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(54) Title: LIGHT-EMITTING DIODE ILLUMINATION SOURCE

(57) Abstract: The invention provides light emitting diode illumination source having excellent properties as an illumination source such as a flat spectral distribution in the wavelength region from green to red and a sufficient emission intensity in the red region, comprising a light emitting diode having multiple peaks with a half-value width of 20 nm or more within a range from 480 to 700 nm in a spectral distribution, wherein the minimum of the intensities of the valleys between the peaks in the wavelength range from 480 to 700 nm is 65 % or more of the maximum peak intensity in the same range, and an illuminator and a backlight for a liquid crystal display using the illumination source.

WO 2006/057421 A1

DESCRIPTION

Light-Emitting Diode Illumination Source

CROSS-REFERENCE TO RELATED APPLICATIONS

This is an application filed pursuant to 35 U.S.C. Section 111(a) with claiming the benefit of U.S. provisional application Serial No. 60/632,986 filed December 6, 2004 and U.S. provisional application Serial No. 60/653,996 filed February 18, 2005 under the provision of 35 U.S.C. 111(b), pursuant to 35 U.S.C. Section 119(e)(1).

TECHNICAL FIELD

The present invention relates to an illumination source using a light emitting diode (LED), an illuminator, and a backlight for a liquid crystal display.

BACKGROUND ART

Light emitting diode devices are improved remarkably in terms of light emitting efficiency and are free from mercury which is a toxic substance, whereby use thereof for illumination instead of conventional fluorescent lamps has energetically been studied in recent years. It is preferred that an illumination source emits a light having a spectral distribution close to that of sunlight. Thus, it is preferred that the illumination source has a flat spectral distribution containing components with every wavelength in the optical region. As white light source using light emitting diode devices, those obtained by a combination of three light emitting diodes for red, green, and blue emission or a combination of a light emitting diode for blue to ultraviolet emission and a

photoluminescent material which absorbs the light emission, to thereby emit light from red to green, have been used. Examples of the former include so-called a three-in-one LED light source in which LEDs for red (AlInGaP), green (InGaN) and blue (InGaN) are included in one unit, and examples of the latter include a light source in which an InGaN-based blue LED and a so-called YAG fluorescent material to absorb a blue light to thereby produce a yellow fluorescence are combined.

DISCLOSURE OF THE INVENTION

However, conventional LED light sources do not have flat spectral distributions and do not include sufficient components for all wavelengths. For example, since a typical example of a spectral distribution curve of a three-in-one type light source as shown in Fig. 4 has sharp peaks within the blue, green, and red wavelength regions and deep valleys between the peaks, it is difficult for such a light source to show colors with wavelengths corresponding to the valleys when used for illumination.

Further, white light sources using a so-called YAG fluorescent material and a blue LED in combination have widely been used as backlights for liquid crystal displays of cellular phones. However, since such a light source has a spectral distribution with only components for blue and its complementary color, yellow as shown in Fig. 3, it is difficult for the light source to show red particularly. In order to improve the distribution, many attempts to develop a fluorescent material for red emission and to mix fluorescent materials for multiple colors have been made. However, it is difficult to mix fluorescent materials with different crystal structures, and therefore attempts to obtain a satisfactory flat

spectral distribution have been unsuccessful.

Accordingly, an object of the present invention is to provide an LED light source having excellent properties for illumination, which has a flat spectral distribution within the green to red wavelength region and has a sufficient emission intensity also in the red region.

The inventors have made intense researches in view of using a light emitting diode as a light source in combination with a multiple kinds of photoluminescent materials to obtain an LED light source having a flat spectral distribution. As a result, the inventors have found out that excellent spectral distribution properties can be obtained by using iridium complexes as photoluminescent materials, and thereby the present invention have been accomplished. Since the iridium complexes used in the invention have chemical structures similar to each other even if they emit different colors, they can be mixed with each other at an arbitrary ratio. Therefore, by mixing multiple kinds of iridium complexes having different emission peak wavelengths, an LED light source having a flat spectral distribution in the green to red regions can be constituted.

Thus, the invention includes the following light emitting diode illumination source, illuminator and backlight for a liquid crystal display.

1. A light emitting diode illumination source, comprising a light emitting diode having multiple peaks with a half-value width of 20 nm or more within a range from 480 to 700 nm in a spectral distribution, wherein the minimum of the intensities of the valleys between the peaks in the wavelength range from 480 to 700 nm is 65 % or more of the maximum peak intensity in the same range.

2. The light emitting diode illumination source according to 1, wherein the emission intensity at 650 nm is 50 % or more of the maximum peak intensity in the range of 480 to 700 nm.

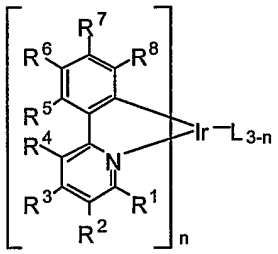
3. The light emitting diode illumination source according to 1 or 2, which is obtained by forming a photoluminescent material on a light emitting diode chip.

4. The light emitting diode illumination source according to 1 or 2, comprising a light emitting diode chip and a photoluminescent material formed thereon.

5. The light emitting diode illumination source according to 3, wherein the photoluminescent material is an iridium complex.

6. The light emitting diode illumination source according to 4, wherein the photoluminescent material is an iridium complex.

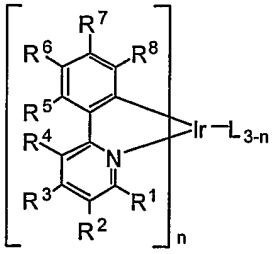
7. The light emitting diode illumination source according to 5, wherein the iridium complex is a mixture of 2 or more iridium complexes represented by formula (1) with an arbitrary mixing ratio.



(1)

(In the formula, R^1 to R^8 each independently represents a hydrogen atom, a halogen atom, or an organic group having 1 to 15 carbon atoms, those adjacent to each other among the R^1 to R^8 substituents may be bonded with each other at 1 or more positions to form a condensed ring, n is 2 or 3, two or three ligands shown in [ ] may be the same or different ones, and L represents a bidentate organic ligand bonded to iridium via atoms other than carbon atom.)

8. The light emitting diode illumination source according to 6, wherein the iridium complex is a mixture of 2 or more iridium complexes represented by formula (1) with an arbitrary mixing ratio.



(1)

(All the symbols in the formula have the same meanings as defined above.)

9. The light emitting diode illumination source according to any one of 1 to 8, wherein the light emitting diode is a blue light emitting diode having a dominant wavelength of 430 to 480 nm.

10. An illuminator using the light emitting diode illumination source according to any one of 1 to 8.

11. A backlight for a liquid crystal display, using the light emitting diode illumination source according to any one of 1 to 8.

The light emitting diode illumination source of the present invention has a flat spectral distribution containing light components with all wavelengths in green to red regions, and thereby can achieve illumination close to natural light, extremely suitable for observing object colors. Further, the photoluminescent materials can be mixed at an arbitrary ratio to control the spectral distribution, so that the illumination light source can be designed according to use and is remarkably useful.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a spectral distribution curve of an LED illumination source according to an example of the present invention.

Fig. 2 is a spectral distribution curve of an LED illumination source according to another example of the invention.

Fig. 3 is a spectral distribution curve of an LED illumination source of a comparative example.

Fig. 4 is a spectral distribution curve of an LED illumination source of a comparative example.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention is described in more detail below.

The light emitting diode illumination source of the invention comprises a light emitting diode having multiple peaks with a half value width of 20 nm or more within a range of 480 to 700 nm in the spectral distribution, and the minimum of the intensities of the valleys between the peaks in the wavelength range of 480 to 700 nm is 65 % or more of the maximum peak intensity in the range.

In the range of 480 to 700 nm in the spectral distribution, there are 2 or more peaks with the half value width of 20 nm or more, preferably 3 or more such peaks, more preferably 4 or more such peaks.

When there is only one such peak, it is difficult to obtain a flat spectral distribution.

Moreover, the half value widths of the peaks are 20 nm or more, preferably 50 nm or more. The peak with a half value width of less than 20 nm makes a spectrum close to a bright line spectrum, which is not preferred in that colors around such peaks look odd.

Further the minimum intensity of the intensities in the valleys between the peaks in the above wavelength range is required to be 65 % or more, preferably 80 % or more, of the maximum peak intensity in the range of 480 to 700 nm. When the minimum intensity

in the valleys is less than 65 %, some hues, within a range from 5B to 10R in a counterclockwise direction, in the hue circle of JIS standard color chart, are imperceptible, therefore it is not preferred.

The emission intensity at 650 nm of the illumination source of the invention is preferably 50 % or more, more preferably 55 % or more, of the maximum peak intensity in the range of 480 to 700 nm. When the intensity is less than 50% of the maximum peak intensity, some hues, within a range from 10R to 5B in a counterclockwise direction, in the hue circle of JIS standard color chart, are imperceptible, therefore it is not preferred.

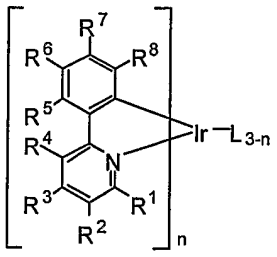
The light emitting diode illumination source of the invention can be obtained by using a light emitting diode device (LED) for ultraviolet to blue emission in combination with multiple photoluminescent materials that absorb a light in the wavelength region to emit a light.

The photoluminescent material (a fluorescent material or a phosphorescent material) absorbs light produced by an LED, to thereby emit light, and generally has an emission spectrum with a half value width of 20 nm or more. An illumination source having a flat spectral distribution can be obtained by forming a mixture of two or more types of such photoluminescent materials on an LED chip. It is preferable that three or more types of such photoluminescent materials be formed on the LED chip, more preferably four or more types.

In the invention, the light emitting diode device for ultraviolet to blue emission is preferably an InGaN-, AlGaN-, or GaN-based light emitting diode device. Since LEDs for ultraviolet emission have short life because of deterioration of sealing resins

caused by ultraviolet ray, an InGaN- or GaN-based blue light emitting diode device is particularly preferred.

As photoluminescent materials, iridium complexes are preferred, and at least one of the iridium complexes is preferably a compound represented by formula (1).



(1)

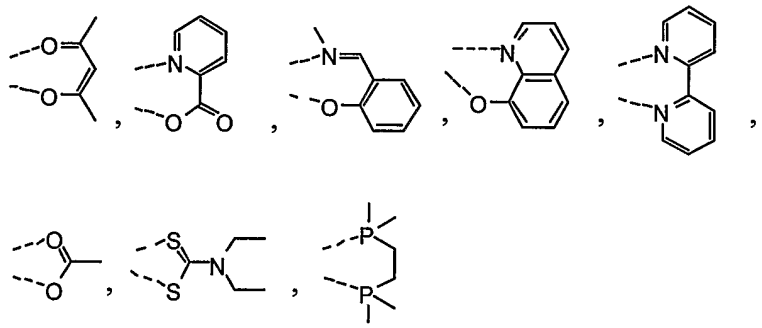
In the formula, R^1 to R^8 each independently represents a hydrogen atom, a halogen atom or an organic group having 1 to 15 carbon atoms, those adjacent to each other among the R^1 to R^8 substituents may be bonded with each other at 1 or more positions to form a condensed ring, n is an integer of 2 or 3, two or more ligands shown in [ ] may be the same or different ones, and L represents a bidentate organic ligand bonded to iridium via atoms other than carbon atom.

Examples of the organic group having 1 to 15 carbon atoms in formula (1) include alkyl groups having 1 to 10 carbon atoms (such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a t-butyl group, an amyl group, a hexyl group, an octyl group, and a decyl group), aryl groups having 6 to 10 carbon atoms (such as a phenyl group, a tolyl group, a xylyl group, a mesityl group, and a naphthyl group), amino groups which may be substituted by an alkyl group having 1 to 10 carbon atoms (such as an amino group, a dimethylamino group, a diethylamino group, and a dibutylamino group), alkoxy groups having 1 to 10 carbon atoms (such as a methoxy group, an ethoxy group, a

propoxy group, an isopropoxy group, a butoxy group, an isobutoxy group, a t-butoxy group, a hexyloxy group, a 2-ethylhexyloxy group, and a decyloxy group), and silyl groups (such as a trimethylsilyl group, a triethylsilyl group, and a t-butyldimethylsilyl group). Further, example of the halogen atoms include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

Among the substituents of R^1 to R^8 on the phenylpyridine ring in formula (1), adjacent substituents may be bonded together at 1 or more positions to form a condensed ring. Examples of the pyridine ring or the benzene ring forming a condensed ring include a quinoline ring, an isoquinoline ring, a naphthalene ring, an anthracene ring, a phthalazine ring, a quinazoline ring and a quinoxaline ring, and examples of the condensed rings formed by the phenylpyridine ring include a benzoquinoline ring and a dibenzoquinoline ring.

The bidentate organic ligand L in formula (1) preferably has a structural formula selected from structures as represented by formula (2):

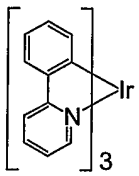


(2)

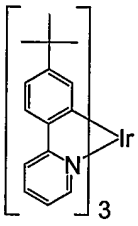
(wherein a dashed line represents a position to be bonded to iridium, and carbon atoms in each ligand may be substituted by an organic group having 1 to 15 carbon atoms.) Specific examples of the organic groups having 1 to 15 carbon atoms in formula (2) include those as mentioned in relation to formula (1).

Specific examples of the iridium complexes represented by

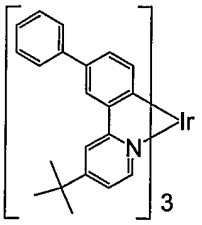
formula (1) include those having structures represented by formulae (E1) to (E20).



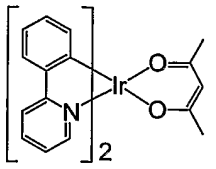
(E1)



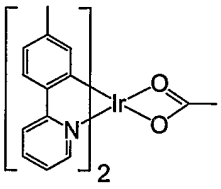
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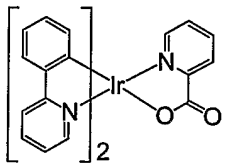
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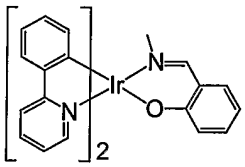
(E4)



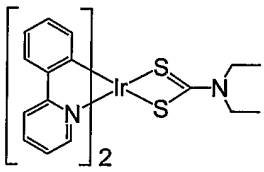
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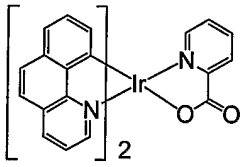
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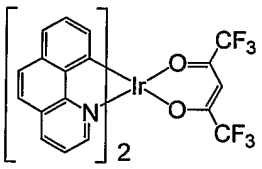
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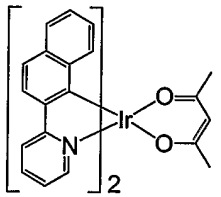
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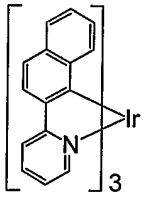
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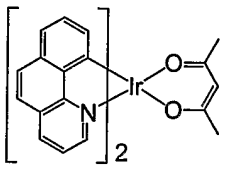
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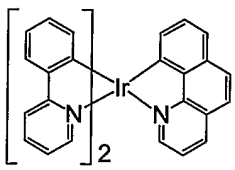
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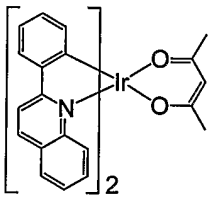
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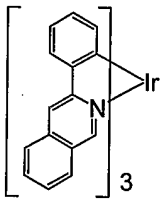
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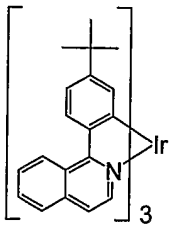
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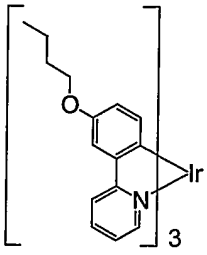
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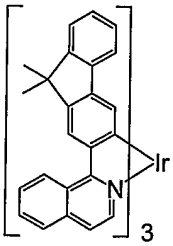
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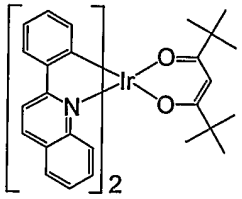
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(E18)



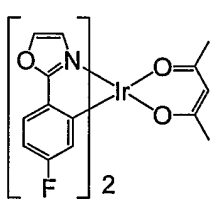
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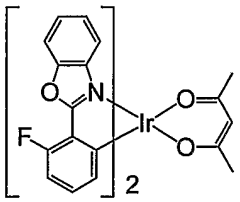
(E20)

Further, a luminescent iridium complex other than those

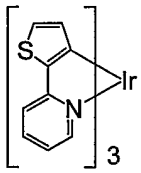
represented by the formula (1) may be used as a photoluminescent material in the invention. Examples of such luminescent iridium complexes include those having structures represented by the following formulae (E21) to (E32).



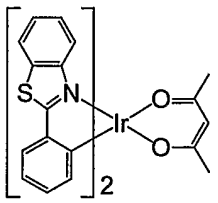
(E21)



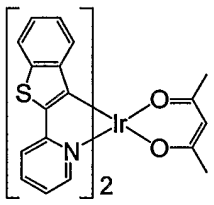
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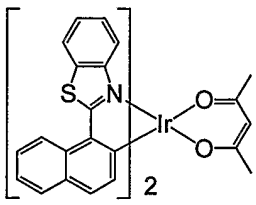
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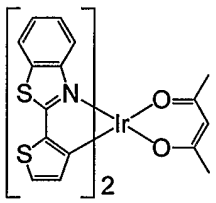
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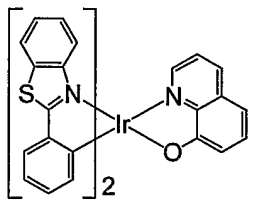
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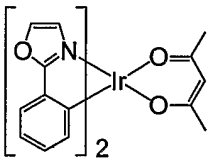
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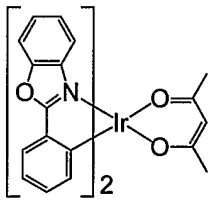
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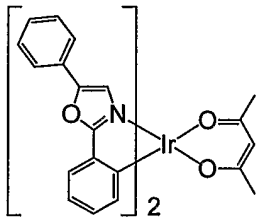
(E28)



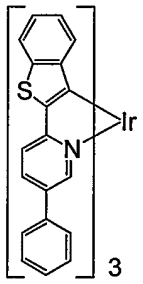
(E29)



(E30)



(E31)



(E32)

Multiple iridium complexes having appropriate different emission peak wavelengths may be mixed to make the spectral distribution flat. Examples of 3-type combinations of the iridium complexes, if mentioned by referring to numbers of the above-mentioned formulae, include (E2)+(E17)+(E14), (E2)+(E17)+(E16), and (E2)+(E14)+(E16).

Further, examples of 4-type combination include (E2)+(E17)+(E14)+(E16).

The mixing ratio of the iridium complexes may be determined depending on purposes of the light source, and for example, when the light source is used for general lighting, the ratio is preferably within the range of E2:E17:E16 = from 50 to 80 % : from 3 to 10 % : from 10 to 30 %. Moreover, in order that the emission intensity at 650 nm is 50 % or more of the peak intensity, 1 to 10 % of the iridium complex E17 must be added as a red component.

In the invention, the photoluminescent material may be used independently or may be used as a dispersion or solution in a binder as described later. Although the photoluminescent material may be disposed at any position of constructional elements as long as the material can be irradiated with a light emitted from the LED light source, it is preferable that a surface of the LED device be coated with the photoluminescent material and the binder.

The binder is generally a thermosetting resin though the binder is not particularly limited as long as it can dissolve or disperse the complex. Examples of the thermosetting resins include polycarbonate resins, polyethersulfone resins, polyacrylate resins, acryl resins, polyvinyl acetal resins, epoxy resins, cyanate resins, phenol resins, polyimide resins, urethane resins and silicone resins. Among the resins, transparent epoxy resin is most preferable from the viewpoints of high transparency and excellent practical characteristics such as adhesiveness.

Examples of the transparent epoxy resin include an epoxy resin such as bisphenol A diglycidyl ether, 2,2-bis(4-glycidyloxycyclohexyl)propane, 3,4-epoxycyclohexylmethyl-3,4-epoxyhexane carboxylate, vinylcyclohexene dioxide, 2-(3,4-

epoxycyclohexane)-5,5-spiro-(3,4-epoxycyclohexane)-1,3-dioxane, bis(3,4-epoxycyclohexyl)adipate, 1,2-cyclopropanedicarboxylic acid bisglycidyl ester, triglycidyl isocyanurate, monoallyl diglycidyl isocyanurate or diallyl monoglycidyl isocyanurate, which is cured by an acid anhydride such as hexahydrophthalic anhydride, methylhexahydrophthalic anhydride, trialkyltetrahydrophthalic anhydride or hydrogenated methylnadic anhydride. One of these epoxy resins or curing agents may be used singly or two or more of them may be used in combination.

EXAMPLES

The present invention will be described in more detail below with reference to Examples and Comparative Examples, however the invention is by no means limited by the Examples.

Example 1:

An InGaN light emitting diode chip having a dominant emission wavelength of 455 nm and an emission output of 4.6 mW was mounted in a surface mount package of 3 mm × 2.5 mm × 2.5 mm in outer size. Then, 4.9 mg of the iridium complex (E2), 0.4 mg of (E17), and 1.7 mg of (E16) were dispersed in 10 g of an epoxy resin (refractive index 1.6, EL438 available from Sanyu Rec Co. Ltd.), poured into a concavity of the surface mount package, and heat-treated at 120 °C for 4 hours to cure the resin, whereby a photoluminescent layer was formed.

The obtained LED light source was energized at 3.27 V and 20 mA and lighted. The emission spectrum thereof is shown in Fig. 1. There were three peaks in the wavelength region of 480 to 700 nm, and the maximum intensity was at 575 nm. There were two valleys

between the peaks, and the minimum intensity was at 530 nm. The ratio of the intensities was 100:78. The emission intensity at 650 nm was 55 % of the maximum intensity in the wavelength region of 480 to 700 nm.

Further, the spectrum curve in the wavelength region of 500 nm or more, where the emission spectra of (E2), (E17), and (E16) were overlapped, was decomposed to three components by a data analysis software PeakFit (manufactured by SYSTAT Software Inc.), and the resulting three spectra had half value widths of approximately 50 nm, 70 nm and 90 nm, respectively.

This LED lamp was used for illumination, and the hue 2.5R defined by JIS standard was visually observed. All the color grades other than those represented by the sign × in Table 1 were perceptible.

Table 1

		Chroma									
value		N	1	2	3	4	6	8	10	12	14
	9										
	8										
	7										
	6										
	5									x	x
	4										
	3										
	2										

N: Achromatic

Shaded zone : Not included in the color plates of the 2.5R hue according to JIS Z8721 standard color system

Example 2:

An InGaN light emitting diode chip having a dominant emission wavelength of 455 nm and an emission output of 4.6 mW was mounted in a surface mount package of 3 mm × 2.5 mm × 2.5 mm in outer size. Then, 4.9 mg of the iridium complex (E2), 0.5 mg of (E17), 0.6 mg of (E14), and 1.0 mg of (E16) were dispersed in 10 g of an epoxy resin (refractive index 1.6, EL438 available from Sanyu Rec Co. Ltd.), charged into a concavity of the surface mount package, and heat-treated at 120 °C for 4 hours to cure the resin, whereby a photoluminescent layer was formed.

The obtained LED light source was energized at 3.27 V and 20 mA and lighted. The emission spectrum thereof is shown in Fig. 2. There were four peaks in the wavelength region of 480 to 700 nm, and the maximum intensity was at 553 nm. There were three valleys between the peaks, and the minimum intensity was at 597 nm. The ratio of the intensities was 100:75. The emission intensity at 650 nm was 51 % of the maximum intensity in the wavelength region of 480 to 700 nm.

Further, as a result of measuring half value widths in the same manner as Example 1, the widths were approximately 50 nm, 70 nm, and 90 nm, respectively.

This LED lamp was used for illumination, and the hue 2.5R defined by JIS standard was visually observed. All the color grades in Table 2 were perceptible.

Table 2

		Chroma									
value		N	1	2	3	4	6	8	10	12	14
	9										
	8										
	7										
	6										
	5										
	4										
	3										
	2										

N: Achromatic

Shaded zone : Not included in the color plates of the 2.5R hue according to JIS Z8721 standard color system

Comparative Example 1:

A white LED light source (model number:NCCW023T, manufactured by Nichia Corporation) using a YAG fluorescent material as a photoluminescent material was subjected to JIS color vision tests in the same manner as Example 1. The results are shown in Table 3. There were imperceptible color grades in a wide range from orange to red.

Further, the emission spectrum is shown in Fig. 3. There was one peak in the wavelength region of 480 to 700 nm, and the maximum intensity was at 570 nm. The emission intensity at 650 nm was 52 % of the maximum intensity in the wavelength region of 480 to 700 nm.

Table 3

		Chroma									
value		N	1	2	3	4	6	8	10	12	14
	9										
	8										
	7										
	6								x		
	5							x	x	x	x
	4							x	x	x	x
	3								x	x	
	2										

N: Achromatic

Shaded zone : Not included in the color plates of the 2.5R hue according to JIS Z8721 standard color system

Comparative Example 2:

A three-in-one-type white LED light source (UVGB1306L manufactured by Stanley Electric Co., Ltd.), where three LEDs for blue, red, and green emission were mounted in a single package, was subjected to JIS color vision tests in the same manner as Example 1. The results are shown in Table 4. There were imperceptible color grades over a wide orange to red region

Table 4

		Chroma									
value		N	1	2	3	4	6	8	10	12	14
	9										
	8										
	7										
	6									x	
	5							x	x	x	x
	4								x	x	x
	3								x	x	
	2										

N: Achromatic

Shaded zone :Not included in the color plates of the 2.5R hue according to JIS Z8721 standard color system

Further, the emission spectrum is shown in Fig. 4. There were two peaks in the wavelength region of 480 to 700 nm, and the maximum intensity was at 623 nm. There were two valleys between the peaks, and the minimum intensity was at 582 nm. The ratio of the intensities was 26:1. The emission intensity at 650 nm was 3 % of the maximum intensity in the wavelength region of 480 to 700 nm.

CLAIMS

1. A light emitting diode illumination source, comprising a light emitting diode having multiple peaks with a half-value width of 20 nm or more within a range from 480 to 700 nm in a spectral distribution, wherein the minimum of the intensities of the valleys between the peaks in the wavelength range from 480 to 700 nm is 65 % or more of the maximum peak intensity in the same range.

2. The light emitting diode illumination source according to claim 1, wherein the emission intensity at 650 nm is 50 % or more of the maximum peak intensity in the range of 480 to 700 nm.

3. The light emitting diode illumination source according to claim 1 or 2, which is obtained by forming a photoluminescent material on a light emitting diode chip.

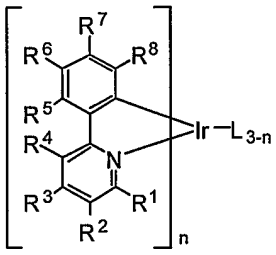
4. The light emitting diode illumination source according to claim 1 or 2, comprising a light emitting diode chip and a photoluminescent material formed thereon.

5. The light emitting diode illumination source according to claim 3, wherein the photoluminescent material is an iridium complex.

6. The light emitting diode illumination source according to claim 4, wherein the photoluminescent material is an iridium complex.

7. The light emitting diode illumination source according to claim 5, wherein the iridium complex is a mixture of 2 or more

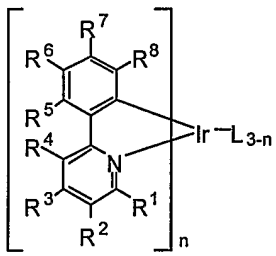
iridium complexes represented by formula (1) with an arbitrary mixing ratio,



(1)

wherein R^1 to R^8 each independently represents a hydrogen atom, a halogen atom, or an organic group having 1 to 15 carbon atoms, those adjacent to each other among the R^1 to R^8 substituents may be bonded with each other at 1 or more positions to form a condensed ring, n is 2 or 3, two or three ligands shown in [ ] may be the same or different ones, and L represents a bidentate organic ligand bonded to iridium via atoms other than carbon atom.

8. The light emitting diode illumination source according to claim 6, wherein the iridium complex is a mixture of 2 or more iridium complexes represented by formula (1) with an arbitrary mixing ratio,



(1)

wherein all the symbols have the same meanings as defined in claim 7.

9. The light emitting diode illumination source according to

claim 1, wherein the light emitting diode is a blue light emitting diode having a dominant wavelength of 430 to 480 nm.

10. An illuminator using the light emitting diode illumination source according to claim 1.

11. A backlight for a liquid crystal display, using the light emitting diode illumination source according to claim 1.

Fig.1

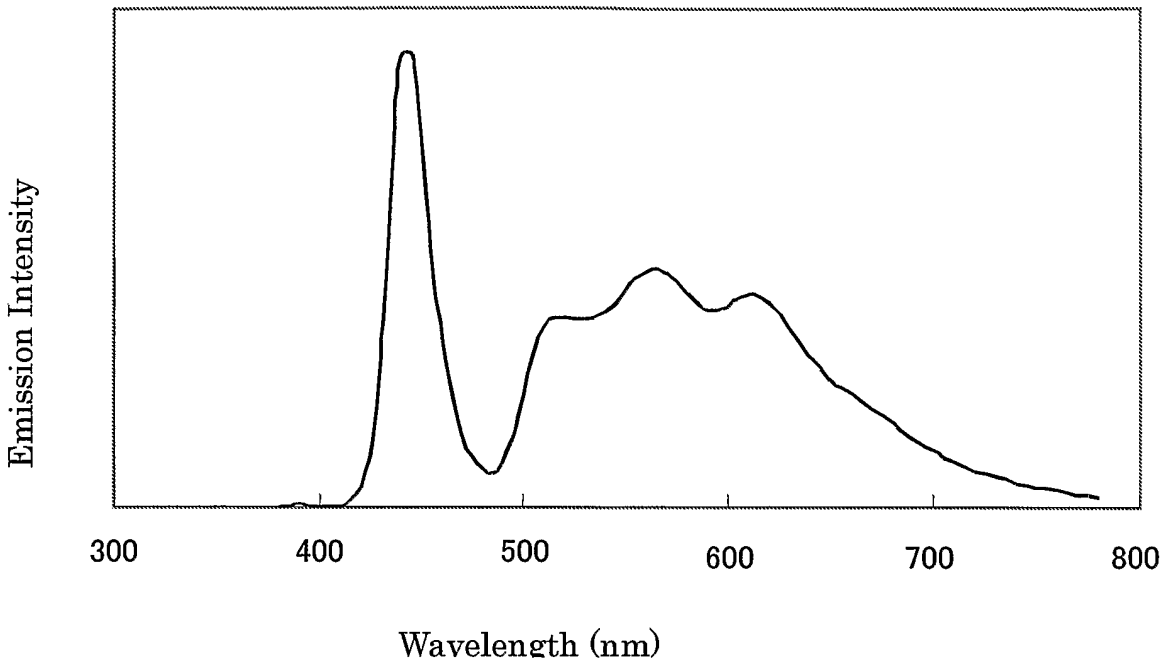

Emission Intensity
300
400
500
600
700
800
Wavelength (nm)

Fig.2

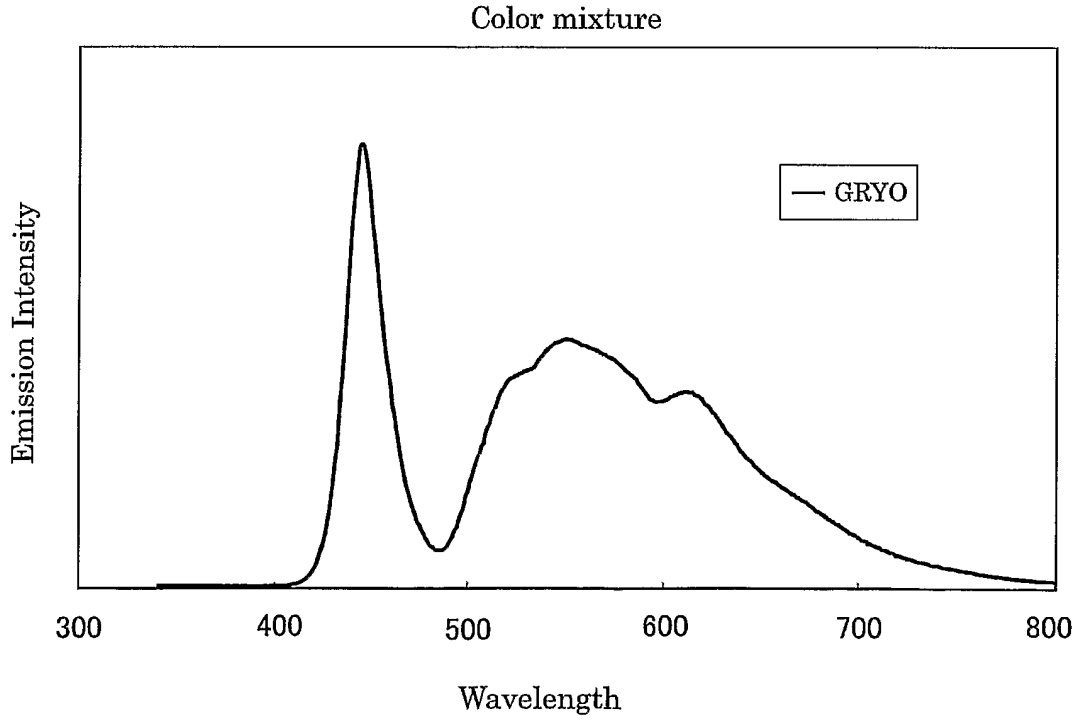

Color mixture
— GRYO
Emission Intensity
300
400
500
600
700
800
Wavelength

Fig.3

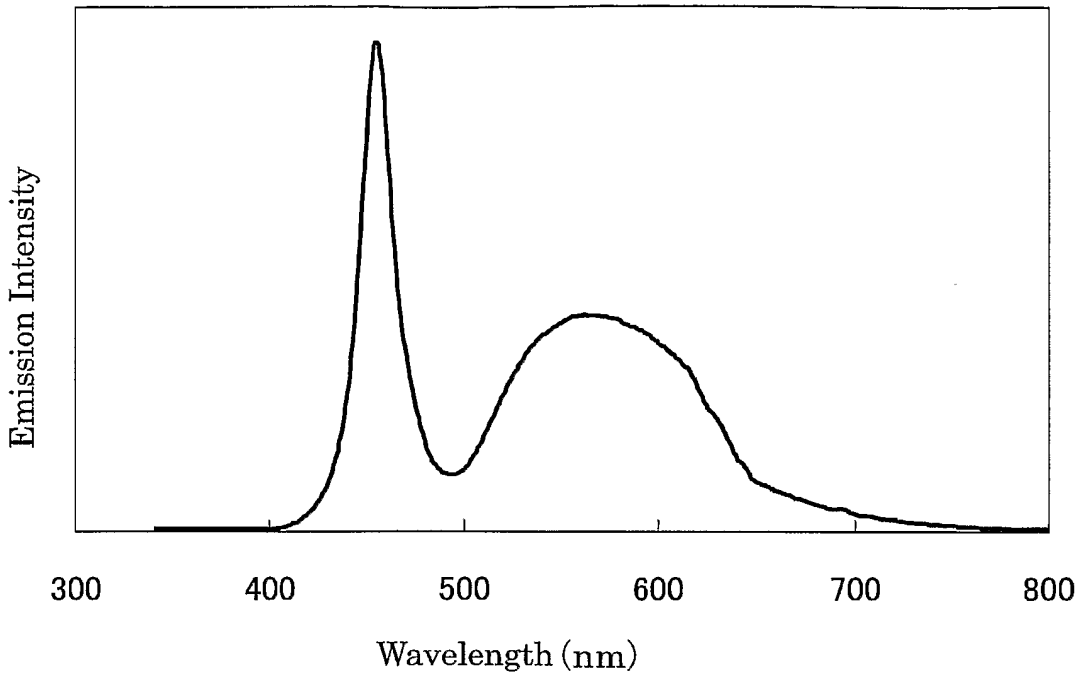
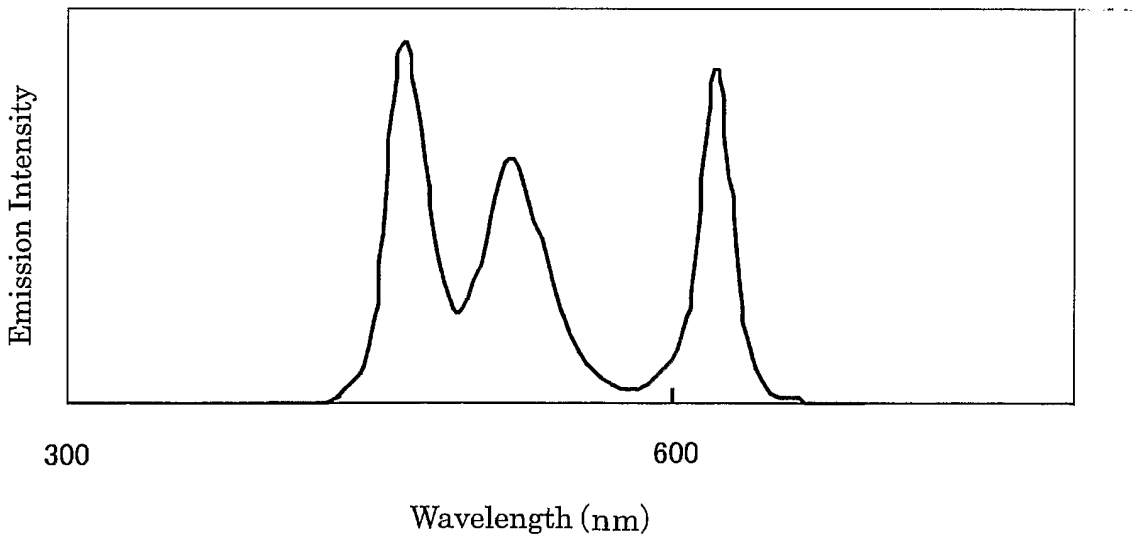

Emission Intensity
300
400
500
600
700
800
Wavelength (nm)

Fig.4


Emission Intensity
300
600
Wavelength (nm)

INTERNATIONAL SEARCH REPORT

PCT/JP2005/021935

A. CLASSIFICATION OF SUBJECT MATTER
H05B33/14 C09K11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC, COMPENDEX, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LAMANSKY S ET AL: "Synthesis and Characterization of Phosphorescent Cyclometalated Iridium Complexes" INORGANIC CHEMISTRY, AMERICAN CHEMICAL SOCIETY, EASTON, US, vol. 40, no. 7, 2001, pages 1704-1711, XP002196399 ISSN: 0020-1669	1-9
Y	pages 1705-170, column 8; figure 1; tables 1,2	10,11

-/--

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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'T' later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2006	21/02/2006
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Wengeler, H

INTERNATIONAL SEARCH REPORT

PCT/JP2005/021935

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LAMANSKY SERGEY ET AL: "Cyclometalated Ir complexes in polymer organic light-emitting devices" JOURNAL OF APPLIED PHYSICS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 92, no. 3, 1 August 2002 (2002-08-01), pages 1570-1575, XP012057001 ISSN: 0021-8979	1-9
Y	page 1570 - page 1574; figures 1,3,5; table 1	10,11
X	KAWAMURA YUICHIRO ET AL: "Energy transfer in polymer electrophosphorescent light emitting devices with single and multiple doped luminescent layers" JOURNAL OF APPLIED PHYSICS, AMERICAN INSTITUTE OF PHYSICS. NEW YORK, US, vol. 92, no. 1, 1 July 2002 (2002-07-01), pages 87-93, XP012056515 ISSN: 0021-8979 pages 87-92; figures 1,5,8-12; table 1	1-9
X	EP 1 398 363 A (FUJI PHOTO FILM CO., LTD) 17 March 2004 (2004-03-17)	1-9
Y	paragraphs '0001!, '0002!; claims 6-9 paragraph '0040!	10,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

JP2005/021935

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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