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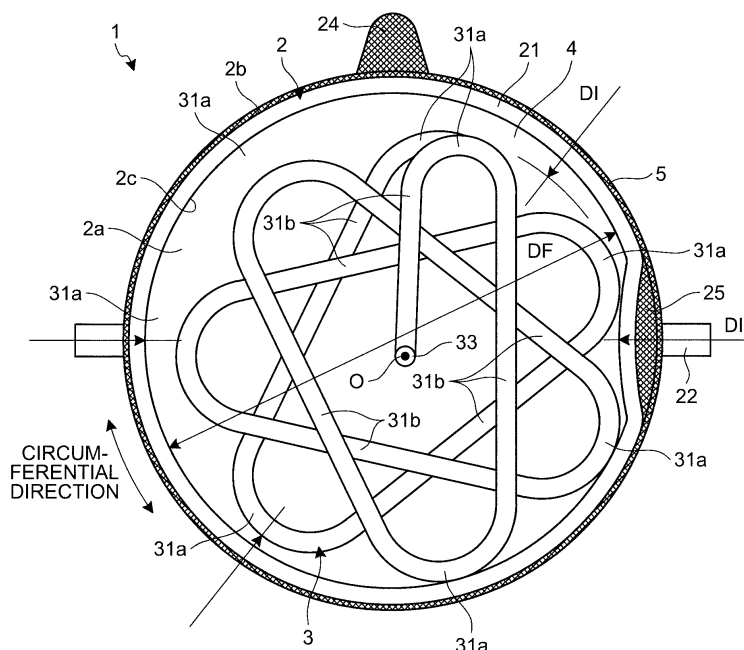
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(54) **Incandescent lamp with visible light reducing optical film**

(57) A lamp (1) according to an embodiment includes: a bulb (2), a filament (3), gas (4), and a multilayer film (5). The filament (3) is arranged on an inside (2a) of the bulb (2) along a tube axis. The gas (4) is filled in the inside (2a) of the bulb (2). The multilayer film (5) is formed on an outer surface (2b) of the bulb (2). Average visible ray transmittance at a wavelength of 380 nm to 780 nm

of the multilayer film (5) is equal to or lower than 24%. In the filament (3), a plurality of projecting sections (31a) projecting toward an inner wall (2c) of the bulb (2) when viewed from the tube axis direction are formed in the circumferential direction and along the tube axis direction.

**FIG.2**



## Description

### FIELD

[0001] Embodiments of the present invention described herein relate to a lamp.

### BACKGROUND

[0002] A lamp including both functions for heating of a space and illumination in a store or the like has been used.

[0003] Since the lamp is used for heating of a space, a user present in the space can visually recognize the lamp irrespective of whether the lamp is lit. The lamp for space heating irradiates the space with light in a visible ray wavelength region when the lamp generates heat. The lamp for space heating is required to have performance of a light source and is also required to be not glaring depending on an environment of use, that is, have a so-called antiglare property.

[0004] It is an object of the embodiments to provide a lamp that improves an antiglare property.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### [0005]

FIG. 1 is a front view showing a lamp in an embodiment.

FIG. 2 is a sectional view showing the lamp.

FIG. 3 is a front view showing a bulb.

FIG. 4 is a front view showing a filament.

FIG. 5 is a diagram showing a manufacturing procedure for the lamp.

FIG. 6 is a diagram showing the manufacturing procedure for the lamp.

FIG. 7 is a diagram showing the manufacturing procedure for the lamp.

FIG. 8 is a diagram showing the manufacturing procedure for the lamp.

FIG. 9 is an explanatory diagram showing electric characteristics of the lamp.

FIG. 10 is an explanatory diagram showing comparison of visible light amounts and infrared ray amounts.

FIG. 11 is an explanatory diagram showing illuminance comparison.

### DETAILED DESCRIPTION

[0006] A lamp 1 according to an embodiment explained below includes a bulb 2, a filament 3, gas 4, and a multilayer film 5. The filament 3 is arranged on an inside 2a of the bulb 2 along a tube axis. The gas 4 is filled in the inside 2a of the bulb 2. The multilayer film 5 is formed on an outer surface 2b of the bulb 2. Average visible ray transmittance at a wavelength of 380 nm to 780 nm of

the multilayer film 5 is equal to or lower than 24%. In the filament 3, a plurality of projecting sections 31a projecting toward an inner wall 2c of the bulb 2 when viewed from the tube axis direction are formed in the circumferential direction and along the tube axis direction.

[0007] In the lamp 1 according to the embodiment explained below, total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is equal to or lower than 22%.

[0008] In the lamp 1 according to the embodiment explained below, a ratio  $DF/DI$  of an outer diameter  $DF$  of the filament 3 and an inner diameter  $DI$  of the bulb 2 is  $0.875 \leq DF/DI \leq 0.975$ .

[0009] In the lamp 1 according to the embodiment explained below, dimples 25 projecting toward the inside 2a of the bulb 2 are formed on the outer surface 2b of the bulb 2.

#### Embodiment

[0010] The embodiment is explained with reference to FIGS. 1 and 2. FIG. 1 is a front view showing the lamp in the embodiment. FIG. 2 is a sectional view of the lamp. In FIG. 1, a part of the lamp in the tube axis direction is omitted. FIG. 2 is an A-A sectional view of FIG. 1.

[0011] The lamp in this embodiment gives heat to an object or a space to be heated. As an example, the lamp is used as a heating device for a space of a store or the like. The lamp 1 includes, as shown in FIG. 1, the bulb 2, the filament 3, the gas 4, the multilayer film 5, metal foils 61 and 62, and outer leads 71 and 72.

[0012] The bulb 2 includes a tubular section 21, seal sections 22 and 23, a chip 24, and the dimples 25. The bulb 2 is formed of, for example, quartz glass, is transparent and uncolored, and is a long object having a large total length  $L$  compared with a tube diameter  $DO$ . The bulb 2 preferably has a tube wall load equal to or smaller than  $36 \text{ W/cm}^2$ . If the tube wall load exceeds  $36 \text{ W/cm}^2$ , for example, likelihood of fusing of the filament 3 increases. Further, a bulb temperature  $[\text{°C}]$  rises. Deformation of the bulb 2 occurs and durability of the bulb 2 is deteriorated.

[0013] In the tubular section 21, the inside 2a is formed as an internal space. The filament 3 is arranged on the inside 2a.

[0014] The seal sections 22 and 23 are arranged at both ends in the tube axis direction of the tubular section 21. The seal sections 22 and 23 are sealing sections and seal the tubular section 21. The seal sections 22 and 23 in this embodiment are formed in a tabular shape by pinch seals. The seal sections 22 and 23 may be formed in a columnar shape by shrink seals.

[0015] The chip 24 is a burn-off notch of an exhaust pipe 24' (see FIG. 3) provided to perform exhaust from the inside 2a and introduction of the gas 4 during manufacturing of the lamp 1. The chip 24 is closed when the lamp 1 is completed.

**[0016]** As shown in FIG. 2, the dimples 25 project toward the inside 2a of the bulb 2 on the outer surface 2b of the bulb 2. An inner diameter DI' of the bulb 2 in positions where the dimples 25 are formed is smaller than the inner diameter DI of the bulb 2 in positions where the dimples 25 are not formed. Therefore, in the positions where the dimples 25 are formed, a gap between the inner wall 2c of the bulb 2 and the filament 3 is small. Therefore, rotation of the filament 3 in the circumferential direction with respect to the bulb 2 and movement of the filament 3 in the tube axis direction can be regulated. A dense portion and a sparse portion of the filament 3 are suppressed from being formed in the tube axis direction. Consequently, it is possible to suppress ununiformity of a visible light amount and an infrared ray amount in the tube axis direction of the lamp 1. At least one dimple 25 only has to be formed. However, in order to regulate the movement of the filament 3 according to the shapes of the bulb 2 and the filament 3, two or more dimples 25 may be formed as in this embodiment. The dimples 25 do not have to be formed.

**[0017]** The filament 3 is arranged along the tube axis on the inside 2a of the bulb 2. A main section 31 and leg sections 32 and 33 are integrally formed. The filament 3 in this embodiment is a metal wire made of tungsten.

**[0018]** The main section 31 is a section that generates heat and emits light during lighting. The main section 31 is arranged on the inside 2a of the bulb 2. The main section 31 is formed by winding the metal wire. In the main section 31, a plurality of projecting sections 31a projecting toward the inner wall 2c of the bulb 2 when viewed from the tube axis direction are formed in the circumferential direction and along the axis direction. That is, the plurality of projecting sections 31a are arranged in a spiral shape along the tube axis direction. The main section 31 in this embodiment is formed by bending the metal wire to be fit in a circle having an outer diameter centering on a center O of the filament 3. In the main section 31, when viewed from the tube axis direction, the plurality of projecting sections 31a are arranged at substantially equal intervals in the circumferential direction. The main section 31 is formed by coupling the respective projecting sections 31a in coupling sections 31b. Two coupling sections 31b, 31b coupled to one projecting section 31a are coupled to ends (ends separated most) of the projecting sections 31a adjacent to each other in the circumferential direction. The main section 31 of the filament 3 is formed as a so-called flower-winding coil.

**[0019]** The ratio DF/DI of the outer diameter DF of the filament 3, that is, the outer diameter of the main section 31, and the inner diameter DI of the bulb 2 is  $0.875 \leq DF/DI \leq 0.975$ . When DF/DI is smaller than 0.875, a dimension difference between the bulb 2 and the filament 3 increases, a holding ability for holding the bulb 2 on the filament 3 is deteriorated, and a backlash occurs in the filament 3. On the other hand, when DF/DI is larger than 0.975, the dimension difference between the bulb 2 and the filament 3 decreases. This makes it difficult to

insert the filament 3 into the bulb 2 during manufacturing of the lamp 1. Therefore, workability is deteriorated.

**[0020]** The leg sections 32 and 33 are arranged at both ends in the tube axis direction of the main section 31. Parts of the leg sections 32 and 33 are arranged to be embedded in the seal sections 22 and 23. The leg sections 32 and 33 are sections that supply electric power to the main section 31. One ends of the leg sections 32 and 33 are respectively connected to both ends of the main section 31. The other ends of the leg sections 32 and 33 are respectively electrically connected to the metal foils 61 and 62.

**[0021]** The gas 4 is filled in the inside 2a of the bulb 2. The gas 4 in this embodiment is an argon gas having about 0.8 atm in which a very small amount of dibromomethane ( $\text{CH}_2\text{Br}_2$ ) is contained. The gas 4 is desirably gas having low thermal conductivity. Specifically, the gas 4 only has to contain one kind of gas among krypton, xenon, argon, neon, and the like or only has to contain gas obtained by combining a plurality of kinds of gas among krypton, xenon, argon, and neon, and the like. Further, the gas 4 may contain one kind of gas among bromine, iodine, and the like or may contain a halogen substance obtained by combining a plurality of kinds of gas among bromine, iodine, and the like.

**[0022]** The multilayer film 5 is formed on the outer surface 2b of the bulb 2. The multilayer film 5 is formed in a region of the tubular section 21 on the outer surface 2b. The multilayer film 5 is formed such that average visible ray transmittance thereof at the wavelength of 380 nm to 780 nm is equal to or lower than 24%. The multilayer film 5 is formed such that total average visible ray transmittance of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 at the wavelength of 380 nm to 780 nm is equal to or lower than 22%. The multilayer film 5 in this embodiment is formed in six layers on the outer surface 2b by alternately vapor-depositing silicon oxide and iron oxide. The multilayer film 5 is visually recognized in gold during extinction of the lamp 1.

**[0023]** "The total average visible ray transmittance of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 at the wavelength of 380 nm to 780 nm" means that, for example, concerning the bulb including the multilayer film 5 formed on the outer surface 2b, transmittance in the visible ray wavelength region of the wavelength of 380 nm to 780 nm is measured at every 5 nm using a spectrophotometer V-570 manufactured by JASCO Corporation, an average of the transmittance in the range of the wavelength of 380 nm to 780 nm is calculated, and a numerical value of the average is set as average visible ray transmittance in the range of the wavelength of 380 nm to 780 nm. "The average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5" can be calculated by, for example, a method explained below. First, glass having transmittance, thickness, and the like substantially equivalent to those of the bulb 2 is used as a measurement sample. Transmittance in the visible ray wavelength region of the

wavelength of 380 nm to 780 nm of the bulb 2 (or the glass equivalent to the bulb 2) is measured at every 5 nm using the spectrophotometer V-57 0 manufactured by JASCO Corporation. Second, "transmittance data in the visible ray wavelength region of the wavelength of 380 nm to 780 nm of the multilayer film 5" can be calculated from "transmittance data in the visible ray wavelength region of the wavelength of 380 nm to 780 nm of the bulb 2 (or the glass equivalent to the bulb 2)" and "total transmittance data in the visible ray wavelength region of the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2" calculated earlier. An average in the range of the wavelength of 380 nm and 780 nm is calculated from "the transmittance data in the visible ray wavelength region of the wavelength of 380 nm to 780 nm of the multilayer film 5" and a numerical value of the average is set as "the average visible ray transmittance in the range of the wavelength of 380 nm to 780 nm of the multilayer film 5".

**[0024]** When the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is higher than 24% (the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is higher than 22%), this is undesirable because glare by a sensory evaluation increases. On the other hand, when the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is equal to or lower than 24% (the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is equal to or lower than 22%), the glare by the sensory evaluation is reduced. In particular, when the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is equal to or lower than 21% (the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is equal to or lower than 19%), the glare by the sensory evaluation is not felt.

**[0025]** One ends of the metal foils 61 and 62 are respectively connected to the leg sections 32 and 33 of the filament 3. The other ends of the metal foils 61 and 62 are respectively connected to the outer leads 71 and 72. The metal foils 61 and 62 are respectively embedded in the seal sections 22 and 23. The metal foils 61 and 62 in this embodiment are molybdenum foils and are arranged to extend along tabular surfaces of the seal sections 22 and 23.

**[0026]** The outer leads 71 and 72 respectively connect the metal foils 61 and 62 and a not-shown external power supply. One ends of the outer leads 71 and 72 are respectively connected to the metal foils 61 and 62. The other ends of the outer leads 71 and 72 are exposed to the outside of the bulb 2. Parts of the outer leads 71 and 72 are respectively embedded in the seal sections 22

and 23. The other ends of the outer leads 71 and 72 are respectively inserted into not-shown connectors together with the seal sections 22 and 23, electrically connected to not-shown cables provided in the connectors, and connected to the power supply via the cables. The outer leads 71 and 72 are molybdenum rods.

**[0027]** A manufacturing process for the lamp 1 is explained. FIG. 3 is a front view showing the bulb. FIG. 4 is a front view showing the filament. FIG. 5 is a diagram showing a manufacturing procedure for the lamp. FIG. 6 is a diagram showing the manufacturing procedure for the lamp. FIG. 7 is a diagram showing the manufacturing procedure for the lamp. FIG. 8 is a diagram showing the manufacturing procedure for the lamp.

**[0028]** As shown in FIG. 3, before machining, the entire bulb 2 is the tubular section 21. The exhaust pipe 24' allows the inside 2a and the outside of the bulb 2 to communicate with each other. As shown in FIG. 4, in the filament 3 the metal foils 61 and 62 and the outer leads 71 and 72 are connected by welding or the like in advance.

**[0029]** First, as shown in FIG. 5, the filament 3 is inserted into the inside 2a of the bulb 2. At this point, the filament 3 is inserted into the inside 2a of the bulb 2 such that the metal foils 61 and 62 are located in positions where the seal sections 22 and 23 are planned to be formed.

**[0030]** Subsequently, as shown in FIG. 6, both ends of the bulb 2 is melted by a gas burner (not shown in the figure) and pinched by a pincher (not shown in the figure) to form the seal sections 22 and 23. Consequently, the main section 31 of the filament 3 is housed in the tubular section 21.

**[0031]** Gas in the tubular section 21 is exhausted from the exhaust pipe 24' and the gas 4 is introduced into the tubular section 21.

**[0032]** As shown in FIG. 7, the exhaust pipe 24' is melted and burnt off by the gas burner (not shown in the figure), the tubular section 21 is sealed, and the gas 4 is filled in the inside 2a of the bulb 2.

**[0033]** As shown in FIG. 8, in a position opposed to the main section 31 of the filament 3 in the bulb 2, the bulb 2 is softened by the gas burner (not shown in the figure) to form the dimples 25.

**[0034]** The multilayer film 5 is formed on the outer surface 2b of the bulb 2. In the region of the tubular section 21 on the outer surface 2b, silicon oxide is vapor-deposited in first, third, and fifth layers, iron oxide is vapor-deposited in second, fourth, and sixth layers, and the multilayer film 5 is formed in six layers from the bulb 2 side. Consequently, the lamp 1 shown in FIG. 1 is manufactured.

**[0035]** Test results of the lamp 1, a conventional product, and a comparative product 1 are explained below. FIG. 9 is an explanatory diagram of electric characteristics of the lamp. FIG. 10 is an explanatory diagram showing comparison of visible light amounts and infrared ray amounts. The "visible light amount" is an integrated value

of spectrophotometry at the wavelength of 380 nm to 780 nm. Specifically, the "visible light amount" was measured using a spectrometer MSR-7000N manufactured by Opto Research Corporation. The "infrared ray amount" is an integrated value of spectrophotometry at the wavelength of 380 nm to 780 nm. Specifically, the "infrared ray amount" was measured using the spectrometer MSR-7000N manufactured by Opto Research Corporation. As both of the visible light amount and the infrared ray amount, values of the "conventional product" are assumed to be 100%. FIG. 11 is an explanatory diagram showing illuminance comparison.

**[0036]** The "present invention 1" and the "present invention 2", which are the lamp 1, the "conventional product", and the "comparative product 1" have the total length L of 337 mm, the tube diameter DO of 10 mm, the inner diameter DI of 8 mm, and the effective light emission length of 280 mm. As shown in FIG. 9, when lamp power is 2500 W, a tube wall load is 36 W/cm<sup>2</sup>, a lamp voltage is 235 V, and a lamp current is 10.6 A. The tube wall load is a value obtained by dividing the lamp power by an inner surface area of the bulb 2. The inner surface area of the bulb 2 is calculated by the tube diameter DI mm  $\times$  3.14 ( $\pi$ )  $\times$  effective light emission length [mm].

**[0037]** In the "present invention 1", the main section 31 of the filament 3 is a flower-winding coil formed by winding a thin wire having length of 7791 mm and a wire diameter of 0.375 mm to form a coil having the outer diameter DF of 7.4 mm. The multilayer film 5 is formed in six layers (first, third, and fifth layers are silicon oxide having thickness of 0.7  $\mu$ m, second, fourth, and sixth layers are iron oxide having thickness of 0.6  $\mu$ m, the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 24%, and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 22%). In the "present invention 2", the filament 3 is the same as the filament 3 in the "present invention 1". The multilayer film 5 is formed in eight layers (first, third, fifth, and seventh layers are silicon oxide having thickness of 0.7  $\mu$ m, second, fourth, sixth, and eighth layers are iron oxide having thickness of 0.6  $\mu$ m, the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 21%, and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 19%).

**[0038]** In the "conventional product", a main section of a filament is a turn coil formed by winding a thin wire having length of 4337 mm and a wire diameter of 0.307 mm to form a coil having the outer diameter DF of 2.4 mm. The "conventional product" does not include the multilayer film 5. The average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 is 95%.

**[0039]** In the "comparative product 1", the main section 31 of the filament 3 is a turn coil formed by winding a thin

wire having length of 4337 mm and a wire diameter of 0.307 mm to form a coil having the outer diameter DF of 2.4 mm. A multilayer film is the multilayer film 5 of the "present invention 1" (the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 24% and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 22%). In the "comparative product 2", a filament is the filament of the "present invention 1" and the "present invention 2". The multilayer film 5 is formed in two layers (a first layer is silicon oxide having thickness of 0.7  $\mu$ m, a second layer is iron oxide having thickness of 0.6  $\mu$ m, the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 28%, and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 26%). In the "comparative product 3", a filament is the filament of the "comparative product 1". The multilayer film 5 is formed in four layers (first and third layers are silicon oxide having thickness of 0.7  $\mu$ m, second and fourth layers are iron oxide having thickness of 0.6  $\mu$ m, the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 26%, and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 24%).

**[0040]** As shown in FIG. 10, in the "comparative product 1", compared with the "conventional product", it is possible to reduce the visible light amount by 40% in a state in which the infrared ray amount is maintained. That is, it is possible to reduce the visible light amount in the lamp in which the filament is the turn coil and the multilayer film is the multilayer film 5. Further, in the "present invention 1" and the "present invention 2", compared with the "conventional product" and the "comparative product 1", it is possible to remarkably reduce the visible light amount in a state in which the infrared ray amount is substantially maintained. That is, in the "present invention 1" and the "present invention 2", the lamp 1 includes both of the filament 3 including the main section 31 configured by the flower-winding coil and the multilayer film 5 (the average visible ray transmittance at the wavelength of 380 nm to 780 nm of the multilayer film 5 is 24% and the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 22%). Therefore, it is possible to remarkably improve the antiglare property. In particular, as in the "present invention 2", it is possible to further improve the antiglare property by forming the multilayer film 5 in eight layers.

**[0041]** As shown in FIG. 11, in the case of the illuminance comparison, the comparison was performed at a measurement distance of 300 mm from the lamp and lamp power of 2500 W. Illuminance was measured using

a colorimeter CL-200 manufactured by Konica Minolta, Inc. In the "comparative product 1", compared with the "conventional product", it is possible to reduce the illuminance to about 67%. In the "comparative product 2", compared with the "conventional product", it is possible to reduce the illuminance to about 30%. In the "comparative product 3", compared with the "conventional product", it is possible to reduce the illuminance to about 20%. In the "present invention 1", compared with the "conventional product", it is possible to reduce the illuminance to about 14%. In the "present invention 2", compared with the "conventional product", it is possible to reduce the illuminance to about 7%. In the sensory evaluation, by setting the illuminance to 70 lx or less, it is possible to evaluate that the lamp is not glaring. Therefore, in the "present invention 1" and the "present invention 2", since the lamp 1 includes both of the filament 3 and the multilayer film 5, the average visible ray transmittance of which at the wavelength of 380 nm to 780 nm is equal to or lower than 24%, it is possible to remarkably improve the antiglare property. Further, in the sensory evaluation, by setting the illuminance to 35 lx or less, it is possible to evaluate that the lamp is not glaring. Therefore, in the "present invention 2", it is possible to remarkably improve the antiglare property. If it is attempted to coat the multilayer film 5 in more than eight layers, film peeling occurs during lamp lighting and reliability of the lamp is spoiled. Therefore, it is desirable to form the multilayer film in eight layers at most.

**[0042]** As explained above, in the filament 3 in which the plurality of projecting sections 31a projecting toward the inner wall 2c of the bulb 2 when viewed from the tube axis direction are formed in the circumferential direction and along the axis direction, a large number of metal wires can be housed in the inside 2a of the bulb 2. Therefore, it is possible to reduce the visible light amount and the illuminance. In the multilayer film 5, the average visible ray transmittance at the wavelength of 380 nm to 780 nm is equal to or lower than 24%. Therefore, compared with the average visible ray transmittance of 95% at the wavelength of 380 nm to 780 nm of the "conventional product", which is the bulb in which the multilayer film 5 is not formed, it is possible to reduce the visible light amount and the illuminance. Therefore, the lamp 1 according to this embodiment can improve the antiglare property.

**[0043]** The multilayer film 5, the average visible ray transmittance of which at the wavelength of 380 nm to 780 nm is equal to or lower than 24%, is formed on the outer surface 2b of the bulb 2. Therefore, during extinction of the lamp 1, it is difficult to directly visually recognize the bulb 2 and the filament 3 from the outside. During extinction of the lamp 1, the multilayer film 5 is visually recognized in gold from the outside. The lamp 1 according to this embodiment can improve a design property during extinction of the lamp 1.

**[0044]** In the embodiment, silicon oxide and iron oxide are used as the multilayer film 5. However, the multilayer

film 5 is not limited to this. In the multilayer film 5, the average visible ray transmittance at the wavelength of 380 nm to 780 nm only has to be equal to or lower than 24%. Therefore, the multilayer film 5 may be formed by vapor-depositing other materials. Any material may be used as long as the total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb 2 and the multilayer film 5 formed on the outer surface 2b of the bulb 2 is 22%. For example, the bulb 2 may be configured by a so-called ruby tube formed of quartz glass containing copper oxide and tin oxide. On the outer side of the bulb 2, the multilayer film 5 may be formed, the total average visible ray transmittance of which and the bulb 2, on the outer surface 2b of which the multilayer film 5 is formed, at the wavelength of 380 nm to 780 nm is 22%.

**[0045]** While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

## Claims

### 1. A lamp (1) comprising:

a bulb (2);  
a filament (3) arranged on an inside (2a) of the bulb (2) along a tube axis;  
gas (4) filled in the inside (2a) of the bulb (2); and  
a multilayer film (5) formed on an outer surface (2b) of the bulb (2), average visible ray transmittance at a wavelength of 380 nm to 780 nm of the multilayer film (5) being equal to or lower than 24%, wherein  
in the filament (3), a plurality of projecting sections (31a) projecting toward an inner wall (2c) of the bulb (2) when viewed from a tube axis direction are formed in a circumferential direction and along the tube axis direction.

2. The lamp (1) according to claim 1, wherein total average visible ray transmittance at the wavelength of 380 nm to 780 nm of the bulb (2) and the multilayer film (5) formed on the outer surface (2b) of the bulb (2) is equal to or lower than 22%.

3. The lamp (1) according to claim 1 or 2, wherein a ratio  $DF/DI$  of an outer diameter  $DF$  of the filament (3) and an inner diameter  $DI$  of the bulb (2) is  $0.875 \leq DF/DI \leq 0.975$ .

4. The lamp (1) according to any one of claims 1 to 3, wherein dimples (25) projecting toward the inside (2a) of the bulb (2) are formed on the outer surface (2b) of the bulb (2).

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FIG.1

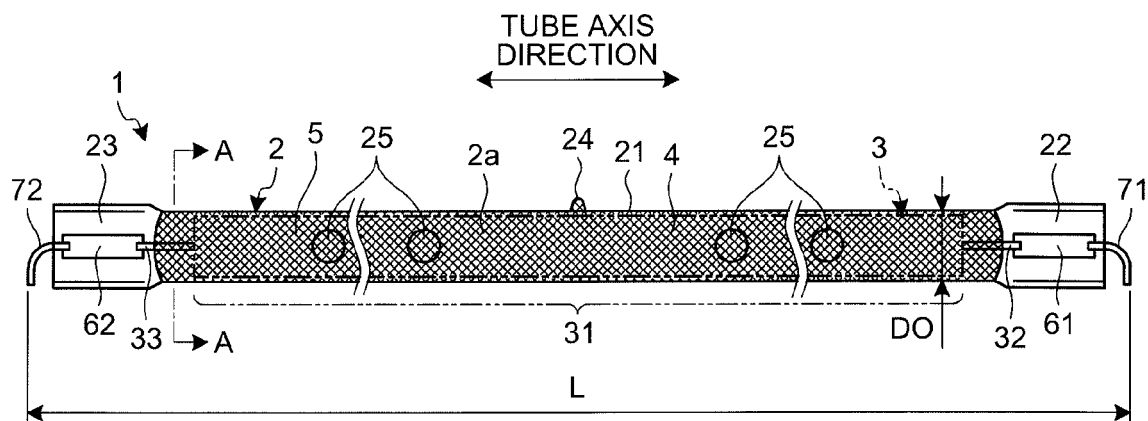


FIG.2

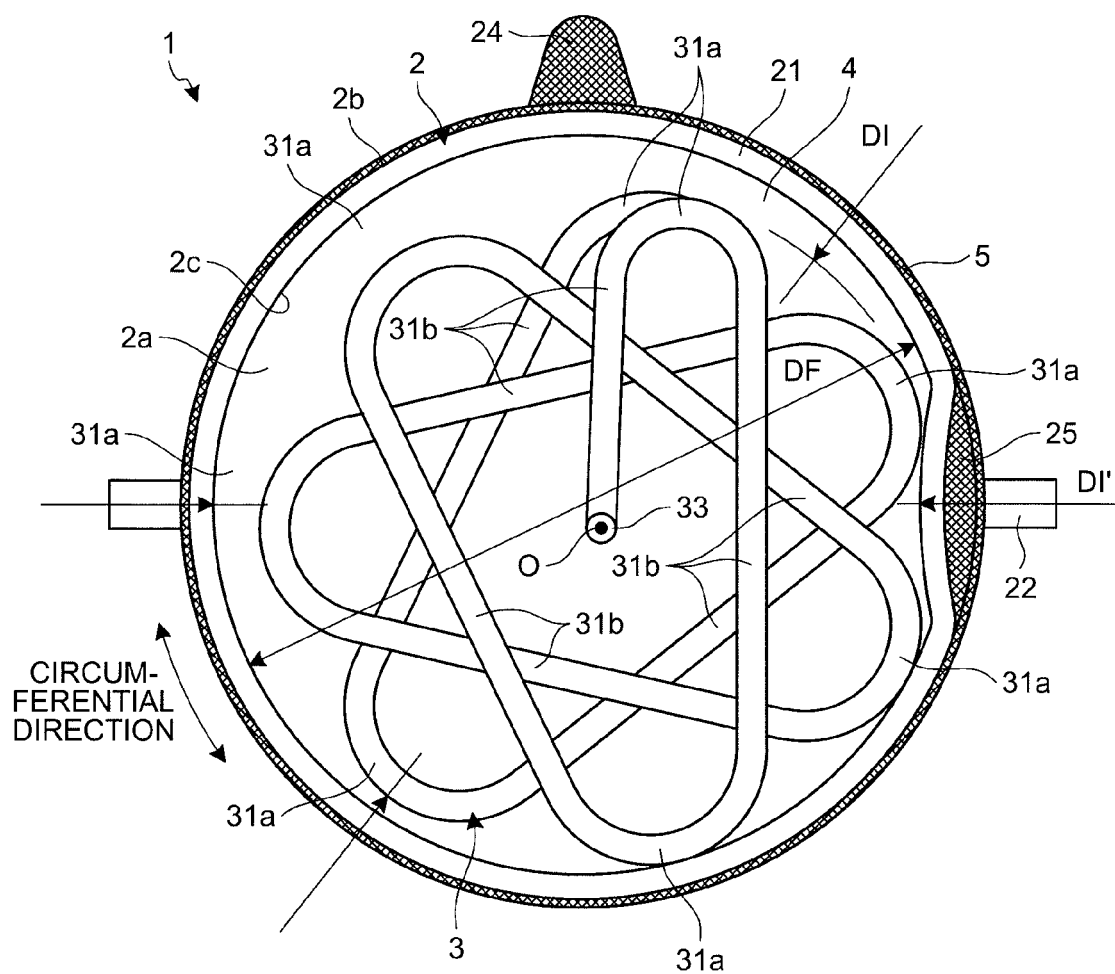


FIG.3

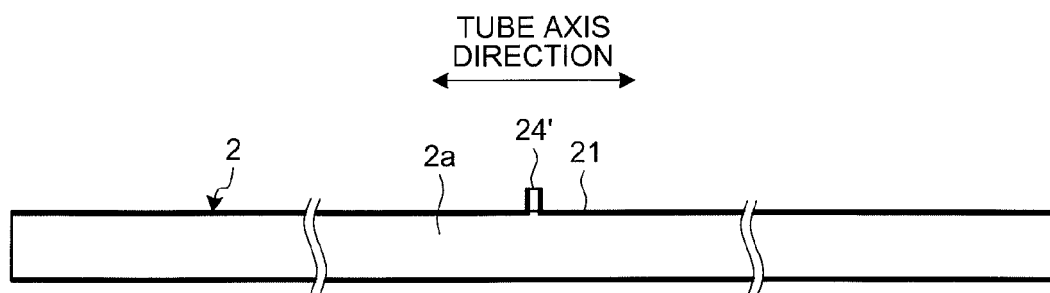


FIG.4

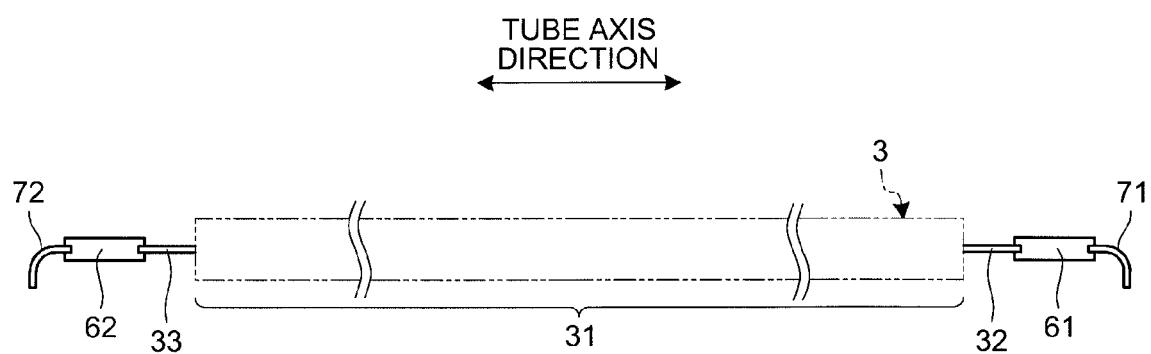


FIG.5

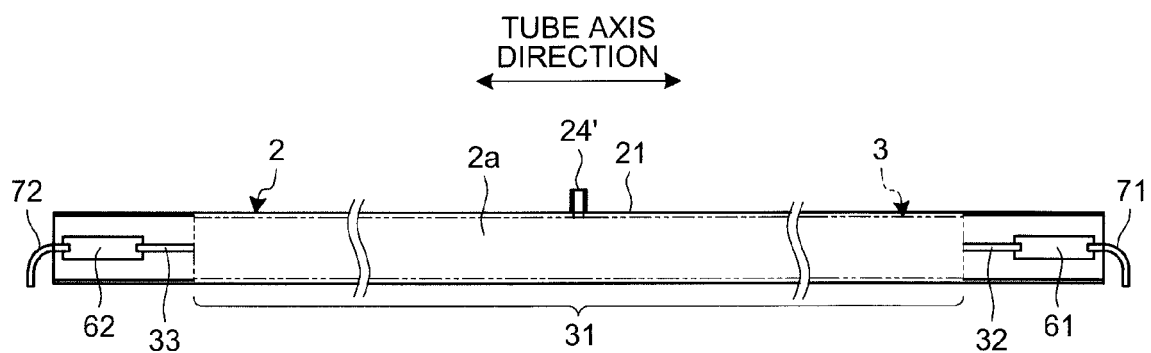


FIG.6

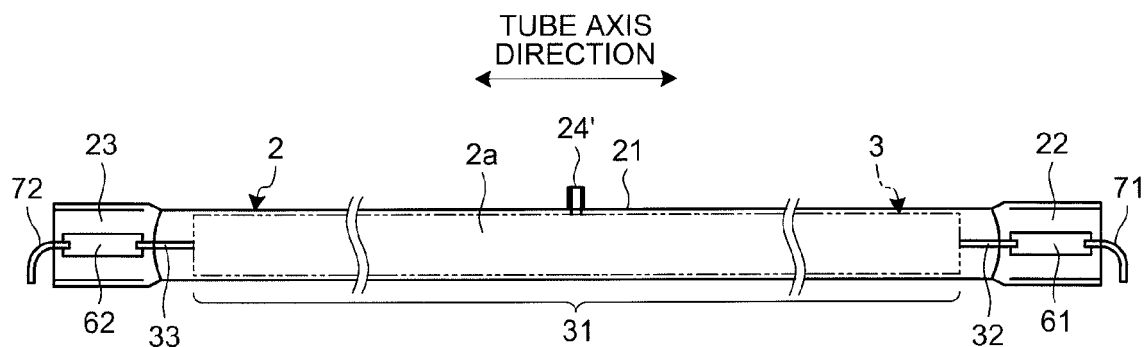


FIG.7

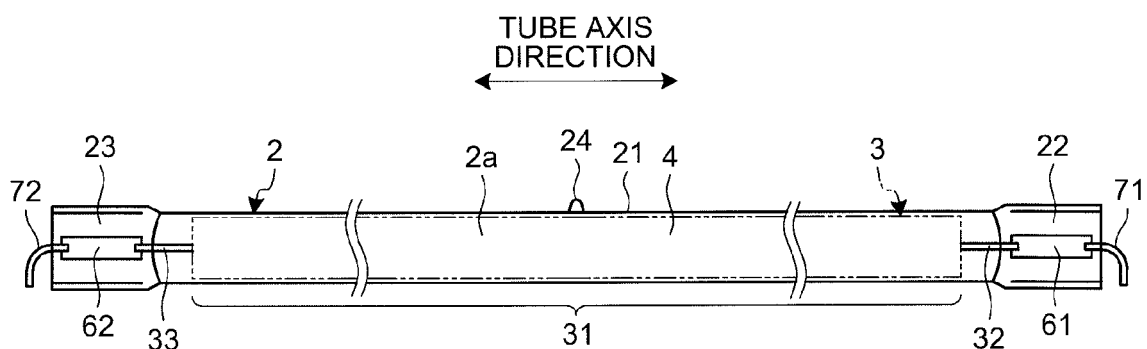


FIG.8

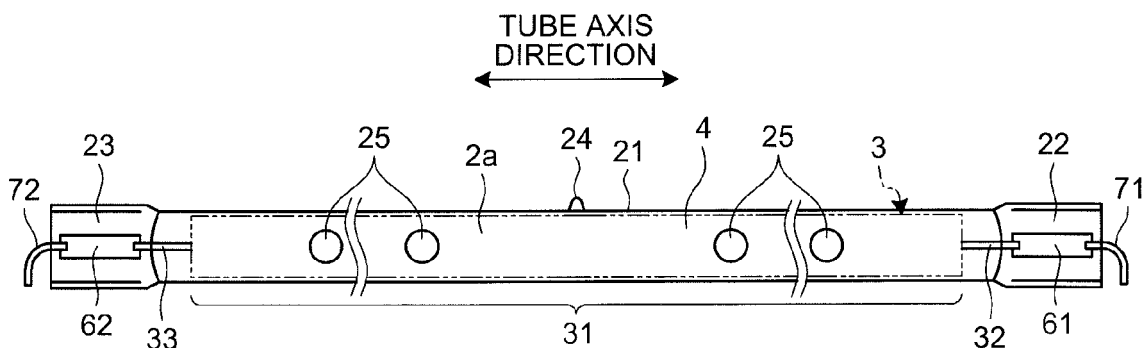


FIG.9

ELECTRIC CHARACTERISTICS OF LAMP  
(COMMON TO CONVENTIONAL PRODUCT, COMPARATIVE  
PRODUCT, AND PRESENT INVENTION)

| WATTAGE<br>[W] | TUBE WALL<br>LOAD<br>[W/cm <sup>2</sup> ] | LAMP<br>VOLTAGE<br>[V] | LAMP<br>CURRENT<br>[A] |
|----------------|-------------------------------------------|------------------------|------------------------|
| 2500           | 36                                        | 235                    | 10.6                   |

FIG.10

COMPARISON OF VISIBLE LIGHT AMOUNTS AND INFRARED RAY AMOUNTS OF  
CONVENTIONAL PRODUCT, COMPARATIVE PRODUCT 1, AND PRESENT INVENTIONS 1 AND 2  
(VISIBLE LIGHT AMOUNT AND INFRARED RAY AMOUNT OF CONVENTIONAL PRODUCT ARE  
RESPECTIVELY ASSUMED TO BE 100%)

|                         | CONVENTIONAL<br>PRODUCT<br>[%] | COMPARATIVE<br>PRODUCT 1<br>[%] | PRESENT<br>INVENTION 1<br>[%] | PRESENT<br>INVENTION 2<br>[%] |
|-------------------------|--------------------------------|---------------------------------|-------------------------------|-------------------------------|
| VISIBLE LIGHT<br>AMOUNT | 100                            | 60                              | 21                            | 19                            |
| INFRARED RAY<br>AMOUNT  | 100                            | 90                              | 87                            | 87                            |

FIG.11

ILLUMINANCE COMPARISON [lx] AT MEASUREMENT DISTANCE OF 300 mm

| CONVENTIONAL<br>PRODUCT<br>(WITHOUT<br>COAT) | COMPARATIVE<br>PRODUCT 1<br>(COAT 6<br>LAYERS) | COMPARATIVE<br>PRODUCT 2<br>(COAT 2<br>LAYERS) | COMPARATIVE<br>PRODUCT 3<br>(COAT 4<br>LAYERS) | PRESENT<br>INVENTION 1<br>(COAT 6<br>LAYERS) | PRESENT<br>INVENTION 2<br>(COAT 8<br>LAYERS) |
|----------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|----------------------------------------------|----------------------------------------------|
| 500                                          | 337                                            | 150                                            | 100                                            | 70                                           | 35                                           |



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Application Number  
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