

"FLUORESCENT LAMP"

The present invention relates to an improvement in a fluorescent lamp.

A three-peak emission system is known as one method of improving a color rendering property without sacrificing the efficacy of the fluorescent lamp. According to this system, three types of phosphors with peak wavelengths of about 450 nm, 540 nm, and 610 nm are used. The half value widths of the light-emission spectra of these phosphors are relatively narrow. A blue-emitting phosphor having the light-emission-spectrum peak wavelength of about 450 nm comprises a divalent europium activated haloborophosphate phosphor such as a divalent europium activated-strontium-magnesium-calcium-cerium haloborophosphate phosphor. A green-emitting phosphor having the light-emission-spectrum peak wavelength of about 540 nm comprises a cerium-terbium activated silicophosphate phosphor (e.g., cerium-terbium activated lanthanum silicophosphate) or a cerium-terbium activated phosphate phosphor (e.g., a cerium-terbium activated lanthanum phosphate). A red-emitting phosphor having the light emission spectrum peak wavelength of about 610 nm comprises a europium activated yttrium oxide phosphor.

Another three-peak emission-type fluorescent lamp is described in Japanese Patent Disclosure (Kokai) No. 57-128778. This fluorescent lamp uses a combination

of $(\text{Ba}, \text{Mg}, \text{Eu})\text{O} \cdot b\text{Al}_2\text{O}_3$ as a blue-emitting phosphor, $\text{MgO} \cdot \text{B}_2\text{O}_3$: Ce, Tb as a green-emitting phosphor, and $(\text{Y}, \text{Eu})_2\text{O}_3$ as a red-emitting phosphor.

5 The lamp diameter has recently been decreased to improve the luminous efficacy at a lower cost. In general, when the lamp diameter is decreased, the lamp tube wall load is increased. The end portions of the fluorescent lamp are blackened, thus resulting in a so-called blackening phenomenon. When the blackening
10 phenomenon occurs in the fluorescent lamp, the brightness of the lamp is decreased.

In the conventional three-peak emission type fluorescent lamp having blue-, green- and red-emitting phosphors, the blackening phenomenon typically occurs
15 when a lamp having a diameter of 26 mm or less is used, thus resulting in poor appearance and lower lamp brightness.

The present invention has been made to overcome the drawbacks described above and has as its object to
20 provide a fluorescent lamp with a high product value by greatly decreasing blackening at the end portions of the lamp.

The present inventors have made various types of experiments to achieve the above object and found that
25 the blackening phenomenon was greatly decreased even when a tube diameter was 26 mm or less in a three peak emission type fluorescent lamp, wherein at least one of

a divalent-europium-activated aluminate phosphor and a manganese-activated aluminate phosphor was used instead of a conventional divalent-europium-activated haloborophosphate phosphor as the blue-emitting phosphor and was combined with the conventional green- and red-emitting phosphors. The present invention is based on this finding.

The phosphors used in the present invention are all known to those skilled in the art and are subjected to the blackening phenomenon when they are used separately. However, when these phosphors are combined they decrease the blackening phenomenon to an extent which could not be expected in the case of using them separately. The decrease in the blackening phenomenon is based on an effect obtained by a combination of the different types of phosphors.

The blue-emitting phosphor used in the present invention essentially consists of at least one of a divalent-europium-activated aluminate phosphor and a divalent-europium- and manganese-coactivated aluminate phosphor, said divalent-europium-activated aluminate phosphor having a general formula $a(M, Eu)O \cdot bAl_2O_3$ [where M is at least one of zinc (Zn), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), lithium (Li), rubidium (Rb) and cesium (Cs), and neither a nor b is zero], and said divalent-europium-and manganese-coactivated aluminate phosphor having a

general formula $a(M, Eu, Mn)O \cdot bAl_2O_3$ [where M, a, and b have the same meanings as defined above]. This blue-emitting phosphor is described in Japanese Patent Disclosure Nos. 56-152882 and 56-152883 and Japanese Patent Publication No. 56-52072.

The green-emitting phosphor essentially consists of at least one of a cerium- and terbium-coactivated rare-earth silicophosphate phosphor and a cerium- and terbium-coactivated rare-earth phosphate phosphor, said cerium- and terbium-coactivated rare-earth silicophosphate phosphor having a general formula $d(LnI, Ce, Tb)_2O_3 \cdot eSiO_2 \cdot fP_2O_5$ [where LnI is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd), lutetium (Lu) and samarium (Sm), and none of d, e, and f is zero], and said cerium- and terbium-coactivated rare-earth phosphate phosphor having a general formula $(LnI, Ce, Tb)PO_4$ [where LnI has the same meanings as defined above].

A red-emitting phosphor essentially consists of a europium-activated rare-earth oxide phosphor having a general formula $(LnII, Eu)_2O_3$ [where LnII is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd), cerium (Ce), terbium (Tb) and samarium (Sm)].

According to the present invention, there is provided a fluorescent lamp having a phosphor film which comprises:

a blue-emitting phosphor essentially consisting of

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at least one of a divalent-europium-activated aluminate phosphor and a divalent europium- and manganese-coactivated aluminate phosphor, said divalent-europium-activated aluminate phosphor having a
5 general formula $a(M, Eu)O \cdot bAl_2O_3$ [where M is at least one of zinc (Zn), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), lithium (Li), rubidium (Rb) and cesium (Cs), and neither a nor b is zero], and said
10 divalent-europium- and manganese-coactivated aluminate phosphor having a general formula $a(M, Eu, Mn)O \cdot bAl_2O_3$ [where M, a, and b have the same meanings as defined above];

a green-emitting phosphor essentially consisting of at least one of a cerium- and terbium-coactivated
15 rare-earth silicophosphate phosphor and a cerium- and terbium-coactivated rare-earth phosphate phosphor, said silicophosphate phosphor having a general formula $d(LnI, Ce, Tb)_2O_3 \cdot eSiO_2 \cdot fP_2O_5$ [where LnI is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd),
20 lutetium (Lu) and samarium (Sm), and none of d, e, and f is zero], and said phosphate phosphor having a general formula $(LnI, Ce, Tb)PO_4$ [where LnI has the same meanings as defined above]; and

a red-emitting phosphor essentially consisting of a
25 europium-activated rare-earth oxide phosphor having a general formula $(LnII, Eu)_2O_3$ [where LnII is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd), cerium

(Ce), terbium (Tb), and samarium (Sm)].

✓ A particularly preferable combination of phosphors is given to be a blue-emitting phosphor as $a(M, Eu, Mn)O \cdot bAl_2O_3$, a green-emitting phosphor as $d(LnI, Ce, Tb)_2O_3 \cdot eSiO_2 \cdot fP_2O_5$, and a red-emitting phosphor as $(LnII, Eu)_2O_3$. By this combination, the blackening phenomenon becomes minimized, and a bright fluorescent lamp is obtained.

The phosphor film preferably has a composition consisting of 0.1 to 40% by weight of the blue-emitting phosphor, 20 to 73% by weight of the green-emitting phosphor, and 5 to 65% by weight of the red-emitting phosphor, where 100% by weight corresponds to the total content of the phosphors.

15 The fluorescent lamp of the present invention decreases the blackening at the end portions of the three peak emission-type fluorescent lamp described above.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawing, in which:

The drawing is a graph showing the light-emission spectrum at the initial ON state of a fluorescent lamp according to an embodiment of the present invention.

25 Tube-end blackening represents a so-called blackening phenomenon at end portions of a fluorescent lamp while the lamp is turned on, thereby degrading the

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outer appearance of the lamp and hence lowering the product value.

Tube-end blackening occurs when a gas in the tube is activated to generate a discharge. Tube-end blackening differs in accordance with the material emitted from the phosphors and the cathode or the type of gas sealed in the tube. However, the blackened portions always occur in the vicinity of the electrodes.

In order to evaluate tube end blackening, a predetermined blackened portion is cut so as to include tube glass and a phosphor screen, and a visible light transmittance of the blackened portion is measured. When blackening is increased, the visible light transmittance is decreased.

A blackened portion of a 40-W fluorescent lamp (tube diameter of 25 mm) having the phosphor film as previously described is subjected to visible light transmittance measurement. The visible light transmittance of the fluorescent lamp according to the present invention is compared with that of a comparative fluorescent lamp having a divalent-europium-activated strontium-calcium-magnesium-cerium haloborophosphate phosphor.

In this case, when the visible light transmittance of the fluorescent lamp is given to be 100%, the visible light transmittance of the comparative fluorescent lamp of the present invention is given to be 115%. The

degree of blackening of the fluorescent lamp of the present invention is decreased by 15%. The tube-end blackening measurement must be performed after the lamp has been operated for a relatively long period of time.

5 The 40-watt fluorescent lamp of the present invention and the conventional fluorescent lamp were turned on for 1,500 hours at a 130% rated load. Blackened portions (i.e., portion between a position spaced by 30 mm from the lamp end and a position spaced by 45 mm from the
10 same lamp end along the longitudinal direction of the lamp) having a length of 15 mm and a width of 15 mm each are cut off from the lamps. These 15 x 15 (mm) blackened portions are given as samples. The visible light transmittances of these samples were measured by a
15 Beckmann transmittance measuring instrument.

When the three-peak emission type fluorescent lamp is used as a fluorescent lamp of high color rendering property in practice, an average color rendering index (Ra) is 80 or more and a lamp efficacy is 80 lm/W or
20 more. In order to provide these characteristics, the blue-, green- and red-emitting phosphors preferably have contents of 0.1 to 40% by weight, 20 to 73% by weight, and 5 to 65% by weight, respectively, when a total content of phosphors is given to be 100% by weight.

25 An alkali metal, boron oxide, gallium oxide or the like can be added to the respective blue-, green- and red-emitting phosphors in small amounts. The phosphors

with such additives can be used to obtain the same effect as in the above embodiment.

The present invention will be described in detail by way of examples.

5 Example 1

A divalent-europium activated barium-magnesium aluminate phosphor having a formula $3(\text{Ba}, \text{Mg}, \text{Eu})\text{O} \cdot 8\text{Al}_2\text{O}_3$ is used as the blue-emitting phosphor. This phosphor is referred to as phosphor (A) hereafter. The phosphor (A)
10 has a narrow light-emission spectrum having a peak wavelength of 452 nm and is suitable as a three-peak-emission-type blue-emitting phosphor.

For a comparative fluorescent lamp, a divalent-europium-activated strontium-magnesium-cerium
15 haloborophosphate phosphor having the formula $3(\text{Sr}, \text{Mg}, \text{Eu}, \text{Ce})\text{O} \cdot 0.92\text{P}_2\text{O}_5 \cdot 0.31\text{CaCl}_2 \cdot 0.09 \cdot \text{B}_2\text{O}_3$ is used as the blue-emitting phosphor. This phosphor is referred to as phosphor (B) hereafter.

11% by weight of the phosphor (A) as the
20 blue-emitting phosphor, 67% by weight of a cerium- and terbium-coactivated lanthanum silicophosphate phosphor having the formula $(\text{La}, \text{Ce}, \text{Tb})_2\text{O}_3 \cdot 0.2\text{SiO}_2 \cdot 0.9\text{P}_2\text{O}_5$ as the green-emitting phosphor, and 22% by weight of a europium-activated yttrium oxide phosphor as the
25 red-emitting phosphor were used to prepare a 40-W 5000-K white fluorescent lamp having a tube diameter of 25 mm of Example 1 by a conventional method. This lamp was

turned on for 1,500 hours and was then subjected to visible light transmittance measurement.

On the other hand, the phosphor (B) as the blue-emitting phosphor, a cerium- and terbium-coactivated lanthanum silicophosphate phosphor as the green-emitting phosphor, and a europium-activated yttrium oxide phosphor as the red-emitting phosphor were used to prepare as the comparative example a 40-watt 5000-K fluorescent lamp having a tube diameter of 25 mm.

The light-emission spectrum distribution of the fluorescent lamp of Example 1 in the initial ON period is shown in the drawing. The visible light transmittance of the comparative example was 100%, and that of Example 1 was 115%, thus decreasing the blackening effect by 15%.

Furthermore, the above phosphors were singly used to prepare similar fluorescent lamps, and these lamps were turned on for 1,500 hours. Visible light transmittances of these lamps having the phosphor (A), the phosphor (B), the $(\text{La,Ce,Tb})_2\text{O}_3 \cdot 0.2\text{SiO}_2 \cdot 0.9\text{P}_2\text{O}_5$ phosphor, and the $(\text{Y,Eu})_2\text{O}_3$ phosphor were 92%, 90%, 104% and 101%, respectively.

Furthermore, as another comparative example, the same blue- and red-emitting phosphors as in Example 1, and $\text{MgO} \cdot \text{B}_2\text{O}_3$: Ce, Tb as a green-emitting phosphor were used to prepare a fluorescent lamp. This lamp was turned on for 1,500 hours, and its visible light

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transmittance was measured to be 99%.

Theoretically, a visible light transmittance of the three-peak emission-type lamp is expected to be 102% at best from the visible light transmittances of the respective phosphors measured above and the contents of the phosphors. However, in practice, the visible light transmittance in Example 1 is obtained to be 115%. This is caused by a combined effect of the phosphors.

The average color rendering index (Ra) in the initial ON period is 84, and the lamp efficacy is 90 lm/W.

The above results are summarized in the following table.

Examples 2 - 7

The combination of phosphors was changed within the ranges of phosphor contents according to the present invention, and fluorescent lamps of Examples 2 to 7 were prepared in accordance with the same method as in Example 1.

In the fluorescent lamps as comparative examples, a $3(\text{Sr}, \text{Mg}, \text{Eu}, \text{Ce})\text{O} \cdot 0.92\text{P}_{205} \cdot 0.31\text{CaCl}_{12} \cdot 0.09\text{B}_{203}$ was used as the blue-emitting phosphor. Other conditions were the same as those in the respective examples. The visible light transmittances, the average color rendering indices, and lamp efficacies of Examples 2 to 7 are shown in the table. It should be noted that the visible light transmittances are given with respect to 100%

visible light transmittance of the comparative example.

Table

Example	Phosphor composition	Content (wt.%)	Visible light transmittance (%)	Average color rendering index (Ra)	Lamp efficacy (lm/w)
1	$3(\text{Ba, Mg, Eu})\text{O} \cdot 0.8\text{Al}_2\text{O}_3$ $(\text{La, Ce, Tb})_2\text{O}_3 \cdot 0.2\text{SiO}_2 \cdot 0.9\text{P}_2\text{O}_5$ $(\text{Y, Eu})_2\text{O}_3$	11 67 22	115	84	90
2	$3(\text{Ba, Mg, Eu, Mn})\text{O} \cdot 0.8\text{Al}_2\text{O}_3$ $(\text{La, Ce, Tb, Gd})_2\text{O}_3 \cdot 0.3\text{SiO}_2 \cdot 0.85\text{P}_2\text{O}_5$ $(\text{Y, Eu, Tb})_2\text{O}_3$	10 66 24	110	86	87
3	$2.8(\text{Ba, Mg, Zn, Eu, Mn})\text{O} \cdot 0.8\text{Al}_2\text{O}_3$ $(\text{La, Ce, Tb})\text{PO}_4$ $(\text{Y, Eu, Sm})_2\text{O}_3$	10 70 20	104	86	84
4	$2.8(\text{Ba, Mg, Eu})\text{O} \cdot 0.798\text{Al}_2\text{O}_3 \cdot 0.02\text{B}_2\text{O}_3$ $(\text{La, Ce, Tb, Lu})_2\text{O}_3 \cdot 0.2\text{SiO}_2 \cdot 0.9\text{P}_2\text{O}_5$ $(\text{Y, Eu})_2\text{O}_3$	14 65 21	113	84	89

Example	Phosphor composition	Content (wt.%)	Visible light transmittance (%)	Average color rendering index (Ra)	Lamp efficacy (lm/w)
5	3(Ba,Mg,Ca,Li,Eu)O·8Al ₂ O ₃ (La,Ce,Tb,Y) ₂ O ₃ ·0.24SiO ₂ ·0.88P ₂ O ₅ (Y,Eu,La) ₂ O ₃	16	113	85	83
		60			
		24			
6	3(Ba,Mg,Zn,Rb,Eu,Mn)O·8Al ₂ O ₃ (La,Ce,Tb,Sm) ₂ O ₃ ·0.26SiO ₂ ·0.87P ₂ O ₅ (Y,Eu,Ce) ₂ O ₃	20	112	86	85
		54			
		26			
7	3(Ba,Mg,Sr,Cs,Eu)O·8Al ₂ O ₃ (La,Ce,Tb)PO ₄ (Y,Eu,Gd) ₂ O ₃	23	106	84	87
		54			
		23			

Claims:

1. A fluorescent lamp having a phosphor film which comprises:

a blue-emitting phosphor essentially consisting
5 of at least one of a divalent-europium-activated
aluminate phosphor and a divalent-europium- and
manganese-coactivated aluminate phosphor, said
divalent-europium-activated aluminate phosphor having a
general formula $a(M, Eu)O \cdot bAl_2O_3$ [where M is at least one
10 of zinc (Zn), magnesium (Mg), calcium (Ca), strontium
(Sr), barium (Ba), lithium (Li), rubidium (Rb) and
cesium (Cs), and neither a nor b is zero], and said
divalent-europium- and manganese-coactivated aluminate
phosphor having a general formula $a(M, Eu, Mn)O \cdot bAl_2O_3$
15 [where M is at least one of zinc (Zn), magnesium (Mg),
calcium (Ca), strontium (Sr), barium (Ba), lithium (Li),
rubidium (Rb) and cesium (Cs), and neither a nor b is
zero];

a green-emitting phosphor essentially consisting of
20 at least one of a cerium- and terbium-coactivated
rare-earth silicophosphate phosphor and a cerium- and
terbium-coactivated rare-earth phosphate phosphor, said
cerium- and terbium-coactivated rare-earth
silicophosphate phosphor having a general formula
25 $d(LnI, Ce, Tb)_2O_3 \cdot eSiO_2 \cdot fP_2O_5$ [where LnI is at least one
of yttrium (Y), lanthanum (La), gadolinium (Gd),
lutetium (Lu) and samarium (Sm), and none of d, e, and f



is zero], and said cerium- and terbium-coactivated rare-earth phosphate phosphor having a general formula $(\text{LnI}, \text{Ce}, \text{Tb})\text{PO}_4$ [where LnI is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd), lutetium (Lu) and samarium (Sm)]; and

a red-emitting phosphor essentially consisting of a europium-activated rare-earth oxide phosphor having a general formula $(\text{LnII}, \text{Eu})_2\text{O}_3$ [where LnII is at least one of yttrium (Y), lanthanum (La), gadolinium (Gd), cerium (Ce), terbium (Tb) and samarium (Sm)].

2. A lamp according to claim 1, wherein said phosphor film contains 0.1 to 40% by weight of said blue-emitting phosphor, 20 to 73% by weight of said green-emitting phosphor, and 5 to 65% by weight of said red-emitting phosphor wherein 100% by weight corresponds to the total weight of said phosphors.

3. A fluorescent lamp according to claim 1 and substantially as hereinbefore described with reference to Examples 1-7.

