range without being influenced by the environmental illumination.

The applied voltage may be changed continuously in accordance with the detection output from the photosensor.

Claims

1. A thin-film EL element comprising a luminous layer (34), a rear electrode (36) and a dielectric layer (35) therebetween, in which the luminous layer is caused to emit light by an electric field applied thereto, characterised in that the dielectric layer includes an insulating film of insulating oxide or nitride whose composition ratio is graded continuously from black to transparent in the direction towards the rear electrode.

2. A thin-film EL element according to claim 1, characterised in that said insulating film is a tantalum oxide (TaO_x where $x < 2.5$).
3. A thin-film EL element according to claim 1, characterised in that the said insulating film is an yttrium oxide (YO_x where $x < 3/2$).
4. A thin-film EL element according to claim 1, characterised in that said insulating film is a silicon oxide (SiO_x where $x < 2$).
5. A thin-film EL element according to claim 1, characterised in that the said insulating film is a silicon nitride (SiN_x where $x < 4/3$).
6. A thin-film EL element according to any preceding claim comprising, on a baseplate (31), a transparent electrode (32), a further dielectric layer (33), said luminous layer (34), said dielectric layer (35) which includes an insulating film of oxide or nitride and said rear electrode (36) laminated in order.
7. A thin-film EL element according to any preceding claim, characterised in that the voltage applied to the luminous layer (34) is controlled by the detection output from a photosensor (37) disposed in the vicinity of the luminous layer.

Patentansprüche

1. Dünnschicht-EL-Element umfassend eine Leuchtfläche, (34) eine rückwärtige Elektrode (36) und eine dielektrische Lage (35) dazwischen, bei dem die Leuchtfläche durch ein daran angelegtes elektrisches Feld zum Aussenden von Licht veranlaßt wird, dadurch gekennzeichnet, daß die dielektrische Lage eine isolierende Schicht eines isolierenden Oxids oder Nitrids enthält, dessen Zusammensetzungsverhältnis in Richtung auf die rückwärtige Elektrode fortlaufend von schwarz bis durchsichtig abgestuft ist.
2. Dünnschicht-EL-Element nach Anspruch 1, dadurch gekennzeichnet, daß die isolierende Schicht ein Tantaloxid (TaO_x mit $x < 2,5$) ist.
3. Dünnschicht-EL-Element nach Anspruch 1, dadurch gekennzeichnet, daß die Isolierschicht ein Yttriumoxid (YO_x mit $x < 3/2$) ist.
4. Dünnschicht-EL-Element nach Anspruch 1, dadurch gekennzeichnet, daß die Isolierschicht ein Siliciumoxid (SiO_x mit $x < 2$) ist.

5. Dünnschicht-EL-Element nach Anspruch 1, dadurch gekennzeichnet, daß die Isolierschicht ein Siliciumnitrid (SiN_x mit $x < 4/3$) ist.
6. Dünnschicht-EL-Element nach einem der vorhergehenden Ansprüche umfassend eine Bodenplatte (31), eine transparente Elektrode (32), eine weitere dielektrische Lage (33), wobei die Leuchtlage (34), die dielektrische Lage (35), die eine isolierende Schicht aus einem Oxid oder Nitrid enthält, und die rückwärtige Elektrode (36) in dieser Reihenfolge laminiert sind.
7. Dünnschicht-EL-Element nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die an die Leuchtlage (34) angelegte Spannung mittels der Nachweisausgabe eines im Bereich der Leuchtlage angeordneten Fotosensors (37) geregelt wird.

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Revendications

1. Élément électroluminescent en film couche comprenant une couche lumineuse (34), un électrode arrière (36) et une couche diélectrique (35) interposée entre elles, dans lequel la couche lumineuse est amenée à émettre de la lumière par un champ électrique qui lui est appliqué, caractérisé en ce que la couche diélectrique comprend une pellicule isolante, en oxyde ou en nitrure isolant, dont le rapport de composition est dégradé en continu du noir au transparent dans la direction allant vers l'électrode arrière.
2. Élément électroluminescent en couche mince selon la revendication 1, caractérisé en ce que la pellicule isolante est un oxyde de tantale (TaO_x où $x < 2,5$).
3. Élément électroluminescent en couche mince selon la revendication 1, caractérisé en ce que la pellicule isolante est un oxyde d'yttrium (YO_x où $x < 3/2$).
4. Élément électroluminescent en couche mince selon la revendication 1, caractérisé en ce que la pellicule isolante est un oxyde de silicium (SiO_x où $x < 2$).
5. Élément électroluminescent en couche mince selon la revendication 1, caractérisé en ce que la pellicule isolante est un nitrure de silicium (SiN_x où $x < 4/3$).
6. Élément électroluminescent en couche mince selon l'une quelconque des revendications pré-

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cédentes comprenant, sur une plaque de base (31), une électrode transparente (32), une autre couche diélectrique (33), la couche lumineuse (34), la couche diélectrique (35) qui comprend une pellicule isolante en oxyde ou en nitrure et l'électrode arrière (36) stratifiées dans cet ordre.

7. Élément électroluminescent en couche mince selon l'une quelconque des revendications précédentes, caractérisé en ce que la tension appliquée à la couche lumineuse (34) est réglée par la sortie de détection d'un détecteur photoélectrique (37) disposé au voisinage de la couche lumineuse.

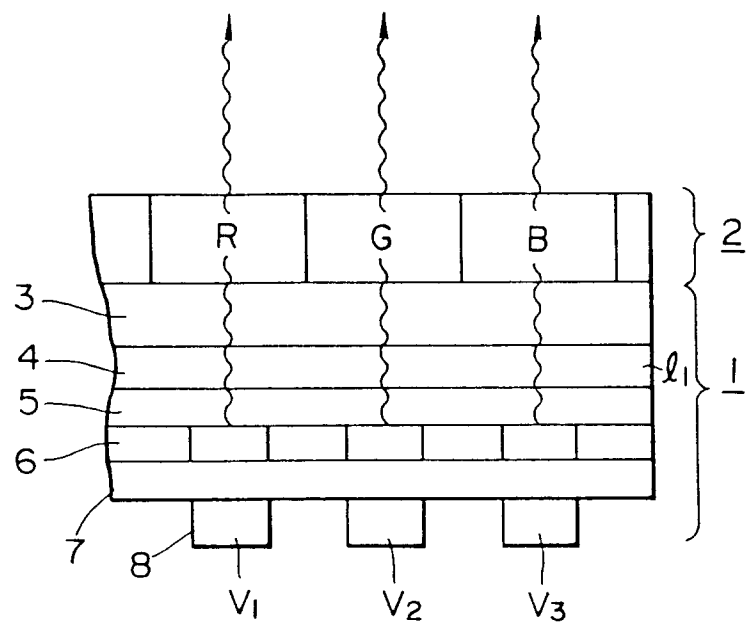


FIG.1 (a)

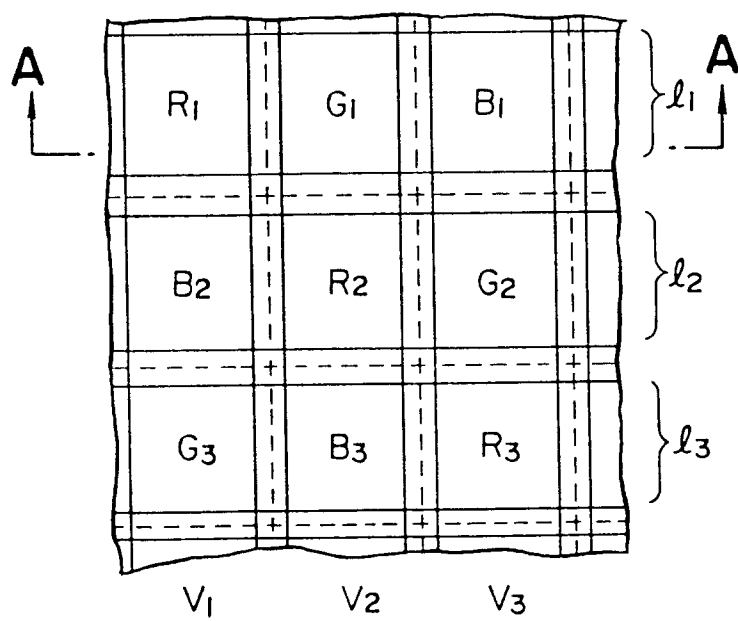


FIG.1 (b)

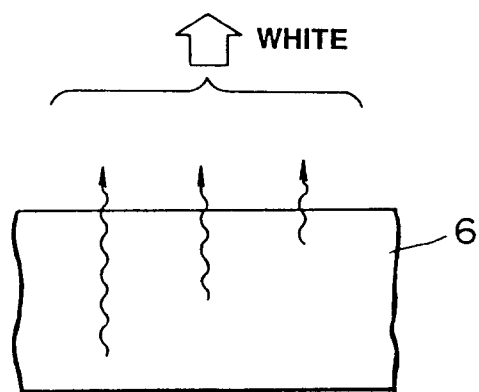


FIG. 2 (a)

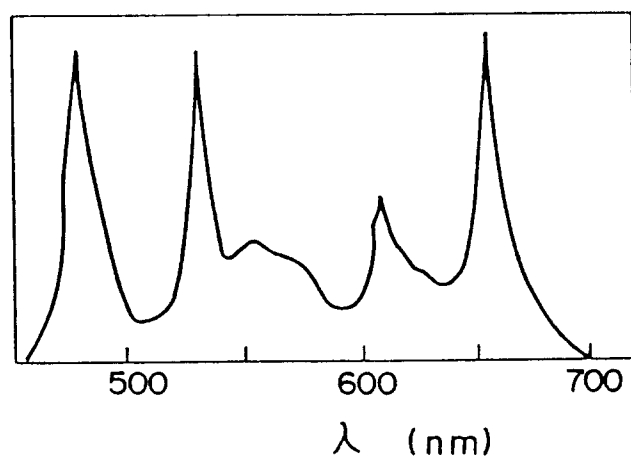


FIG. 2 (b)

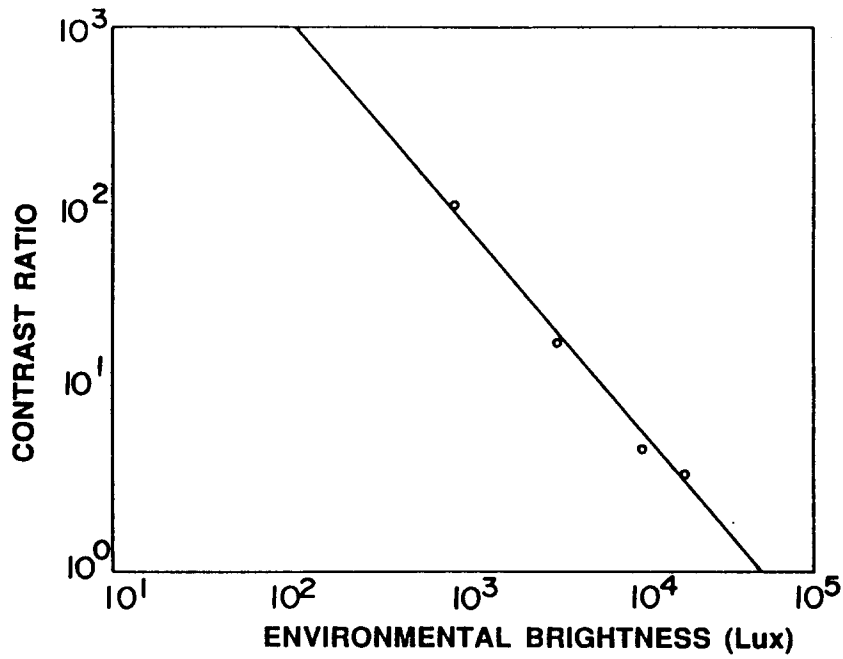


FIG. 3

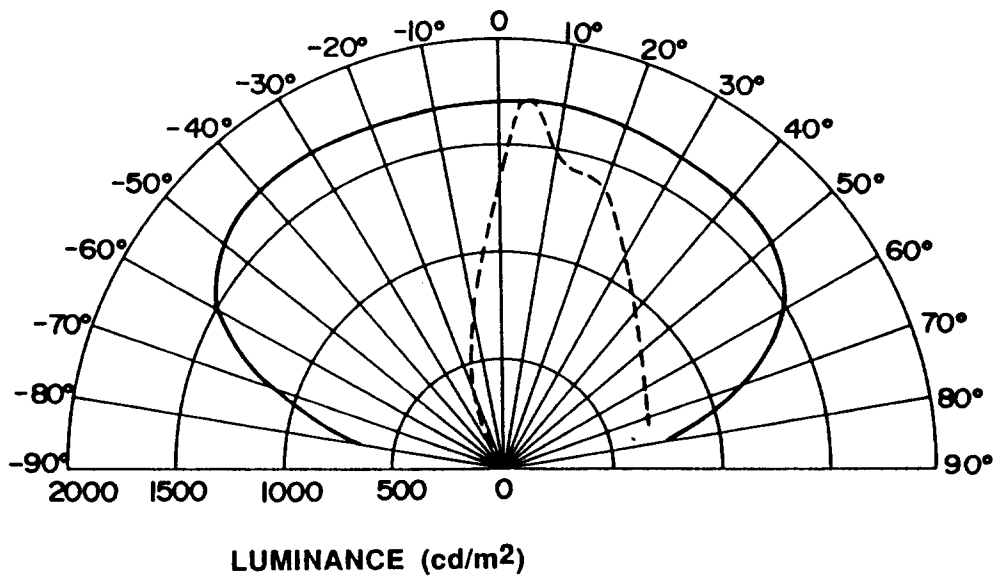


FIG. 4

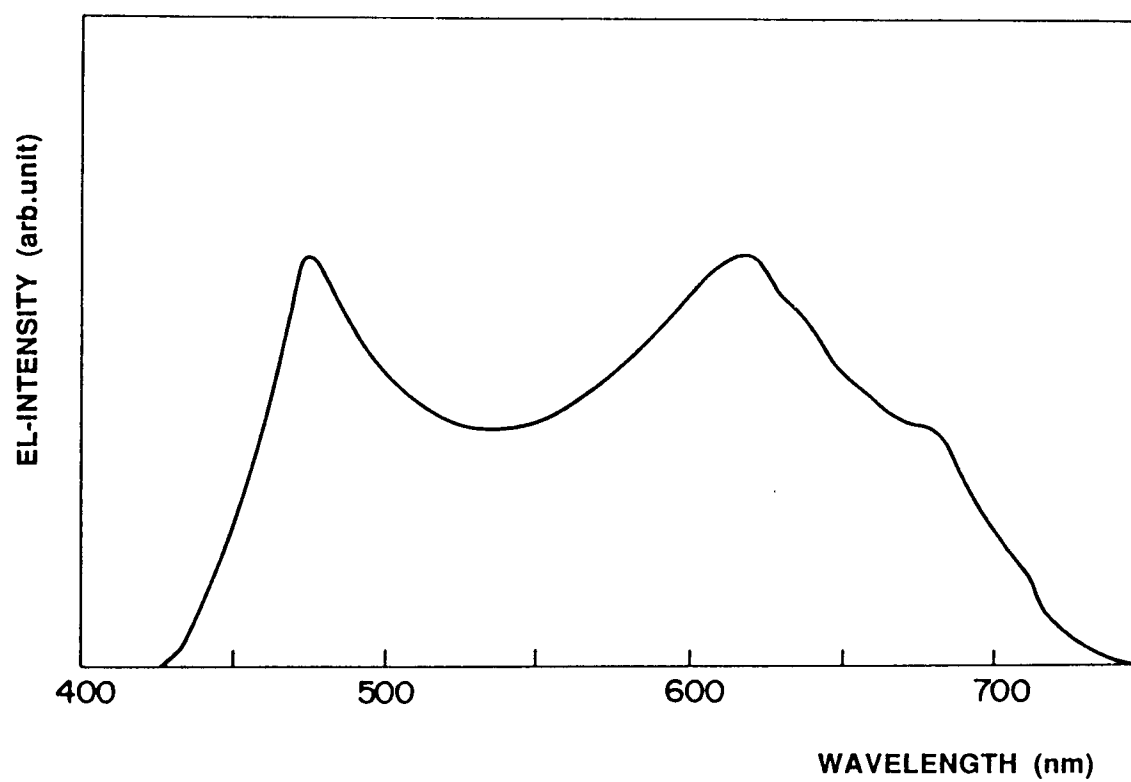


FIG.5

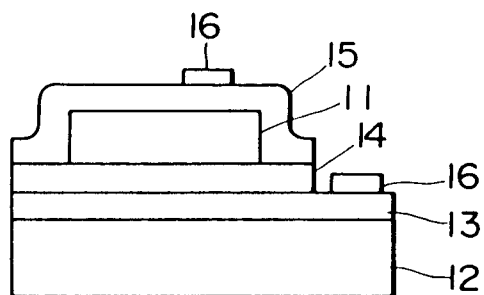


FIG. 6

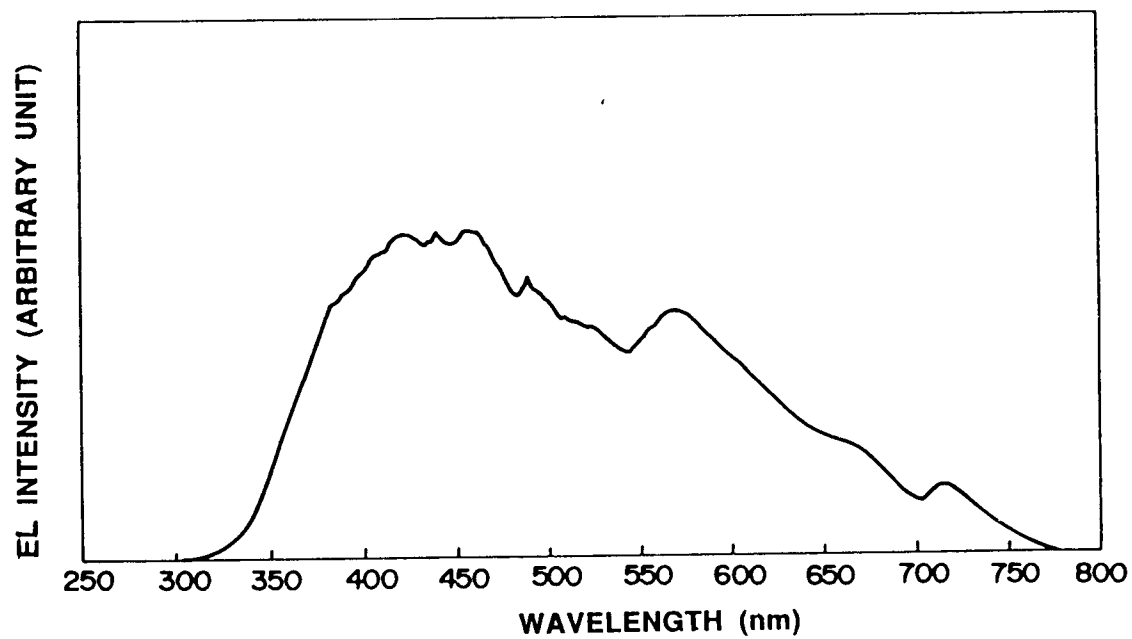


FIG. 7

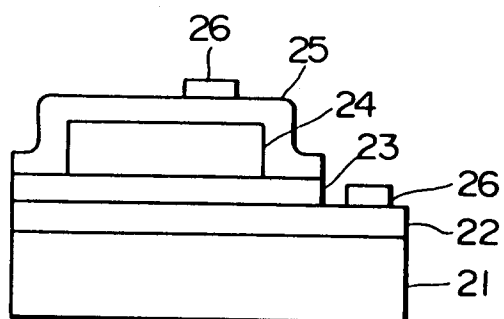


FIG. 8

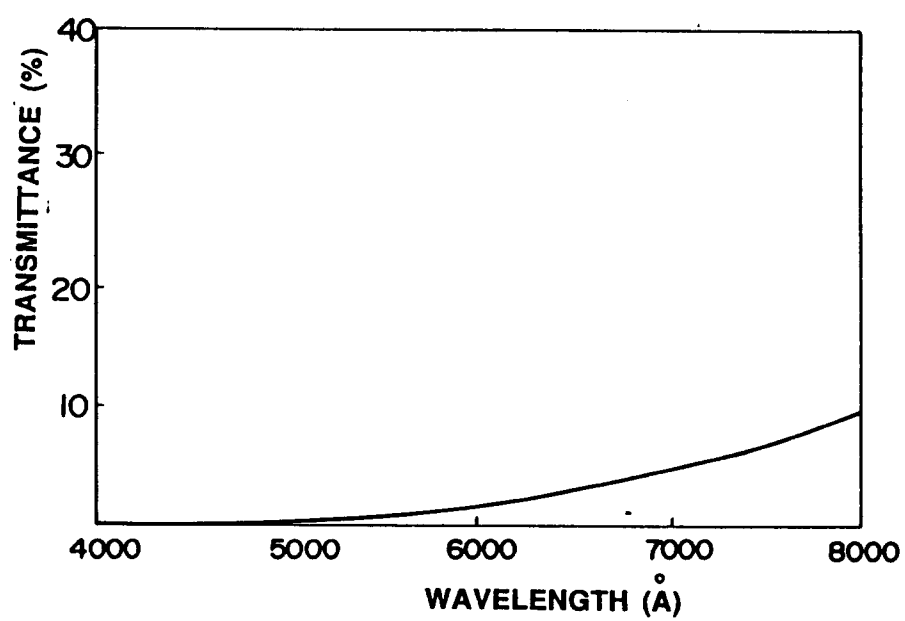


FIG. 9

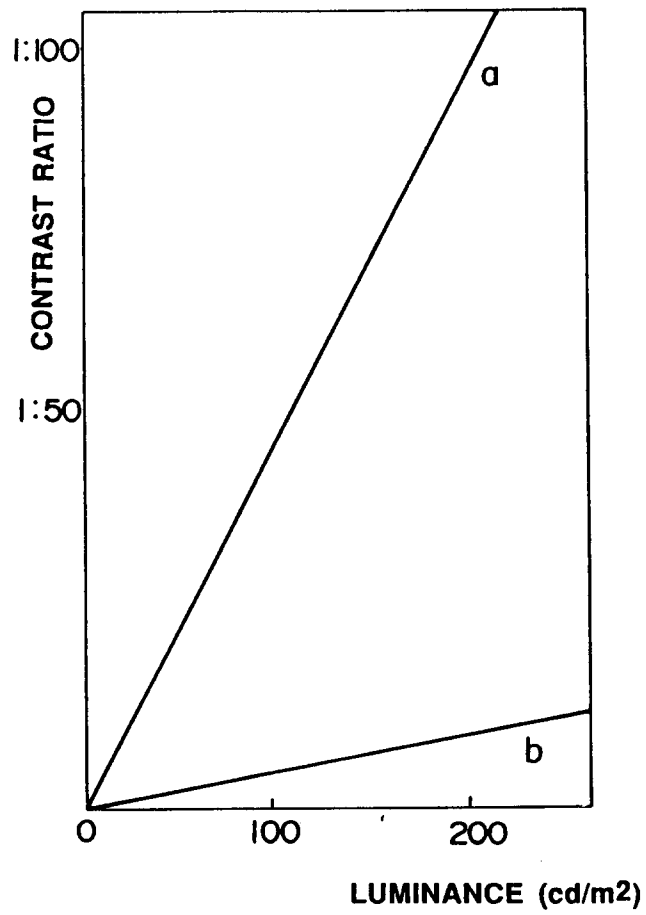


FIG.10

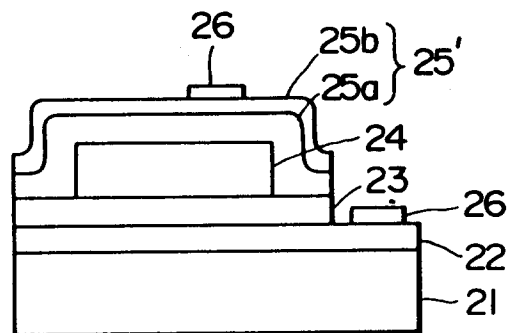


FIG.11

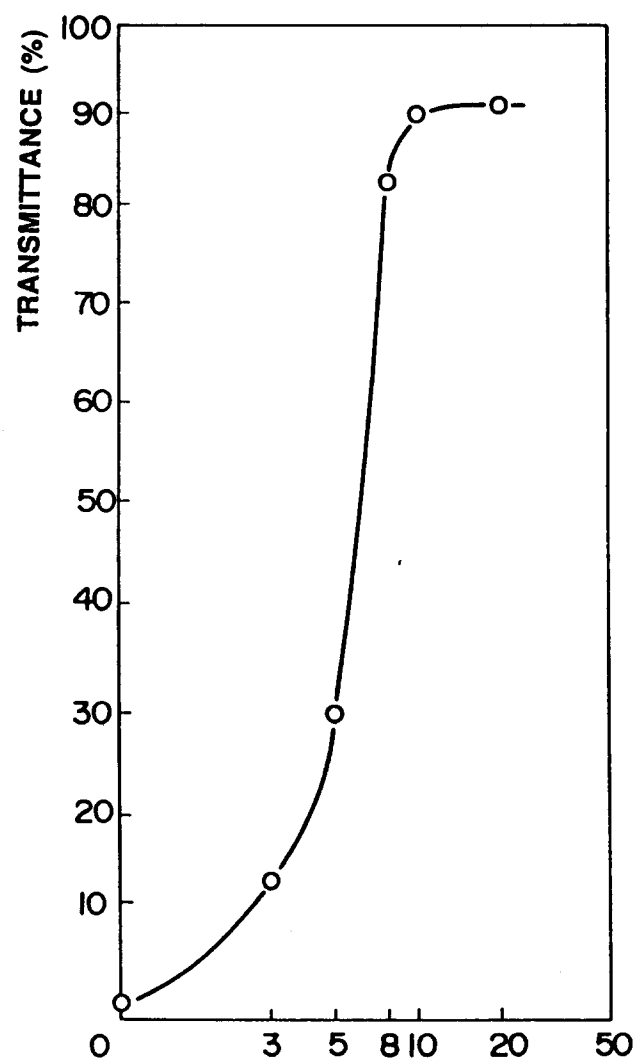


FIG.12

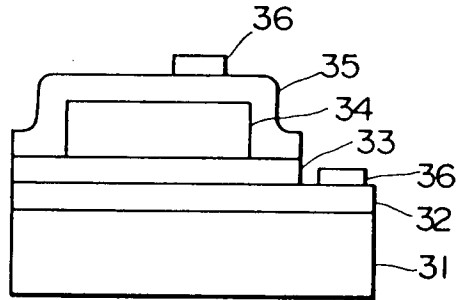


FIG.13

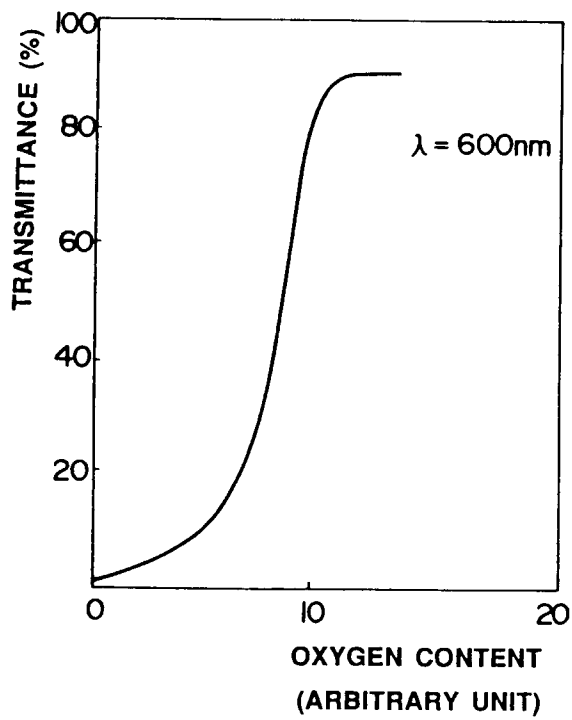


FIG.14 (a)

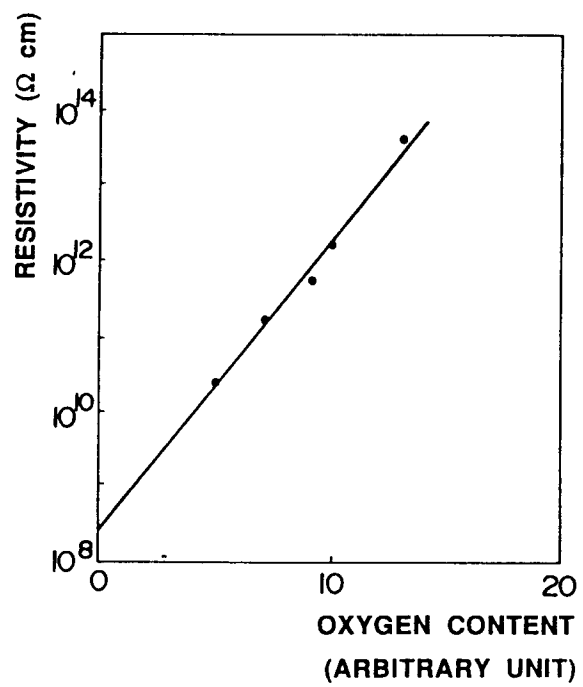


FIG.14 (b)

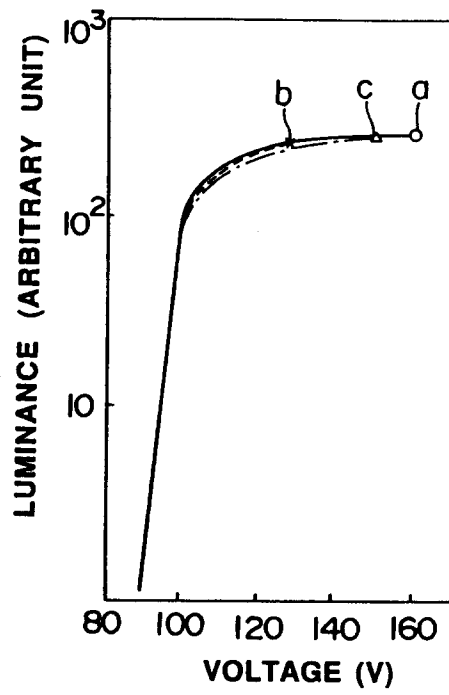


FIG. 15

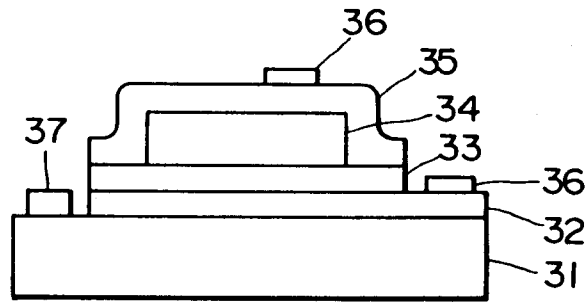


FIG. 16

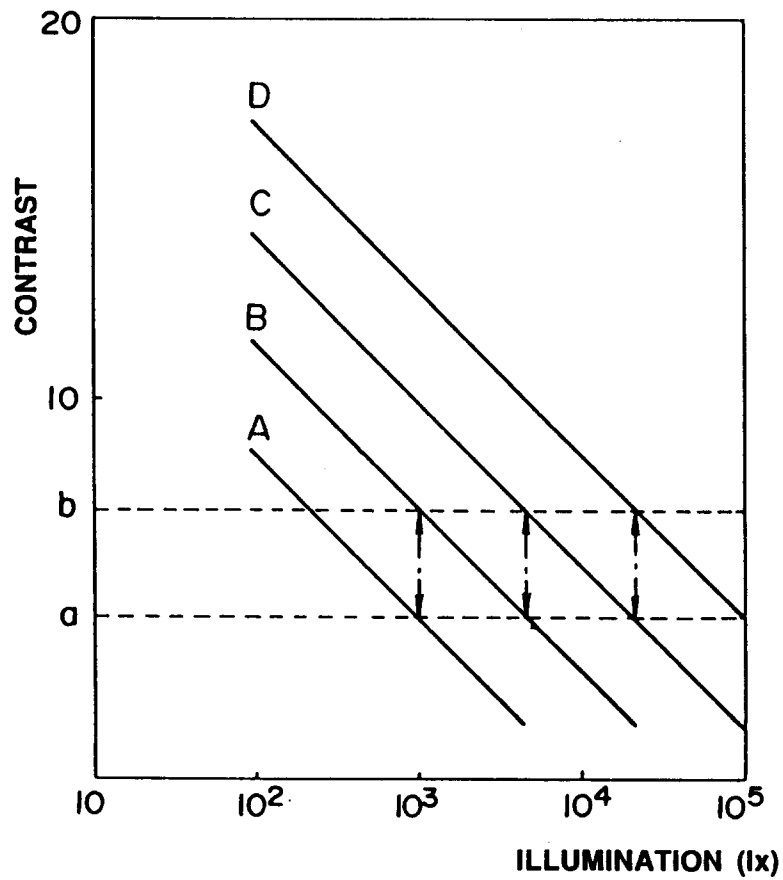


FIG. 17

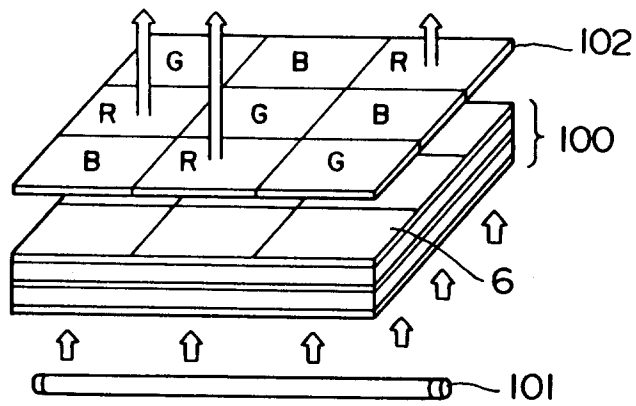


FIG.18

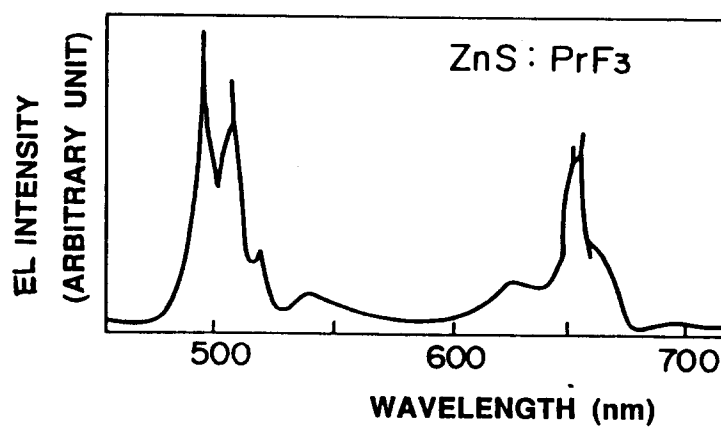


FIG.19