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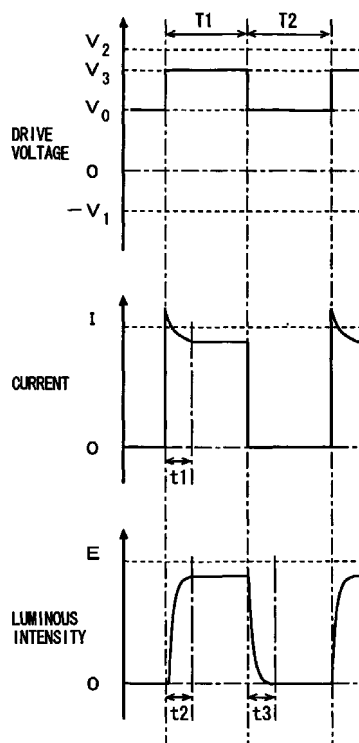
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(54) **Driving method and drive for organic electroluminescence element and display employing the same**

(57) A drive pulse application circuit applies a drive pulse alternately changing between a first voltage higher than a luminescence starting voltage and a second voltage higher than 0 V and not more than the luminescence starting voltage across a hole injection electrode and an electron injection electrode of an organic EL element.

FIG. 3



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Description

[0001] The present invention relates to a driving method for an organic electroluminescence element, a drive for an organic electroluminescence element and a display employing the same.

Description of the Prior Art

[0002] Following recent diversification of information apparatuses, requirement for flat display elements having smaller power consumption as compared with generally used CRTs (cathode ray tubes) is increased. A display employing an organic electroluminescence element (hereinafter referred to as an organic EL element) is actively subjected to research and development as one of such flat display elements. The display employing an organic EL element has average or high efficiency, is thin and lightweight, and has no viewing angle dependency.

[0003] The organic EL element injects electrons and holes into a luminescent part from an electron injection electrode and a hole injection electrode respectively for recombining the electrons and the holes at the luminescence center and exciting organic molecules for fluorescing when the organic molecules return from the excited state to a ground state. The organic EL element is formed by a plurality of luminous elements arranged on a substrate in the form of a matrix.

[0004] Such an organic EL element can advantageously be driven with a low voltage of about 5 V to 20 V. Further, the organic EL element, capable of obtaining luminous elements luminescing in proper colors by selecting fluorescent materials serving as luminescent materials, is expected for application to a multi- or full-color display. In addition, the organic EL element capable of surface luminescence with a low voltage can also be employed as a backlight for a display such as a liquid crystal display.

[0005] Reliability is an important factor for putting the organic EL element into practice. While a number of organic luminescent materials and doping materials have heretofore been studied for improving the luminescence life of the organic EL element, a method of increasing the life of the organic EL element by controlling a current supplied to the organic EL element is recently studied.

[0006] For example, each of Japanese Patent Laying-Open Nos. 11-3060 (1999) and 11-8064 (1999) discloses a technique of successively applying a forward-bias voltage and a reverse-bias voltage to an organic EL element.

[0007] In order to apply the organic EL element to a display, however, it is necessary to improve luminous efficiency (the ratio of luminance to applied power (unit: lm/W)) while attaining a long life. Therefore, it is desired to attain a long luminescence life while ensuring high luminous efficiency.

[0008] An object of the present invention is to provide a driving method for an organic electroluminescence element capable of attaining a long luminescence life while ensuring high luminous efficiency over a long period.

[0009] Another object of the present invention is to provide a drive for an organic electroluminescence element capable of attaining a long luminescence life while ensuring high luminous efficiency over a long period.

[0010] Still another object of the present invention is to provide a display employing an organic electroluminescence element capable of attaining a long luminescence life while ensuring high luminous efficiency over a long period.

[0011] According to an aspect of the present invention, a driving method for an organic electroluminescence element having a pair of electrodes comprises a step of applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting voltage and a second voltage higher than 0 V and not more than the luminescence starting voltage across the electrodes of the organic electroluminescence element.

[0012] When the first voltage exceeding the luminescence starting voltage is applied across the electrodes of the organic electroluminescence element in the driving method, a current flows to the organic electroluminescence element so that the organic electroluminescence element luminesces.

[0013] At this time, charging is caused due to influence by the capacitance of the organic electroluminescence element itself when rising to the first voltage so that the current is instantaneously increased and thereafter stabilized to a constant value. In this case, the second voltage higher than 0 V and not more than the luminescence starting voltage has been applied across the electrodes of the organic electroluminescence element before rising to the first voltage, whereby the charging time is reduced. Therefore, luminous intensity is increased to a constant level in a shorter time.

[0014] When the second voltage is applied across the electrodes of the organic electroluminescence element, charges stored in the organic electroluminescence element upon application of the first voltage flow in the organic electroluminescence element for some time without flowing out. Thus, holes and electrons recombine to contribute to the luminescence. Consequently, the luminescence continues for a constant time also after falling to the second voltage, and thereafter stops.

[0015] Thus, the luminous intensity is increased to the constant level in a short time upon application of the first voltage and the luminescence continues in the initial stage of application of the second voltage, whereby the total luminescent time is increased. Further, it is not necessary to apply a high voltage for obtaining prescribed average luminance. Consequently, high luminous efficiency is attained.

[0016] The first and second voltages are alternately applied to the organic electroluminescence element so that the organic electroluminescence element intermittently luminesces, whereby reduction of the luminance remains small over a long period and a long life is attained.

[0017] The second voltage is preferably substantially equal to the luminescence starting voltage. In this case, higher luminous efficiency can be attained.

[0018] The duty ratio of the drive pulse is preferably greater than zero and not more than 50 %. Thus, the luminescence life of the organic electroluminescence element is improved. In particular, the duty ratio of the drive pulse is more preferably not more than 10 %. Thus, the luminescence life of the organic electroluminescence element is further improved. The duty ratio of the drive pulse is further preferably at least 0.2 %. Further, the duty ratio or the drive pulse may be at least 1 %. Thus, the luminescence life of the organic electroluminescence element is further improved.

[0019] According to another aspect of the present invention, a drive for driving an organic electroluminescence element having a pair of electrodes comprises a drive pulse application circuit applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting voltage and a second voltage higher than 0 V and not more than the luminescence starting voltage across the electrodes of the organic electroluminescence element.

[0020] In this drive, luminous intensity is increased to a constant level in a short time upon application of the first voltage and the luminescence continues in an initial stage of application of the second voltage, whereby the total luminescent time is increased. Further, it is not necessary to apply a high voltage for obtaining prescribed average luminance. Consequently, high luminous efficiency is attained.

[0021] The first and second voltages are alternately applied to the organic electroluminescence element so that the organic electroluminescence element intermittently luminesces, whereby reduction of luminance remains small over a long period and a long life is attained.

[0022] The second voltage is preferably substantially equal to the luminescence starting voltage. In this case, higher luminous efficiency can be attained.

[0023] The duty ratio of the drive pulse is preferably greater than zero and not more than 50 %. Thus, the luminescence life of the organic electroluminescence element is improved. In particular, the duty ratio of the drive pulse is more preferably not more than 10 %. Thus, the luminescence life of the organic electroluminescence element is further improved. The duty ratio of the drive pulse is further preferably at least 0.2 %. Further, the duty ratio or the drive pulse may be at least 1 %. In this case, the luminescence life of the organic electroluminescence element is further improved.

[0024] According to still another aspect of the present invention, a display comprises one or a plurality of organic electroluminescence elements each having a pair of electrodes and a drive applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting voltage and a second voltage higher than 0 V and not more than the luminescence starting voltage across the electrodes of each of one or a plurality of organic electroluminescence elements.

[0025] In the display, luminous intensity is increased to a constant level in a short time upon application of the first voltage and the luminescence continues in an initial stage of application of the second voltage, whereby the total luminescent time is increased. Further, it is not necessary to apply a high voltage for obtaining prescribed average luminance. Consequently, high luminous efficiency is attained.

[0026] The first and second voltages are alternately applied to the organic electroluminescence element so that the organic electroluminescence element intermittently luminesces, whereby reduction of luminance remains small over a long period and a long life is attained.

[0027] The drive may include a first driver supplying a drive signal to one of the electrodes of each of one or a plurality of organic electroluminescence elements and a second driver supplying a selection signal to the other one of the electrodes of each of one or a plurality of organic electroluminescence elements, and the drive signal and the selection signal may be so set as to apply the drive pulse across the electrodes of a selected organic electroluminescence element.

[0028] In this case, the drive pulse alternately changing between the first voltage higher than the luminescence starting voltage and the second voltage higher than 0 V and not more than the luminescence starting voltage is applied across the electrodes of the selected organic electroluminescence element by the first and second drivers, so that the selected organic electroluminescence element luminesces.

[0029] Each organic electroluminescence element includes a transparent substrate, a hole injection electrode, an organic luminescent layer and an electron injection electrode in this order, and the pair of electrodes are the hole injection electrode and the electron injection electrode.

[0030] The second voltage is preferably substantially equal to the luminescence starting voltage. In this case, higher luminous efficiency can be attained.

[0031] The duty ratio of the drive pulse is preferably greater than zero and not more than 50 %. Thus, the luminescence life of the organic electroluminescence element is improved. In particular, the duty ratio of the drive pulse is more preferably not more than 10 %. Thus, the luminescence life of the organic electroluminescence element is further improved. The duty ratio of the drive pulse is further preferably at least 0.2 %. Further, the duty ratio or the drive pulse

may be at least 1 %. Thus, the luminescence life of the organic electroluminescence element is further improved.

[0032] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

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Fig. 1 is a model diagram showing an exemplary structure of an organic EL element and a drive pulse application circuit;

Fig. 2 is a voltage waveform diagram of a drive pulse applied by the drive pulse application circuit shown in Fig. 1 to the organic EL element;

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Fig. 3 illustrates a drive voltage applied to the organic EL element, a current flowing in the organic EL element and luminous intensity of the organic EL element in Inventive Example;

Fig. 4 illustrates a drive voltage applied to the organic EL element, a current flowing in the organic EL element and luminous intensity of the organic EL element in comparative example 1;

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Fig. 5 illustrates a drive voltage applied to the organic EL element, a current flowing in the organic EL element and luminous intensity of the organic EL element in comparative example 2;

Fig. 6 illustrates the relation between luminous efficiency of the organic EL element and the drive voltage;

Fig. 7 illustrates time changes of luminance in a continuous luminescence experiment on Inventive Example and comparative examples 1 and 2;

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Fig. 8 illustrates time changes of luminous efficiency in the continuous luminescence experiment on Inventive Example and comparative examples 1 and 2;

Fig. 9 illustrates results of measurement of drive pulse duty ratio dependency of a luminescence life;

Fig. 10 is a block diagram showing an exemplary structure of a display employing a drive according to the present invention; and

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Fig. 11 is a waveform diagram showing exemplary drive pulses applied to organic EL elements of respective rows of the display shown in Fig. 10.

[0033] Fig. 1 is a model diagram showing an exemplary structure of an organic electroluminescence element (hereinafter referred to as an organic EL element) 20 and a drive pulse application circuit 10.

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[0034] In the organic EL element 20 shown in Fig. 1, a hole injection electrode 2 of ITO (indium-tin oxide) serving as a transparent conductive film is formed on a glass substrate 1. A hole transport layer 3 of 200 Å in thickness made of MTDATA (4,4',4''-tris(3-methylphenylphenylamino)triphenyl-amine) having a molecular structure expressed in the following chemical formula (1) is formed on the hole injection electrode 2. An organic luminescent layer 4 of 300 Å in thickness prepared by doping TPD (N,N'-diphenyl-N,N'-(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine) having a molecular structure expressed in the following chemical formula (2) with 5 % of rubrene having a molecular structure expressed in the following chemical formula (3) is formed on the hole transport layer 3. An electron transport layer 5 of 500 Å in thickness made of Alq₃ (tris(8-hydroxy-quinolate)aluminum) having a molecular structure expressed in the following chemical formula (4) is formed on the organic luminescent layer 4. An electron injection electrode 6 of 2000 Å in thickness made of MgIn is formed on the electron transport layer 5.

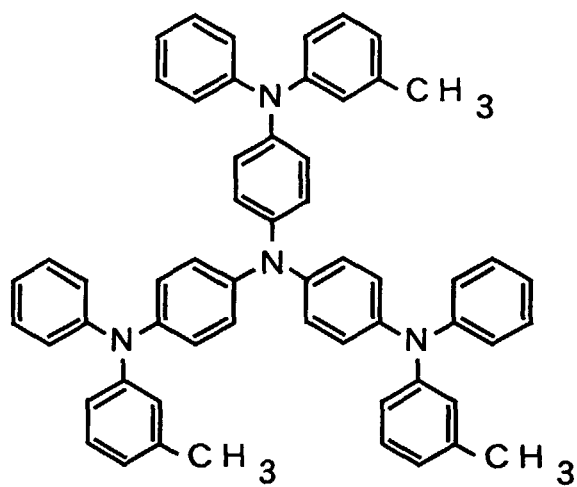
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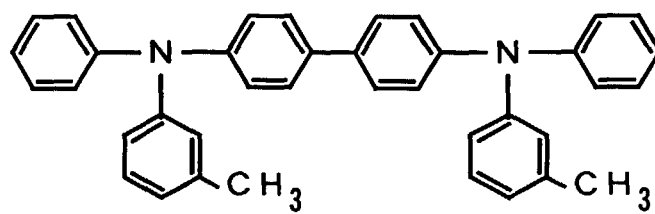
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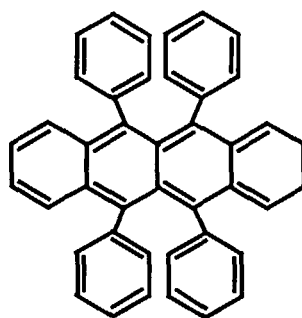
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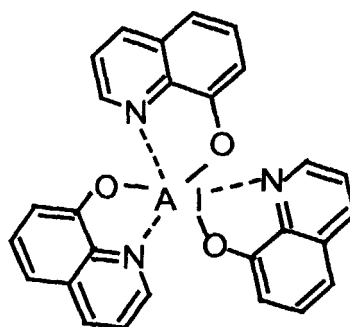
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(3)



(4)



[0035] The drive pulse application circuit 10 is connected between the hole injection electrode 2 and the electron injection electrode 6 of the organic EL element 20. The drive pulse application circuit 10 applies a drive pulse to the organic EL element 20 as described later. Thus, the organic luminescent layer 4 of the organic EL element 20 luminesces so that light 100 outgoes from the rear surface of the glass substrate 1.

[0036] Fig. 2 is a voltage waveform diagram of the drive pulse applied by the drive pulse application circuit 10 shown in Fig. 1 to the organic EL element 20.

[0037] As shown in Fig. 2, the drive pulse alternately changes between a first voltage higher than a luminescence starting voltage (luminescence threshold voltage) V_0 and a second voltage higher than 0 V and lower than the luminescence starting voltage V_0 . The frequency of the drive pulse is in the range of 30 Hz to 10 kHz, for example.

[0038] The period when the drive pulse is at the first voltage is referred to as a luminous period T1, and the period when the drive pulse is at the second voltage is referred to as a non-luminous period T2.

[0039] The organic EL element 20 is substantially luminous in the luminous period T1 and substantially non-luminous in the non-luminous period T2. More correctly, the luminous period T1 includes a non-luminous time of the organic EL element 20, and the non-luminous period T2 includes a luminous time of the organic EL element 20, as described later.

[0040] A continuous luminescence experiment was made by applying drive voltages to the organic EL element 20 by driving methods according to Inventive Example and comparative examples 1 and 2 for analyzing voltage waveforms, current waveforms and luminous intensity values and examining time changes of luminance and luminous efficiency.

[0041] The drive pulse shown in Fig. 2 was applied to the organic EL element 20 by the drive pulse application circuit 10 shown in Fig. 1 in Inventive Example, while a constant voltage higher than the luminescence starting threshold voltage V_0 was applied to the organic EL element 20 in comparative example 1 and a forward bias voltage and a reverse bias voltage were alternately applied to the organic EL element 20 in comparative example 2.

[0042] Fig. 3 shows the drive voltage applied to the organic EL element 20, a current flowing in the organic EL element 20 and luminous intensity of the organic EL element 20 in Inventive Example. Fig. 4 shows the drive voltage applied to the organic EL element 20, a current flowing in the organic EL element 20 and luminous intensity of the organic EL element 20 in comparative example 1. Fig. 5 shows the drive voltage applied to the organic EL element 20, a current flowing in the organic EL element 20 and luminous intensity of the organic EL element 20 in comparative example 2. Referring to Fig. 5, the period when the drive voltage is set to the forward bias voltage is referred to as a luminous period T1, and the period when the drive voltage is set to the reverse bias voltage is referred to as a non-luminous period T2.

[0043] In this continuous luminescence experiment, each drive voltage was so set that the average value of the current flowing in the organic EL element 20 was regularly constant from starting of luminescence to the end of the experiment, for driving the organic EL element 20 with a constant current. When the organic EL element 20 is deteriorated by continuous luminescence and internal resistance is increased, therefore, it follows that the drive voltage gradually increases.

[0044] Table 1 shows experimental conditions for Inventive Example and comparative examples 1 and 2.

Table 1

INVENTIVE EXAMPLE	FREQUENCY:1kHz DUTY RATIO OF DRIVE VOLTAGE:50% FIRST VOLTAGE (INITIAL): $V_3=5.4V$ SECOND VOLTAGE: $V_0=3.8V$
COMPARATIVE EXAMPLE 1	DRIVE VOLTAGE: DC 5 V
COMPARATIVE EXAMPLE2	FREQUENCY:1kHz DUTY RATIO OF DRIVE VOLTAGE:50% FORWARD BIAS VOLTAGE (INITIAL): $V_2=5.8V$ REVERSE BIAS VOLTAGE (CONSTANT): $-V_1=-10V$

[0045] In this continuous luminescence experiment, the drive voltages were so adjusted as to attain the same average luminance in Inventive Example and comparative examples 1 and 2. Initial average luminance levels of Inventive Example and comparative examples 1 and 2 were set to the same level of 300 cd/m^2 .

[0046] As shown in Fig. 3, the drive voltage is set to a first voltage V_3 higher than the luminescence starting voltage V_0 in the luminous period T1 in Inventive Example. Further, the drive voltage is set to a second voltage identical to the luminescence starting voltage V_0 in the non-luminous period T2.

[0047] When the drive voltage is set to the first voltage V_3 in the luminous period T1, a current flows in the organic EL element 20, which in turn luminesces. When the drive voltage rises, charging is caused due to influence by the capacitance of the organic EL element 20 itself so that the current is instantaneously increased and thereafter stabilized to a constant value. In this case, a charging time t_1 is reduced since the drive voltage has been set to the luminescence threshold voltage V_0 in the preceding non-luminous period T2. Therefore, luminous intensity is increased to a constant level in a shorter time t_2 .

[0048] When the drive voltage is set to the luminescence threshold voltage V_0 in the non-luminous period T2, the current flowing in the organic EL element 20 reaches zero. At this time, charges stored in the organic EL element 20 in the luminous period T1 flow in the organic EL element 20 for some time without flowing out. Thus, holes and electrons recombine to contribute to the luminescence. Consequently, the luminescence continues in an initial time t_3 of the non-luminous period T2. Thereafter the luminescence of the organic EL element 20 stops.

[0049] As shown in Fig. 4, the drive voltage is set to a constant voltage higher than the luminescence starting voltage V_0 in comparative example 1. Thus, a constant current continuously flows in the organic EL element 20, which in turn continuously luminesces with constant luminous intensity.

[0050] As shown in Fig. 5, the drive voltage is set to a forward bias voltage V_2 higher than the luminescence starting voltage V_0 in the luminous period T1 in comparative example 2. Further, the drive voltage is set to a reverse bias voltage $-V_1$ in the non-luminous period T2. In this case, the drive voltage in the luminous period T1 is set higher than the first voltage V_3 in Inventive Example and the drive voltage in comparative example 1, in order to equalize average luminance of comparative example 2 with those of Inventive Example and comparative example 1.

[0051] When the drive voltage is set to the forward bias voltage V_2 in the luminous period T1, a current flows in the organic EL element 20, which in turn luminesces. Charging is caused in an initial period of the luminous period T1 due to influence by the capacitance of the organic EL element 20 itself so that a large current flows in the organic EL element 20 and the current is thereafter stabilized to a constant value. Therefore, the organic EL element 20 remains non-luminous in the initial stage of the luminous period T1 while luminous intensity starts to increase in a delay by a prescribed time from application of the forward bias voltage V_2 and is thereafter stabilized to a constant level. In this case, a charging time t_4 is lengthened since the drive voltage has been set to the reverse bias voltage $-V_1$ in the preceding non-luminous period T2. Consequently, a time t_6 required for the luminous intensity to rise to the constant level is lengthened.

[0052] When the drive voltage is set to the reverse bias voltage $-V_1$ in the non-luminous period T2, a large reverse current first flows due to discharge of charges stored in the organic EL element 20, and thereafter the current approaches zero due to rectification of the organic EL element 20 and reaches zero at a time t_5 . In this case, the charges stored in the organic EL element 20 are immediately reversely discharged and hence the luminescence stops simultaneously with application of the reverse bias voltage $-V_1$.

[0053] Fig. 6 illustrates the relation between the luminous efficiency of the organic EL element 20 and the drive voltage. As shown in Fig. 6, the luminous efficiency of the organic EL element 20 is maximized when the drive voltage is

set to the luminescence starting voltage V_0 , and reduced as the drive voltage is increased. Therefore, the luminous efficiency is reduced when driving the organic EL element 20 with a high voltage.

[0054] In the driving method according to Inventive Example, the luminous intensity is increased to the prescribed level in a short time in the luminous period T1 while the luminescence of the organic EL element 20 continues in the initial stage of the non-luminous period T2 as shown in Fig. 3, whereby the total luminescent time is increased. Further, the drive voltage can be set lower than that in comparative example 2 in order to attain prescribed average luminance. Consequently, the luminous intensity is increased.

[0055] In the driving method according to comparative example 2, a long time is required for increasing the luminous intensity to a prescribed level in the luminous period T1 while the organic EL element 20 is absolutely non-luminous in the non-luminous period T2, and hence the total luminescent time is reduced. Further, the drive voltage must be set high for attaining prescribed average luminance. Thus, the luminous efficiency is reduced.

[0056] When setting the drive voltage not to the reverse bias voltage $-V_1$ but to 0 V in the non-luminous period T2, the luminous efficiency exhibits a tendency similar to that shown in Fig. 5 although the same is slightly improved as compared with comparative example 2.

[0057] Fig. 7 illustrates time changes of luminance in the continuous luminescence experiment on Inventive Example and comparative examples 1 and 2. The half-life of the luminance is regarded as the life.

[0058] The life of comparative example 1 was about 3000 hours, while that of comparative example 2 was about 10000 hours. The life of Inventive Example was about 7000 hours, i.e., at least twice that of comparative example 1.

[0059] Fig. 8 illustrates time changes of luminous efficiency in the continuous luminescence experiment on Inventive Example and comparative examples 1 and 2.

[0060] As shown in Fig. 8, comparative example 2 exhibited low initial luminous efficiency of 3.8 (lm/W), which was gradually reduced following continuous luminescence. Comparative example 1 exhibited the highest initial luminous efficiency of 5.0 (lm/W), which was abruptly reduced following continuous luminescence to reach a level similar to the luminous efficiency of comparative example 2 after a lapse of 3000 hours. While Inventive Example exhibited initial luminous efficiency of 4.6 (lm/W) slightly lower than that of comparative example 1, reduction of the luminous efficiency following continuous luminescence was so small that the luminous efficiency of Inventive Example exceeded that of comparative example 1 after a lapse of several 100 hours. Further, Inventive Example constantly exhibited higher luminous efficiency than comparative example 2.

[0061] According to a drive and a driving method of Inventive Example, as hereinabove described, a long luminescence life can be attained while ensuring high luminous efficiency, and reduction of the luminous efficiency remains small in continuous luminescence over a long period.

[0062] In the driving method according to the present invention, the second voltage of the drive pulse is preferably set in the range of at least 70 % of the luminescence starting voltage V_0 and not more than the luminescence starting voltage V_0 for attaining higher luminous efficiency, more preferably set in the range of at least 80 % of the luminescence starting voltage V_0 and not more than the luminescence starting voltage V_0 , further preferably set in the range of at least 90 % of the luminescence starting voltage V_0 and not more than the luminescence starting voltage V_0 , and most preferably set to the luminescence starting voltage V_0 .

[0063] The relation between the luminescence life and the duty ratio of the drive pulse was measured with reference to the organic EL element 20 shown in Fig. 1. The organic EL element 20 was driven with a constant current, and the drive pulse shown in Fig. 2 was applied to the organic EL element 20. In this case, the frequency of the drive pulse was set to 100 Hz, and the duty ratio of the drive pulse was set to 50 %, 10 % and 1 %. The second voltage was set to the luminescence starting voltage V_0 . For the purpose of comparison, the organic EL element 20 was driven with a direct current (duty ratio: 100 %).

[0064] Fig. 9 shows the results of measurement of drive pulse duty ratio dependency of the luminescence life. Referring to Fig. 9, the horizontal axis shows the duty ratio of the drive pulse, and the vertical axis shows the ratio of improvement of the luminescence life upon pulse driving with respect to the luminescence life upon dc driving. When the luminance is reduced to 70 % of the initial level, the organic EL element 20 is regarded as getting to the end of its life.

[0065] As shown in Fig. 9, the ratio of improvement of the luminescence life was about twice to three times that upon dc driving when the duty ratio of the drive pulse was 50 %, while a remarkable ratio of improvement of the luminescence life of at least 20 times was attained when the duty ratio of the drive pulse was not more than 10 %. When the duty ratio of the drive pulse was not more than 1 %, the ratio of improvement of the luminescence life was slightly lowered as compared with that with the drive pulse having the duty ratio of 10 %. Also when the duty ratio of the drive pulse was 0.2 %, a ratio of improvement of the luminescence life similar to that with the drive pulse having the duty ratio of 1 % was attained although this result is now shown in Fig. 9.

[0066] It is understood from the aforementioned results that the duty ratio of the drive pulse is preferably greater than zero and not more than 50 %. The duty ratio of the drive pulse is more preferably not more than 10 %. The duty ratio of the drive pulse is further preferably at least 0.2 %.

[0067] Fig. 10 is a block diagram showing an exemplary structure of a display employing a drive according to the present invention.

[0068] In the display shown in Fig. 10, a plurality of organic EL elements 20 each having the structure shown in Fig. 1 are arranged on a common substrate in the form of a matrix of n rows and m columns, where n and m represent arbitrary integers of at least two.

[0069] Hole injection electrodes 2 (see Fig. 1) of a plurality of organic EL elements 20 forming each row are connected with a drive signal line 31. A plurality of such drive signal lines 31 corresponding to the plurality of rows are connected with a row driver 30. The row driver 30 applies a drive signal to the plurality of drive signal lines 31 respectively.

[0070] Electron injection electrodes 6 (see Fig. 1) of a plurality of organic EL elements 20 forming each column are connected with a column selection signal line 41. A plurality of such column selection signal lines 41 corresponding to the plurality of columns are connected with a column driver 40. The column driver 40 sequentially applies a column selection signal to the plurality of column selection lines 41.

[0071] The drive signal applied to the drive signal lines 31 by the row driver 30 and the column selection signal applied to the column signal selection lines 41 by the column driver 40 are so set as to apply the first voltage V_3 higher than the luminescence starting voltage V_0 to luminous organic EL elements 20 while applying the second voltage, equal to the luminescence starting voltage V_0 , to non-luminous organic EL elements 20.

[0072] Fig. 11 is a waveform diagram showing exemplary drive pulses applied to organic EL elements 20 of first to n -th rows of the display shown in Fig. 10. As shown in Fig. 11, the first voltage higher than the luminescence starting voltage V_0 is applied to the organic EL elements 20 in a luminous state while the second voltage equal to the luminescence starting voltage V_0 is applied to the organic EL elements 20 in a non-luminous state. The luminance varies with the level of the first voltage applied to the organic EL elements 20 in the luminous state.

[0073] While the organic EL element 20 shown in Fig. 1 has the organic luminescent layer 4 formed by doping TPD with rubrene, the drive and the driving method according to the present invention are also readily applicable to various organic EL elements employing other organic materials.

[0074] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Claims

1. A driving method for an organic electroluminescence element having a pair of electrodes, comprising a step of applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting voltage and a second voltage higher than 0 V and not more than said luminescence starting voltage across said electrodes of said organic electroluminescence element.
2. The driving method according to claim 1, wherein said second voltage is substantially equal to said luminescence starting voltage.
3. The driving method according to claim 1, wherein the duty ratio of said drive pulse is greater than zero and not more than 50 %.
4. The driving method according to claim 3, wherein the duty ratio of said drive pulse is not more than 10 %.
5. A drive for driving an organic electroluminescence element having a pair of electrodes, comprising: a drive pulse application circuit applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting voltage and a second voltage higher than 0 V and not more than said luminescence starting voltage across said electrodes of said organic electroluminescence element.
6. The drive according to claim 5, wherein said second voltage is substantially equal to said luminescence starting voltage.

7. The drive according to claim 5, wherein

the duty ratio of said drive pulse is greater than zero and not more than 50 %.

5 8. The drive according to claim 7, wherein

the duty ratio of said drive pulse is not more than 10 %.

9. A display comprising:

10 one or a plurality of organic electroluminescence elements each having a pair of electrodes; and
a drive applying a drive pulse alternately changing between a first voltage exceeding a luminescence starting
voltage and a second voltage higher than 0 V and not more than said luminescence starting voltage across
said electrodes of each of said one or a plurality of organic electroluminescence elements.

15 10. The display according to claim 9, wherein

said drive includes:

20 a first driver supplying a drive signal to one of said electrodes of each of said one or a plurality of organic elec-
troluminescence elements, and
a second driver supplying a selection signal to the other one of said electrodes of each of said one or a plurality
of organic electroluminescence elements, and
said drive signal and said selection signal are so set as to apply said drive pulse across said electrodes of
selected said organic electroluminescence element.

25 11. The display according to claim 10, wherein

each of said organic electroluminescence elements include a transparent substrate, a hole injection electrode,
an organic luminescent layer and an electron injection electrode in this order, and said pair of electrodes are
30 said hole injection electrode and said electron injection electrode.

12. The display according to claim 10, wherein

said second voltage is substantially equal to said luminescence starting voltage.

35 13. The display according to claim 10, wherein

the duty ratio of said drive pulse is greater than zero and not more than 50 %.

40 14. The display according to claim 13, wherein the duty ratio of said drive pulse is not more than 10 %.

45

50

55

FIG. 1

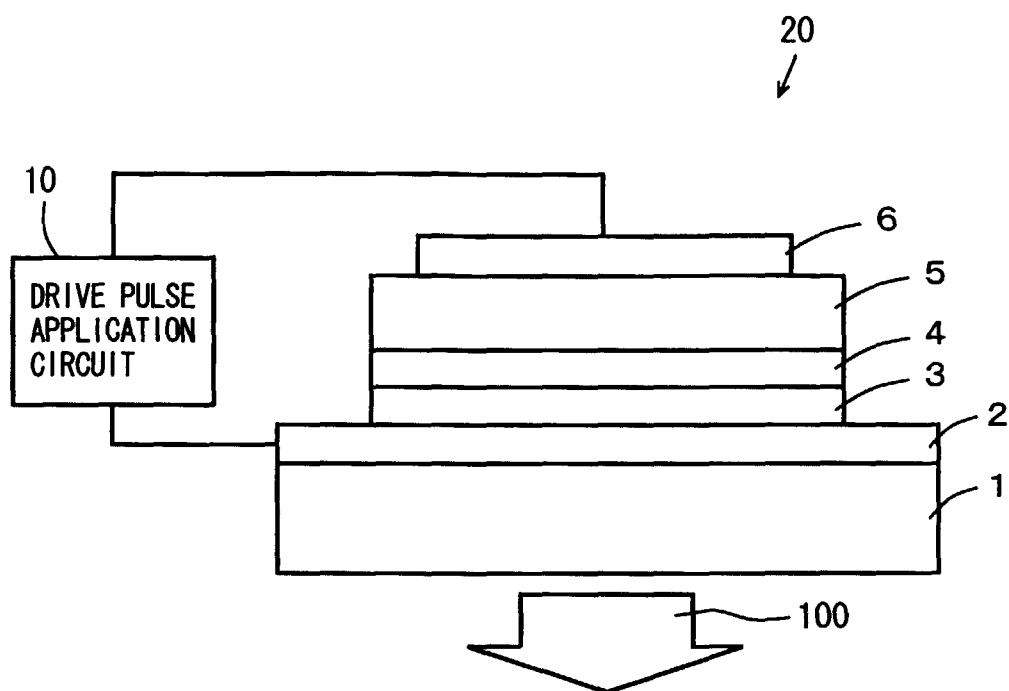
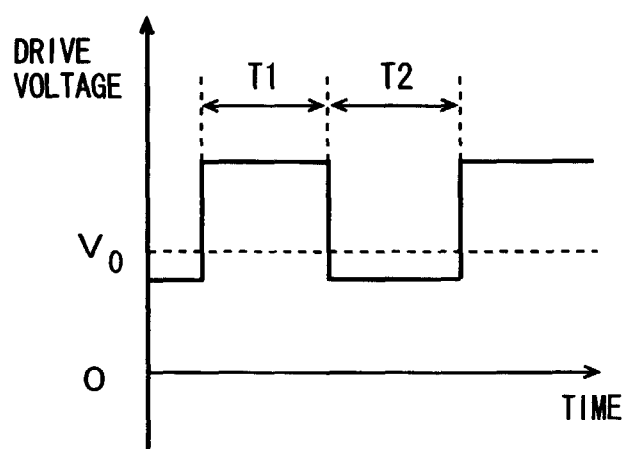
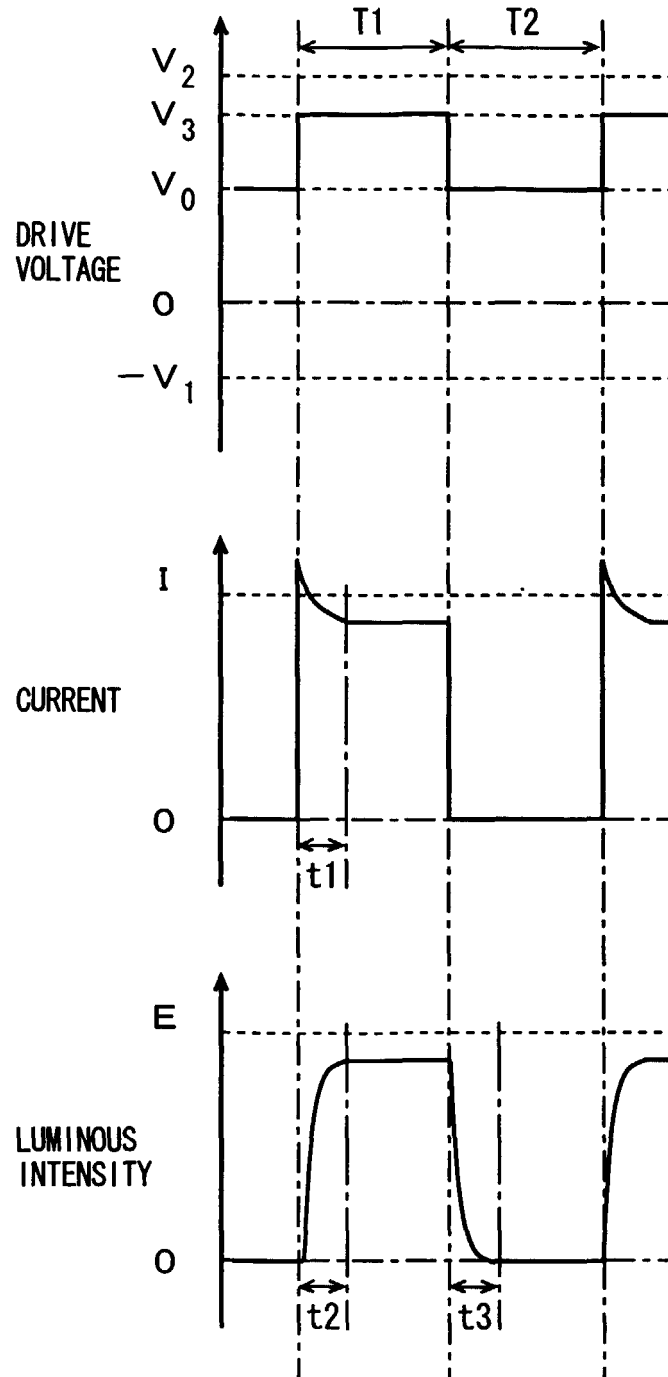


FIG. 2



F I G. 3



F I G. 4

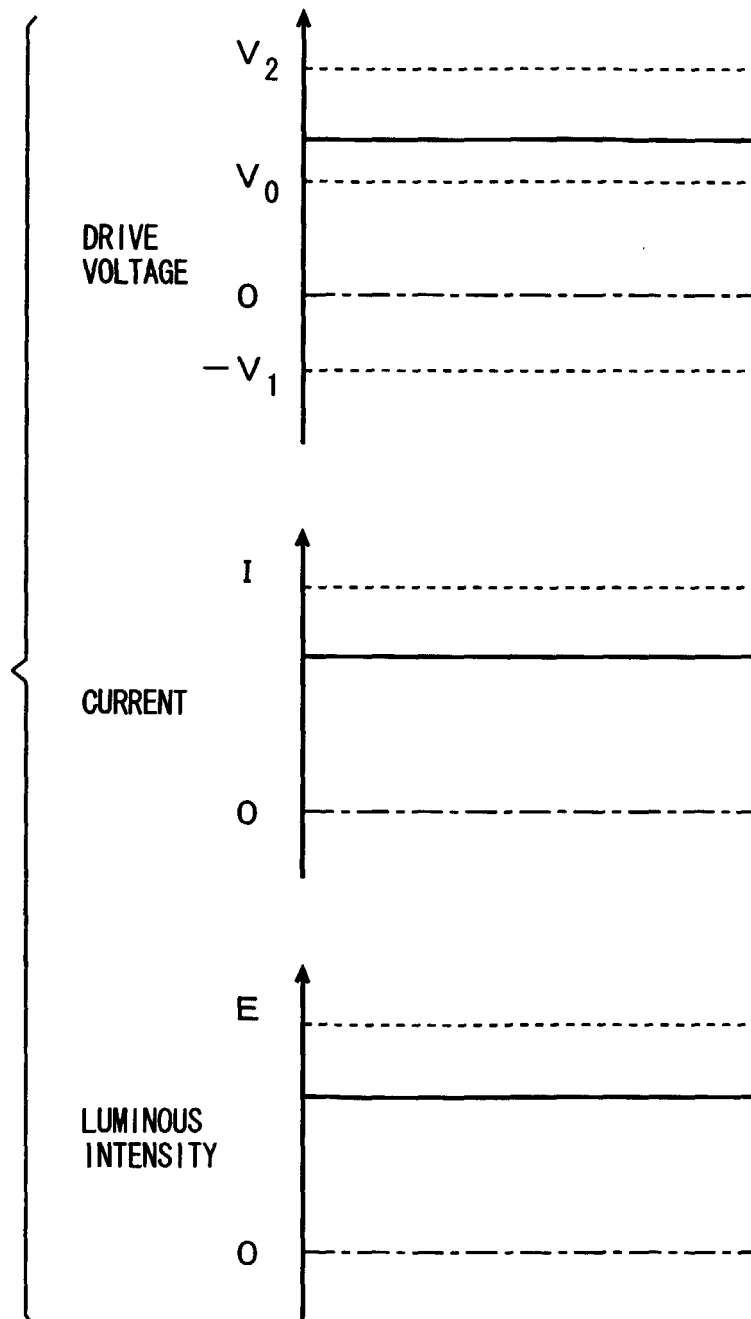


FIG. 5

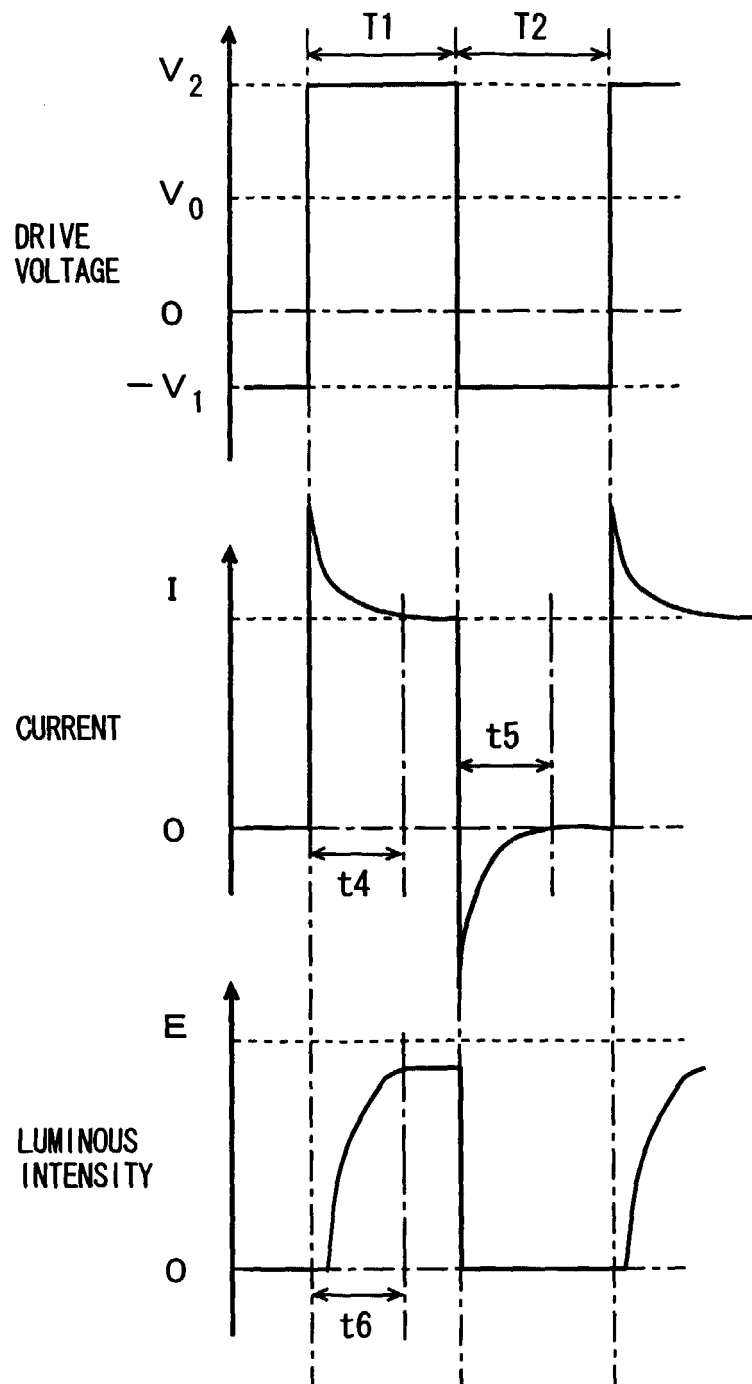


FIG. 6

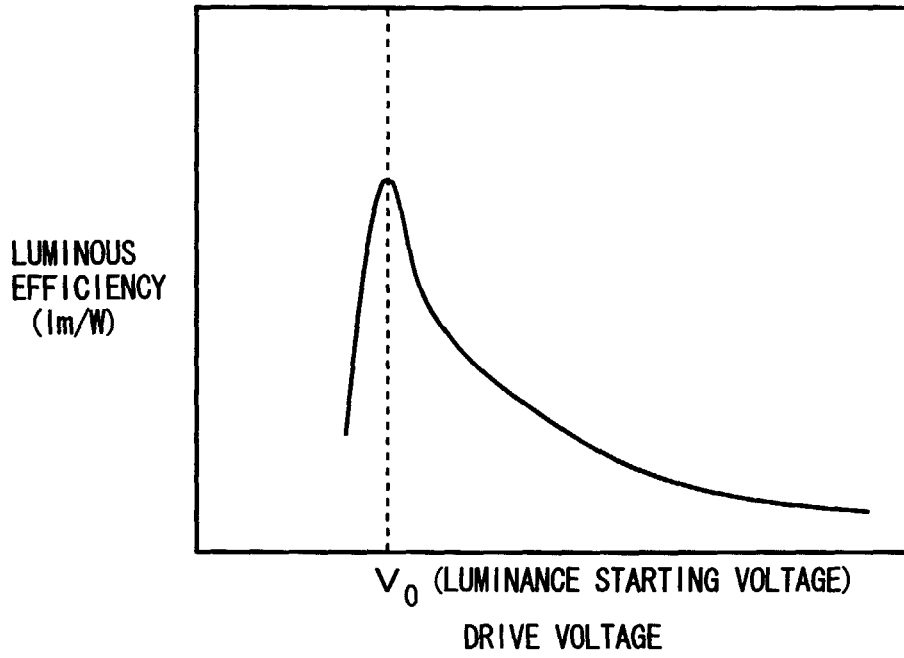


FIG. 7

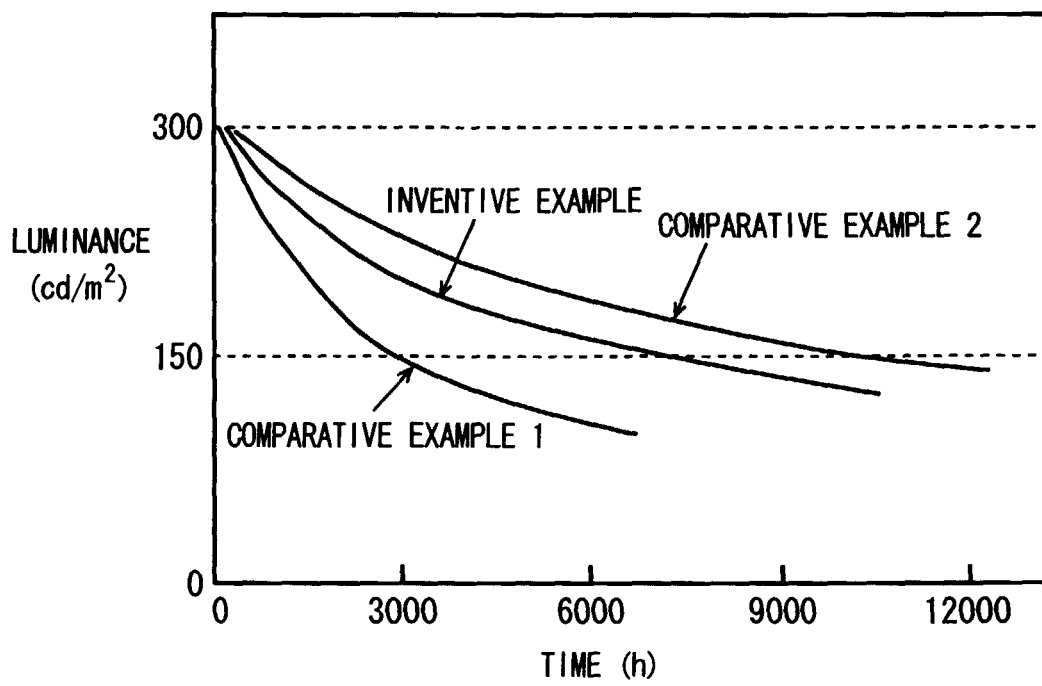


FIG. 8

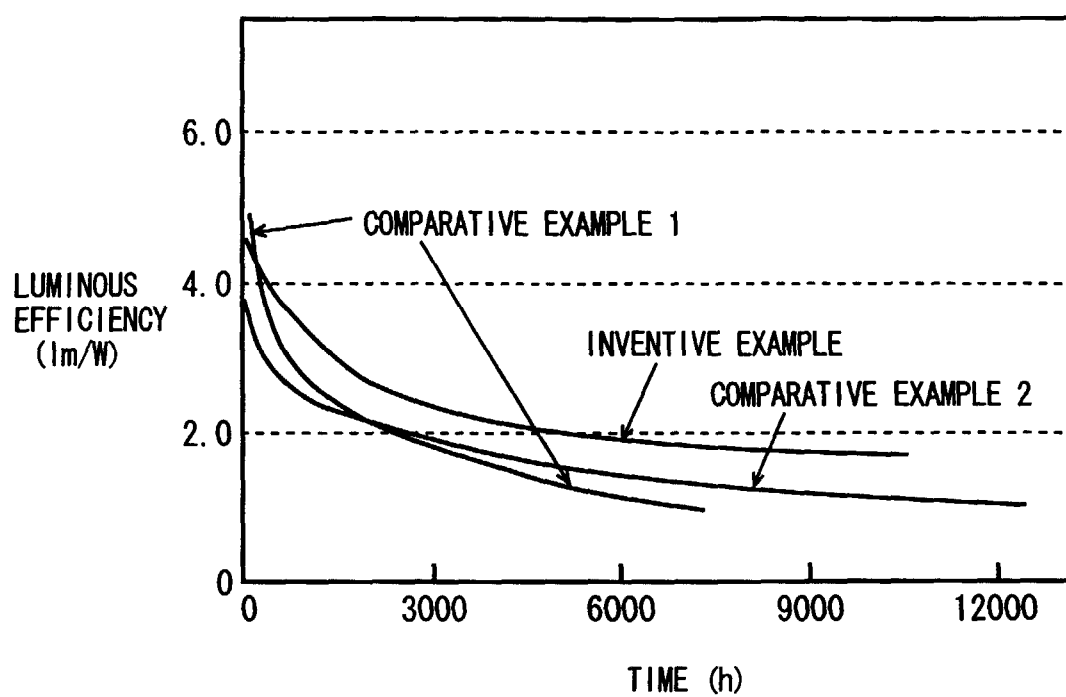


FIG. 9

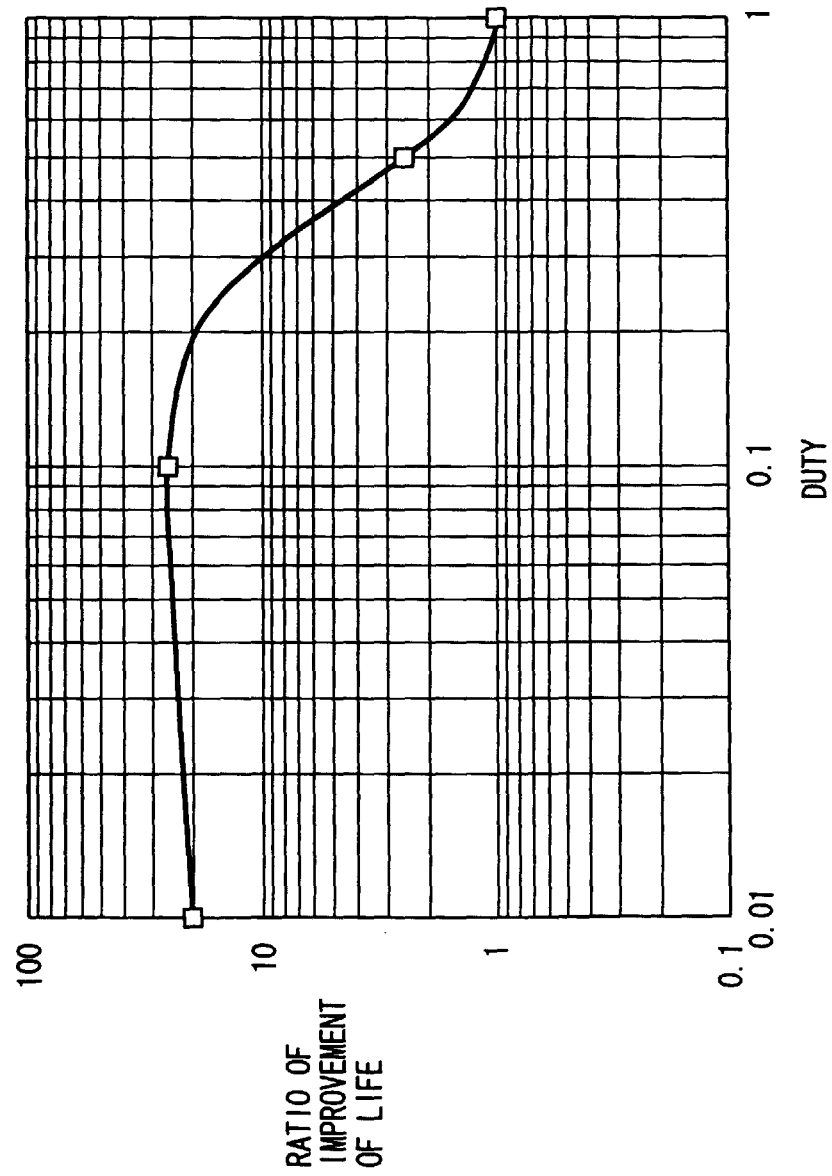


FIG. 10

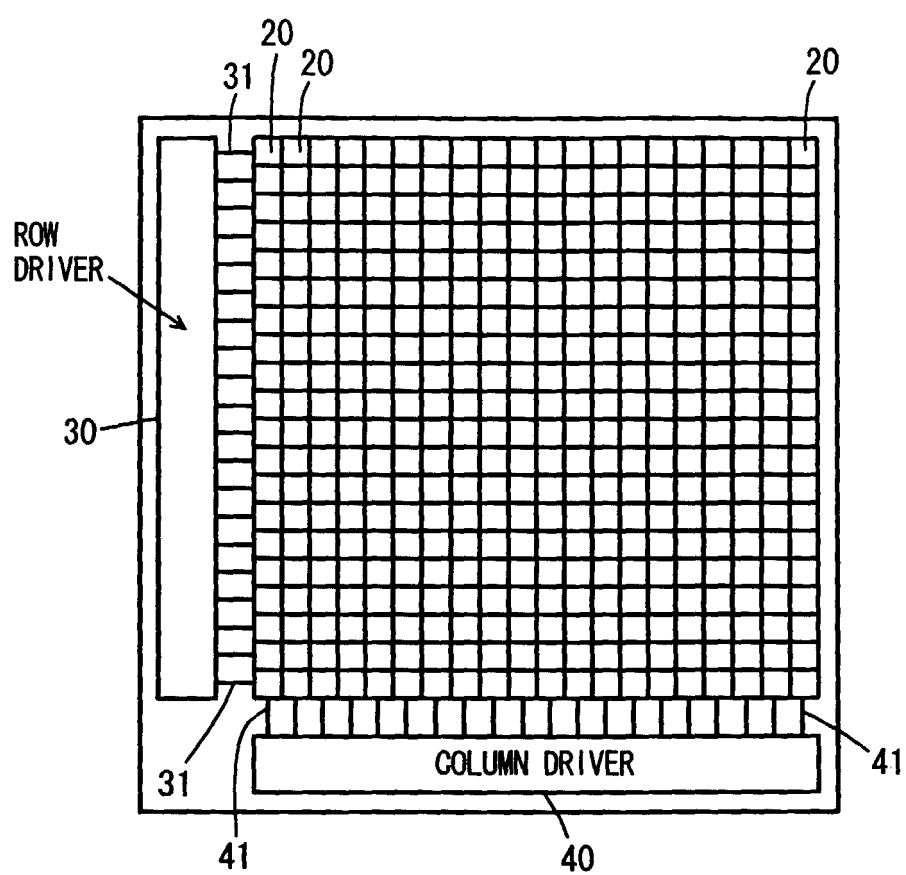


FIG. 11

