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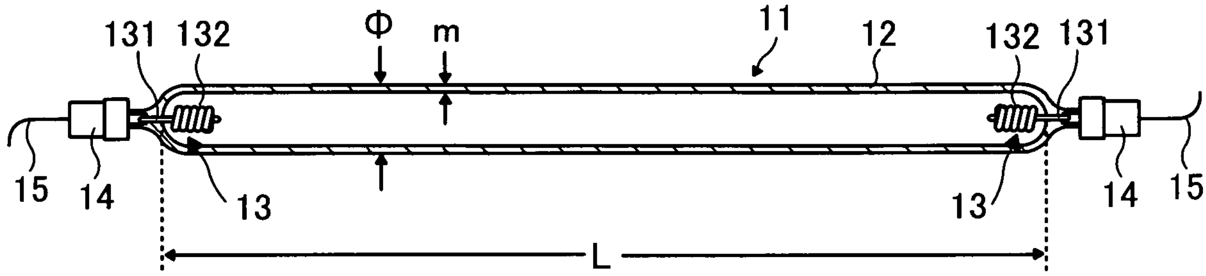
(54) **High-pressure discharge lamp**

(57) A high-pressure discharge lamp includes, at both ends of a hermetic vessel that is made of a UV transmissive material and has at least a rare gas sealed therein, two discharge electrodes provided such that each discharge electrode includes one end. In at least one of two discharge electrodes, an emitter material of oxides of at least one kind or more of rare earth elements in a concentration from 0.5 to 5.0vol% expressed in terms of the quantity of metal simple substances of the rare earth elements is contained in an electrode member using tungsten as a base material.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a high-pressure discharge lamp, and in particular to a material of a tungsten electrode for use in the discharge lamp.

BACKGROUND ART

[0002] AC discharge type high-pressure discharge lamps are currently employed for curing and drying during manufacturing processes of liquid crystals or curing of adhesives. An electrode used in this AC discharge type high-pressure discharge lamp is required to have both the characteristic of a cathode of emitting electrons and the characteristic of an anode of being hard to consume and deform. As an electrode that meets both of these characteristic requirements, a tungsten electrode containing thorium oxide is known (Japanese Patent Application Laid-Open No. 2007-179849 (JP-A-2007-179849)).

[0003] This electrode is a tungsten electrode in which the content of thorium (Th) at a depth of 5 nm from the surface of the electrode is in a range from 0.25 to 4.98AC%. AC% (atomic concentration%) as used here denotes the number of thorium (Th) atoms in the range from the surface of the electrode to a depth of 5 nm as a percent of the total of all the number of atoms and the number of molecules including the number of atoms of tungsten (W) and thorium (Th) and the number of molecules of thorium (Th) oxide existing in this range.

[0004] The foregoing tungsten electrode containing thorium oxide has a low work function, and thus a good cathode characteristic. That is, a low work function allows electrons to be emitted at low voltage, and also allows a lamp to stably operate for a long time when the lamp has been discharged. In this way, the tungsten electrode containing thorium oxide has a good electron emission characteristic and allows electron emission at relatively low temperatures. The temperature of the electrode therefore does not rise, allowing blackening and deteriorating translucency of a discharge tube due to evaporation of thorium oxide to be suppressed.

[0005] Further, thorium oxide has the highest melting point among oxides, thus having an effect of reducing the temperature of the electrode, and therefore has a good anode characteristic. That is, due to the effect of thorium oxide reducing the temperature of the electrode, improvements are made in regard to consumption and resistance to deformation of the electrode. Further, because thorium oxide has a high melting point, its amount of evaporation is small and it is less reactive with quartz glass being a material for the discharge tube. Accordingly, consumption and deformation of tungsten can be suppressed, and blackening and deteriorating translucency of the discharge tube can also be suppressed.

[0006] Thus, it is possible for the foregoing tungsten electrode containing thorium oxide to have high levels of characteristics required of both a cathode and an anode. By the use of the tungsten electrode containing thorium oxide in a high-pressure discharge lamp, consumption and deformation of an electrode and phenomena, such as blackening and deteriorating translucency, of the discharge tube can therefore be suppressed.

[0007] However, because thorium oxide used for the electrode according to the foregoing JP-A-2007-179849 is a radioactive substance, there is a problem in that thorium oxide has adverse effects on environments.

DISCLOSURE OF THE INVENTION

[0008] Accordingly, one of the objects of the present invention is to provide a high-pressure discharge lamp that can suppress consumption and deformation of an electrode and can suppress blackening and deteriorating translucency of a discharge tube without using an environmental pollutant.

[0009] A high-pressure discharge lamp according to one aspect of the present invention includes a discharge tube that is made of a UV transmissive material and that has at least a rare gas sealed therein, and two discharge electrodes provided at both ends in the discharge tube so as to each include one end. In the high-pressure discharge lamp, at least one of the two discharge electrodes is a discharge electrode using tungsten as a base material and containing, in the base material, an emitter material of oxides of at least one kind or more of rare earth elements in a concentration from 0.5 to 5.0vol% expressed in terms of the quantity of metal simple substances of the rare earth elements.

[0010] Also, a high-pressure discharge lamp according to another aspect of the present invention includes a discharge tube that is made of a UV transmissive material and that has at least mercury and a rare gas sealed therein, and two discharge electrodes provided at both ends in the discharge tube so as to each include one end. In the high-pressure discharge lamp, at least one of the two discharge electrodes is a discharge electrode using tungsten as a base material and containing, in the base material, an emitter material of oxides of at least one kind or more of rare earth elements in a concentration from 0.5 to 5.0vol% expressed in terms of the quantity of metal simple substances of the rare earth elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a cross-sectional view along an axis of a high-pressure discharge lamp according to an embodiment of the present invention.

Fig. 2 is an enlarged cross-sectional view of the main part of the high-pressure discharge lamp shown in Fig. 1.

Fig. 3 is a table showing a relationship among the concentration of an emitter material and the particle size of the emitter material and blackening and deteriorating translucency of a hermetic vessel when the high-pressure discharge lamp shown in Fig. 1 is turned on by the condition of experiment 1.

Fig. 4 is a table showing a relationship among the concentration of an emitter material and blackening and deteriorating translucency of a hermetic vessel when the high-pressure discharge lamp shown in Fig. 1 is turned on by the condition of experiment 2.

Fig. 5 is a microphotograph of a cross section along an electrode member of the high-pressure discharge lamp shown in Fig. 1.

Fig. 6A is a microphotograph showing a crystal state of the electrode member of the high-pressure discharge lamp shown in Fig. 1.

Fig. 6B is a microphotograph showing a crystal state of the electrode member of the high-pressure discharge lamp shown in Fig. 1.

Fig. 7A is a microphotograph for comparison with the crystal state of Fig. 6A.

Fig. 7B is a microphotograph for comparison with the crystal state of Fig. 6B.

Fig. 8 is a simplified view of the crystal states shown in Figs. 6A and 6B.

Fig. 9 is a simplified view of the crystal states shown in Figs. 7A and 7B.

DETAILED DESCRIPTION OF THE INVENTION

[0012] A high-pressure discharge lamp according to an embodiment of the present invention will be described below with reference to the drawings.

[0013] Fig. 1 is a cross-sectional view along an axis of a high-pressure discharge lamp according to an embodiment of the present invention. Fig. 2 is an enlarged cross-sectional view of an electrode part of the high-pressure discharge lamp of Fig. 1.

[0014] In a high-pressure discharge lamp 11 shown in Fig. 1, a hermetic vessel 12 is an arc tube made of quartz, which is UV transmissive. Wound coil electrodes 13 are disposed facing each other at both ends inside the hermetic vessel 12 as shown in Fig. 1. Each of wound coil electrodes 13 is supported by each of sockets 14 at both ends outside the hermetic vessel 12.

[0015] Rare gases such as argon (Ar) gas, mercury(Hg) ,ferrum(Fe),tin(Sn)and mercury halide are sealed inside the hermetic vessel 12. As the mercury halide, mercury iodide (HgI_2) can be used. The high-pressure discharge lamp having the hermetic vessel 12 has large luminescence peaks at wavelengths of about 358 nm, 365 nm and 378 nm.

[0016] Rare gases such as argon (Ar) gas, mercury and thallium halide may be sealed inside the hermetic vessel 12. As the thallium halide, thallium iodide (TlI) can be used. The high-pressure discharge lamp having the hermetic vessel 12 has large luminescence peaks at wavelengths of about 352 nm, 365 nm and 378 nm, and particularly about 352 nm and 378 nm. Thallium bromide may be employed instead of thallium iodide.

[0017] As shown in Fig. 2, the wound coil electrode 13 includes an electrode member 131 and a coil 132 spirally wound around an end of the electrode member 131. The coil 132 is provided so as to increase the surface area of a tip of the electrode member 131 to suppress temperature rise of the electrode member 131. The other end of the electrode member 131 is bonded to electrode foil 133. The other end of the electrode foil 133 whose one end is connected with the other end of the electrode member 131 is connected to an external lead 15 in the inside of the socket 14 as shown in Fig. 1.

[0018] The electrode member 131 is a member in which an emitter material is contained in tungsten (W). The emitter material has a capacity of emitting electrons from the electrode member 131 and also has a capacity of decreasing the temperature of the electrode member 131. The emitter material is made of an oxide of any one kind of rare earth elements, for example, of lanthanum (La), cerium (Ce), europium (Eu) and praseodymium (Pr) in a concentration from 0.5 to 2.5vol% expressed in terms of the quantity of metal simple substances of the rare earth elements. Note that this concentration range has been derived from results of experiment 1 and experiment 2 shown below. If a high-pressure discharge lamp with the electrode 13 containing an emitter material having a concentration out of this concentration range is turned on, the hermetic vessel 12 is blackened or its translucency deteriorates.

[0019] In case that the outer diameter ϕ of the hermetic vessel 12 is less than 40mm, it is preferable that the concentration range of an emitter material is from 0.5 to 2.5vol%. In case that the outer diameter ϕ of the hermetic vessel 12 is 40mm or more,it is preferable that the concentration range of an emitter material is from 0.5 to 5.0vol%.

[0020] Vol% can be obtained from the following equation:

$$B = \{ V_{em} / (V_W + V_{em}) \} \times 100$$

$$= [(m_{em} / \rho_{em}) / \{ (m_W / \rho_W) + (m_{em} / \rho_{em}) \}] \times 100$$

[0021] In the above equation, B represents vol%, V_W represents the volume of tungsten, and V_{em} represents the volume of the rare earth element included in tungsten. That is, vol% refers to a ratio of the volume of the contained rare earth element to the volume of tungsten.

[0022] These volumes V_W and V_{em} can be determined from their respective masses (m_W, m_{em}) and densities (ρ_W, ρ_{em}). Here, tungsten contains an oxide of a rare earth element, resulting in the electrode member 131 formed with tungsten containing the rare earth element. Note that the foregoing mass m_{em} is a mass calculated from the mass of a rare earth oxide contained in tungsten.

[0023] Using the high-pressure discharge lamp 11 described above, the following experiment 1 and experiment 2 were carried out.

[0024] The hermetic vessel 12 of the high-pressure discharge lamp 11 used in the experiment 1 had an outer tube diameter ϕ of 27.5 mm, a thickness m of 1.5 mm and a light emission length L of 1000 mm, and had a lamp current value of 11.0 A in specifications. This high-pressure discharge lamp 11 was turned on in accordance with ratings at a rated voltage of 1150 V, a rated current of 10.5 A and a rated power of 12 kW. Then, blackening and deteriorating translucency were observed at both ends of the hermetic vessel 12 after 500 hours. The results are shown in Fig. 3.

[0025] In Fig. 3, using the electrode members 131 in which emitter materials having different concentrations and different average particle sizes are each contained in tungsten for each kind of emitter material, results of evaluation in five degrees of the states of blackening and the states of deteriorating translucency of lamps having these electrode members 131 are shown. In Fig. 3, it is shown that the larger the value is in evaluation of blackening and deteriorating translucency, the worse the characteristics are. Further, the overall evaluation of the state of blackening and the state of deteriorating translucency is determined by the sum of evaluation of the state of blackening and evaluation of the state of deteriorating translucency.

[0026] Then, the hermetic vessel 12 of the high-pressure discharge lamp 11 used in the experiment 2 had an outer tube diameter ϕ of 84.0 mm, a thickness m of 1.5 mm and a light emission length L of 1490 mm, and had a lamp current value of 23.4 A in specifications. This high-pressure discharge lamp 11 was turned on in accordance with ratings at a rated voltage of 1925 V, a rated current of 23.4 A and a rated power of 44 kW. Then, blackening and deteriorating translucency were observed at both ends of the hermetic vessel 12 after 500 hours. The results are shown in Fig. 4.

[0027] In Fig. 4, using the electrode members 131 in which emitter materials having different concentrations are each contained in tungsten for each kind of emitter material, results of evaluation in five degrees of the states of blackening and the states of deteriorating translucency of lamps having these electrode members 131 are shown. In Fig. 4, it is shown that the larger the value is in evaluation of blackening and deteriorating translucency, the worse the characteristics are. Further, the overall evaluation of the state of blackening and the state of deteriorating translucency is determined by the sum of evaluation of the state of blackening and evaluation of the state of deteriorating translucency.

[0028] From the results shown in Fig. 3 and Fig. 4, the followings were found.

[0029] First, it was found that an emitter material included in the electrode member 131 used in the high-pressure discharge lamp 11 turned on by experiment 1 represented as EXCELLENT in the box of overall evaluation had a content in the range from 0.5 to 2.5vol% expressed in terms of the quantity of simple substances of the rare earth element. It was found that an emitter material included in the electrode member 131 used in the high-pressure discharge lamp 11 turned on by experiment 2 represented as EXCELLENT in the box of overall evaluation had a content in the range from 0.5 to 5.0vol% expressed in terms of the quantity of simple substances of the rare earth element.

[0030] In the case of the emitter material having a concentration more than 2.5vol% as shown in Fig. 3 or in the case of the emitter material having a concentration more than 5.0vol% as shown in Fig. 4, the translucency of the hermetic vessel 12 deteriorated. The reason for this was that the quantity of the emitter material on the surface of the electrode member 131 increased, and therefore the emitter material scattered during the on-state of the lamp. This may cause the scattered emitter material to adhere to the internal surface of the hermetic vessel 12 and the like. This adhesion may result in decreased illuminance and crystallization of quartz caused by the emitter material, leading to breakage of the hermetic vessel 12.

[0031] On the other hand, in the case of the emitter material having a concentration less than 0.5vol% as shown in Fig. 3 and Fig. 4, the hermetic vessel 12 was blackened. The reason for this was that the electrode member 131 was in a state close to pure tungsten, and therefore the characteristic of electron emission from the electrode member 131 became worse, resulting in an increase in spot temperature. The increased spot temperature facilitated degradation of the electrode member 131, and evaporated tungsten to blacken the hermetic vessel 12.

[0032] It was also found that an emitter material included in the electrode member 131 used in the high-pressure discharge lamp 11 represented as EXCELLENT in the box of overall evaluation had an average particle size less than 3 μm. Here, the average particle size was determined using an image as shown in Fig. 5 obtained by cutting the electrode member 131 along the axis direction and enlarging the cross section by a factor of 1000 by a laser microscope. That is, the average particle size was determined by measuring the maximum sizes (fillet sizes) of emitter material particles included in any circle of 50 μm in the image shown in Fig. 5, and dividing the sum of the maximum sizes of the emitter material particles by the number of the emitter material particles.

[0033] In the case of the emitter material having an average particle size of 3 μm or more, the hermetic vessel was blackened. The reason for this was that the particle size of the emitter material was large, and therefore it became difficult for particles of the emitter material to move in a crystallized area on the surface of the electrode member 131. As a result, it became difficult for the emitter material to be supplied to the surface of the electrode member 131, and therefore effects obtained by containing an emitter material were difficult to be obtained.

[0034] That is, it was found from the foregoing experimental results that the average particle size of an emitter material that allowed suppression of consumption and deformation due to discharging of the electrode member 131 and also allowed sufficient suppression of blackening and deteriorating translucency of the hermetic vessel 12 was less than 3 μm. It is preferable that this average particle size be as small as possible, and a more preferable range is 1.5 μm or less.

[0035] From the above, it was found that, when an emitter material that was an oxide of a rare earth element having a concentration from 0.5 to 5.0vol% expressed in terms of the quantity of simple substances of the rare earth element and that had an average particle size less than 3 μm was contained in the electrode member 131, consumption and deformation due to discharging of the electrode member 131 could be suppressed, and also blackening and deteriorating translucency of the hermetic vessel 12 could be sufficiently suppressed.

[0036] Next, a method of manufacturing the foregoing electrode member 131 will be described. Although the manufacturing method is not particularly limited, the electrode member 131 may be manufactured, for example, by the following method.

[0037] First, predetermined amounts of nitrate of a rare earth metal in an aqueous solution state and tungsten powder having an average particle size from 2 to 3μ m and a purity of 99.95% or more are mixed in a porcelain dish and are dried. Thereafter, the nitrate of the rare earth metal is decomposed in a hydrogen atmosphere at 700 to 900°C to be finely dispersed as an oxide, and concurrently the tungsten powder is reduced. The powder of the emitter material in a form of an oxide may be mixed with the tungsten powder in a ball mill. In such a case, however, a bulky emitter material particle is left in the bulky state when a sintered compact thereof is produced. As a result, it becomes difficult for an emitter material of according to the embodiment of the present invention to have a particle size less than 3 μm. Therefore, the aforementioned method is preferable as a method of manufacturing powder.

[0038] Subsequently, a molded compact having a predetermined size is produced by pressing to a size of about 15 mm long × 15 mm wide × 650 mm high by using a die. Thereafter, electric-current sintering is performed in a hydrogen atmosphere to obtain a sintered compact of about 12.5 mm long × 12.5 mm wide × 540 mm high.

[0039] Next, the sintered compact heated at 1400 to 1700°C is extended while being beaten, so that the sintered compact is extended in a thin shape. Subsequently, the sintered compact extended in a thin shape is polished so that the sintered compact is in a concentric shape having a fixed diameter. Finally, the surface of the sintered compact polished to a concentric shape is polished by an electrolytic process, thereby forming the electrode member 131.

[0040] After the electrode member 131 is formed, cleaning of the hermetic vessel 12 is performed in a hydrogen atmosphere at 1200 to 1400°C, and then a vacuum process is performed at 2000°C or less. The wound coil electrode 13 with the coil 132 at the tip of the electrode member 131 is disposed in this hermetic vessel 12, thus enabling the aforementioned high-pressure discharge lamp 11 to be obtained.

[0041] By using the electrode member 131 described above, it is possible to form the high-pressure discharge lamp 11 that can suppress consumption and deformation of the electrode member 131 and suppress blackening and deteriorating translucency of the hermetic vessel 12.

[0042] Here, when a longitudinal direction of tungsten crystal at the tip of the electrode member 131 is a long axis (L) and a sectional direction of the electrode member 131 is a short axis (W), L/W is set to 3.0 or more to enable consumption and deformation of the electrode member 131 to be further suppressed and also blackening and deteriorating translucency of the hermetic vessel 12 to be further suppressed. This will be described below.

[0043] The tip of the electrode member 131 serves as a starting point of discharging, and therefore is melted to form a molten layer. At this point, when the length of the molten layer from the tip of the electrode member 131 toward the axis direction is M and the diameter of the electrode member 131 is D, M/D is in the range of 0.01 or more and 0.5 or less. The molten layer is formed either in part of the starting point (spot) of discharging or over the whole tip portion of the electrode member 131. In either case, however, when the molten layer is recrystallized, the particle size of tungsten crystal is made bulky. It is preferable that the recrystallized tungsten crystal be long in the axis direction as shown in the microphotographs in Figs. 6A and 6B. The reason for this is that long tungsten crystal as shown in Figs. 6A and 6B allows an emitter material contained in the electrode member 131 to easily move to the surface of the electrode member 131. On the contrary, if recrystallized tungsten crystal is in a fine state as in the microphotographs shown in Figs. 7A and 7B, it becomes difficult for an emitter material in the electrode member 131 to move to the surface of the electrode member 131.

[0044] The reason for this is that in the case of long tungsten crystal as shown in Fig. 8, in which Figs. 6A and 6B are schematically illustrated, an emitter material can easily move in grain boundaries of tungsten crystal, and therefore an emitter material in the electrode member 131 can easily move to the surface of the electrode member 131.

[0045] On the contrary, in the case of fine tungsten crystal as shown in Fig. 9, in which Figs. 7A and 7B are schematically illustrated, it becomes difficult for an emitter material to move in grain boundaries of tungsten crystal, and therefore an emitter material in the electrode member 131 is difficult to move to the surface of the electrode member 131.

[0046] Accordingly, regarding the size of crystal formed under the molten layer, assuming that the longitudinal direction of the electrode member 131 is a long axis (L), and the sectional direction of the electrode member 131 is a short axis (W), it is preferable that L/W be large. Specifically, it has been confirmed by the present inventors that L/W of 3.0 or more is preferable, and a more preferable value of L/W is 5.0 or more.

[0047] The foregoing electrode member 131 may further contain at least one kind of aluminum (Al), silicon (Si) and potassium (K) of 0.001 to 0.01mass% to further improve resistance to deformation of the electrode member 131. This will be described below.

[0048] Al, Si and K are used as a doped material, and they may be contained in the foregoing electrode member 131 to improve the resistance to deformation of the electrode member 131. It has been confirmed by the present inventors that the content of this doped material is preferably 0.001 to 0.01mass% of any one kind of Al, Si and K. If the content is less than 0.001mass%, effects due to containing the material cannot be sufficiently obtained. If the content is more than 0.01mass%, problems arise in the sinterability and workability.

[0049] Further, by containing the foregoing various doped materials in the electrode member 131, it is possible to enlarge crystal of tungsten. Accordingly, it is estimated that movement of an emitter material in the inside of the electrode member 131 is facilitated.

[0050] Note that a method of manufacturing the electrode member 131 containing such a doped material is the same as the aforementioned manufacturing method except that predetermined amounts of nitrate of a rare earth metal in an aqueous solution state, tungsten powder doped with a predetermined amount of Al, Si and K, and pure water are mixed in a porcelain dish and are dried.

[0051] Also, by using the electrode member 131 having a working rate of 80% or more, it is possible to further suppress consumption and deformation of the electrode member 131 and suppress blackening and deteriorating translucency of the hermetic vessel 12. This will be described below.

[0052] The foregoing working rate means a rate of an amount to be worked in working from a sintered compact to a final electrode form. Assuming that the cross sectional area of the sintered compact is S1 and the cross sectional area of the electrode member 131 is S2, the working rate is represented by the following expression: $[(S2-S1)/S1]\times 100$ (%). The working rate has effects on dispersion of an emitter material in the electrode member 131 and the size L/W of crystal produced at the tip of the electrode member 131. That is, a higher working rate causes a material to be broken into smaller pieces and be dispersed more finely in a tungsten matrix as the working from a sintered compact state to the final electrode form progresses. It therefore becomes easier for the emitter material to be supplied to the surface of the electrode member 131. Further, a higher working rate causes the thermal energy with which the electrode member 131 is loaded to be increased by working from a sintered compact state to the final electrode form, and the like. This energy functions as driving energy of recrystallization of melted tungsten, and therefore facilitates generation of crystal with large L/W and facilitates supply of the emitter material to the surface of the electrode member 131. Accordingly, use of the electrode member 131 with high workability is preferable, and specifically use of the electrode member 131 having a workability of 80% or more is preferable.

[0053] As described above, in the high-pressure discharge lamp 11 according to the embodiment of the present invention, consumption and deformation of the electrode member 131 can be suppressed, and blackening and deteriorating translucency of the hermetic vessel 12 can be suppressed.

[0054] Specific examples of the foregoing high-pressure discharge lamp 11 will be described below.

(Example 1)

[0055] The high-pressure discharge lamp 11 according to Example 1 is a metal halide lamp 11 with the electrode members 131 made of tungsten containing La_2O_3 having 0.6vol% and an average particle size of 3 μm provided at both ends of the hermetic vessel 12. Hg, Fe, Sn and HgI_2 are sealed in the inside of the vessel 12. Ar is further sealed as a seal gas. In this lamp, the hermetic vessel 12 is made of a crystal tube having high UV transmissivity, and has an outer diameter ϕ of 27.5 mm and a light emission length of 1000 mm in specifications.

[0056] This metal halide lamp 11 was turned on in accordance with ratings at a rated voltage of 1310 V, a rated current of 12.2 A and a rated power of 16 kW. Then, blackening and deteriorating translucency were observed at both ends of the hermetic vessel 12 after 500 hours. As a result, consumption and deformation of the electrode member 131 were able to be suppressed and blackening and deteriorating translucency of the hermetic vessel 12 were also able to be suppressed.

(Example 2)

[0057] The high-pressure discharge lamp 11 according to Example 2 is a metal halide lamp 11 with the electrode members 131 made of tungsten containing La_2O_3 having 2.0vol% and an average particle size of 3 μm provided at both ends of the hermetic vessel 12. Hg, TlI and NaI are sealed in the inside of the vessel 12. A mixed gas of Ne-Ar is further sealed as a seal gas. In this lamp, the hermetic vessel 12 is made of a crystal tube having high light transmissivity, and has an outer diameter ϕ of 84 mm and a light emission length of 1430 mm in specifications. Further, the hermetic vessel 12 has a dual structure in which the hermetic vessel 12 is enclosed in an outer tube having an outer diameter ϕ of 120 mm larger than that of this vessel 12.

[0058] This metal halide lamp 11 was turned on in accordance with ratings at a rated voltage of 1925 V, a rated current of 23.4 A and a rated power of 44 kW. Then, blackening and deteriorating translucency were observed at both ends of the hermetic vessel 12 after 500 hours. As a result, consumption and deformation of the electrode member 131 were able to be suppressed and blackening and deteriorating translucency of the hermetic vessel 12 were also able to be suppressed.

[0059] In the above, the high-pressure discharge lamp 11 according to the embodiment of the present invention has been described. However, the present invention is not limited to the foregoing examples.

[0060] For example, an emitter material included in the electrode member 131 may contain two or more kinds of oxides of rare earths. Even in this case, the same effects can be obtained when the total of amounts of simple substances of rare earth elements contained is in the aforementioned range.

[0061] Also, even in the case of using two or three kinds of doped materials, the same effects can be obtained when their total amount is within a range from 0.001 to 0.01mass%.

[0062] Rare gases, mercury and metal halide are sealed inside the foregoing hermetic vessel 12. However, rare gases and mercury or rare gases and metal halide may be sealed inside the hermetic vessel 12.

[0063] In each of the foregoing AC discharge type high-pressure discharge lamps 11, it has been found that, by limiting the concentration of an emitter material and the average particle size of the emitter material as described above, it is possible to suppress blackening and deteriorating translucency. The reason for this is that use of a substance as mentioned above as the emitter material can suppress temperature rise of the electrode member 131. Accordingly, the electrode member 131 described in relation to each of the foregoing high-pressure discharge lamps 11 can also be applied to a cathode of a DC discharge type high-pressure discharge lamp.

[0064] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. A high-pressure discharge lamp comprising:

   a discharge tube (12) made of a UV transmissive material, the discharge tube (12) having at least a rare gas sealed therein; and
   two discharge electrodes (13) provided at both ends in the discharge tube (12) so as to each include one end, wherein at least one of the two discharge electrodes (13) is a discharge electrode using tungsten as a base material and containing, in the base material, an emitter material of oxides of at least one kind or more of rare earth elements in a concentration from 0.5 to 5.0vol% expressed in terms of quantity of metal simple substances of the rare earth elements.

2. The high-pressure discharge lamp according to claim 1, wherein, in tungsten crystal at a tip of the discharge electrode (13) containing the emitter material, assuming that the longitudinal direction of the electrode is a long axis (L) and the sectional direction of the electrode is a short axis (W), L/W is 3.0 or more.

3. The high-pressure discharge lamp according to claim 1 or 2, wherein the emitter material has an average particle size less than 3 μm.

4. The high-pressure discharge lamp according to any one of claims 1 to 3, wherein the emitter material is made of at least one kind or more of oxides of lanthanum (La), cerium (Ce), europium (Eu) and praseodymium (Pr).

5. The high-pressure discharge lamp according to any one of claims 1 to 4, wherein the emitter material further contains at least one kind of aluminum (Al), silicon (Si) and potassium (K) of 0.001 to 0.01mass%.

6. The high-pressure discharge lamp according to any one of claims 1 to 5, wherein a metal halide is further contained in the discharge tube.

7. A high-pressure discharge lamp comprising:

a discharge tube (12) made of a UV transmissive material, the discharge tube (12) having at least mercury and a rare gas sealed therein; and
two discharge electrodes (13) provided at both ends in the discharge tube (12) so as to each include one end, wherein at least one of the two discharge electrodes (13) is a discharge electrode using tungsten as a base material and containing, in the base material, an emitter material of oxides of at least one kind or more of rare earth elements in a concentration from 0.5 to 5.0vol% expressed in terms of quantity of metal simple substances of the rare earth elements.

8. The high-pressure discharge lamp according to claim 7, wherein, in tungsten crystal at a tip of the discharge electrode (13) containing the emitter material, assuming that the longitudinal direction of the electrode is a long axis (L) and the sectional direction of the electrode is a short axis (W), L/W is 3.0 or more.

9. The high-pressure discharge lamp according to claim 7 or 8, wherein the emitter material has an average particle size less than 3 μm.

10. The high-pressure discharge lamp according to any one of claims 7 to 9, wherein the emitter material is made of at least one kind or more of oxides of lanthanum (La), cerium (Ce), europium (Eu) and praseodymium (Pr).

11. The high-pressure discharge lamp according to any one of claims 7 to 10, wherein the emitter material further contains at least one kind of aluminum (Al), silicon (Si) and potassium (K) of 0.001 to 0.01mass%.

12. The high-pressure discharge lamp according to any one of claims 7 to 11, wherein a metal halide is further contained in the discharge tube (12).

FIG.1

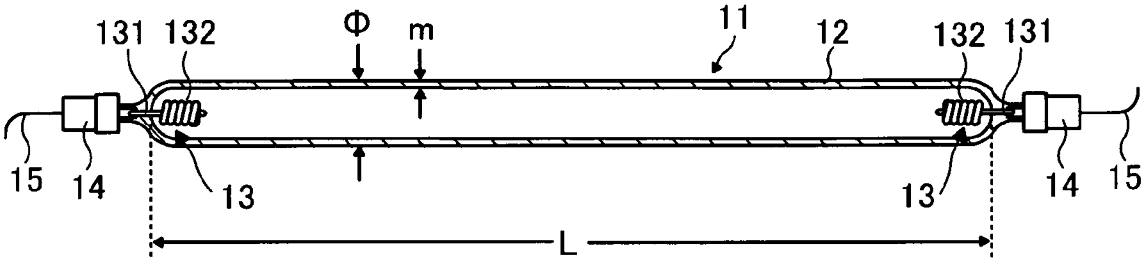


FIG.2

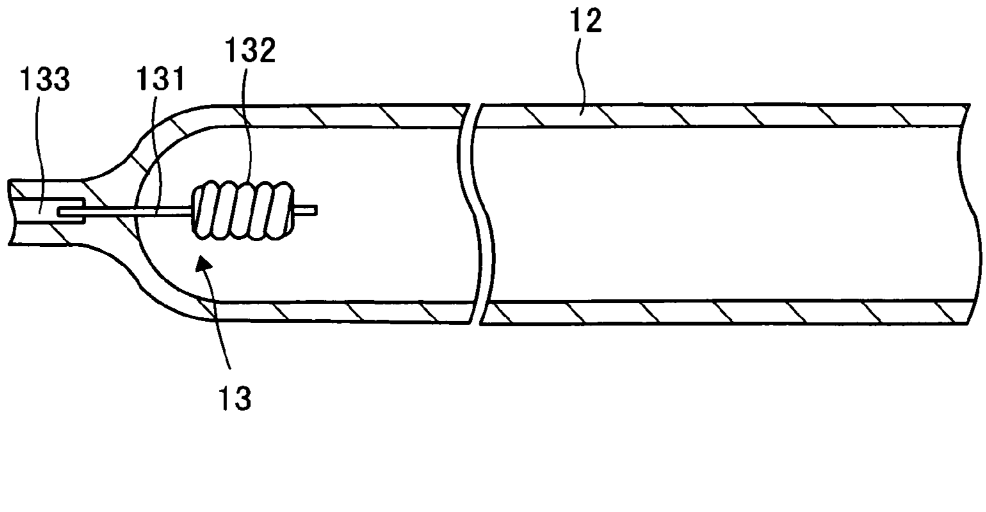


FIG.3

No.	composition (vol%)	average particle size of emitter (μm)	blacking	deteriorating translucency	overall evaluation
	States of blacking and deteriorating translucency 500 hours after turn-on (good: 1 - bad: 5)				
	Overall evaluation (blacking + deteriorating translucency ≦ 4: excellent(○), = 5: good(△), ≧ 6: fair(×))				
1	3.8%ThO_2- W(comparative example)	1.0	2	2	○
2	0.5%Ce_2O_3-W	1.0	3	1	○
3	0.7%Ce_2O_3-W	1.0	2	1	○
4	1.0%Ce_2O_3-W	1.0	2	2	○
5	1.5%Ce_2O_3-W	1.0	2	2	○
6	2.0%Ce_2O_3-W	1.0	2	2	○
7	2.3%Ce_2O_3-W	1.0	1	2	○
8	2.5%Ce_2O_3-W	1.0	1	3	○
9	0.4%Ce_2O_3-W(comparative example)	1.0	4	1	△
10	0.3%Ce_2O_3-W(comparative example)	1.0	4	1	△
11	0.2%Ce_2O_3-W(comparative example)	1.0	5	1	×
12	2.6%Ce_2O_3-W(comparative example)	1.0	1	4	△
13	2.7%Ce_2O_3-W(comparative example)	1.0	1	4	△
14	2.8%Ce_2O_3-W(comparative example)	1.0	1	5	×
15	1.5%Ce_2O_3-W(comparative example)	5.0	4	2	×
16	1.5%Ce_2O_3-W(comparative example)	4.0	4	2	×
17	1.5%Ce_2O_3-W(comparative example)	3.5	4	2	×
18	1.5%Ce_2O_3-W	3.0	3	2	△
19	1.5%Ce_2O_3-W	2.0	2	2	○
20	1.5%Ce_2O_3-W	1.5	2	2	○
21	1.5%Ce_2O_3-W	1.8	2	2	○
22	0.5%Ce_2O_3-W (K:0.001wt%)	1.0	3	1	○
23	0.5%Ce_2O_3-W (K:0.006wt%)	1.0	2	1	○
24	0.5%Ce_2O_3-W (K:0.01wt%)	1.0	2	1	○
25	0.5%Ce_2O_3-W (K:0.012wt%) (comparative example)	unworkable	unworkable	unworkable	unworkable
26	0.5%Eu_2O_3-W	1.0	3	1	○
27	0.7%Eu_2O_3-W	1.0	2	1	○
28	1.0%Eu_2O_3-W	1.0	2	2	○
29	1.5%Eu_2O_3-W	1.0	2	2	○
30	2.0%Eu_2O_3-W	1.0	2	2	○
31	2.3%Eu_2O_3-W	1.0	1	2	○
32	2.5%Eu_2O_3-W	1.0	1	3	○
33	0.4%Eu_2O_3-W(comparative example)	1.0	4	1	△
34	0.3%Eu_2O_3-W(comparative example)	1.0	4	1	△
35	0.2%Eu_2O_3-W(comparative example)	1.0	5	1	×
36	2.6%Eu_2O_3-W(comparative example)	1.0	1	4	△
37	2.7%Eu_2O_3-W(comparative example)	1.0	1	4	△
38	2.8%Eu_2O_3-W(comparative example)	1.0	1	5	×
39	1.5%Eu_2O_3-W(comparative example)	5.0	4	2	×
40	1.5%Eu_2O_3-W(comparative example)	4.0	4	2	×
41	1.5%Eu_2O_3-W(comparative example)	3.5	4	2	×
42	0.5%Eu_2O_3-W	1.0	3	1	○

FIG.4

States of blacking and deteriorating translucency 500 hours after turn-on (good: 1 - bad: 5)					
Overall evaluation (blacking + deteriorating translucency ≦ 4: excellent(○), = 5: good(△), ≧ 6: fair(×))					
No.	composition (vol%)	average particle size of emitter (μm)	blacking	deteriorating translucency	overall evaluation
1	0.3%Ce_2O_3-W	1.0	3	1	×
2	0.3%La_2O_3-W	1.0	3	1	×
3	0.7%Ce_2O_3-W	1.0	2	1	○
4	0.7%La_2O_3-W	1.0	2	1	○
5	1.0%Ce_2O_3-W	1.0	1	1	○
6	1.0%La_2O_3-W	1.0	1	1	○
7	2.5%Ce_2O_3-W	1.0	1	1	○
8	2.5%La_2O_3-W	1.0	1	2	○
9	5.0%Ce_2O_3-W	1.0	2	2	○
10	5.0%La_2O_3-W	1.0	1	2	○
11	6.0%Ce_2O_3-W	1.0	2	4	×
12	6.0%La_2O_3-W	1.0	1	4	△

FIG.5

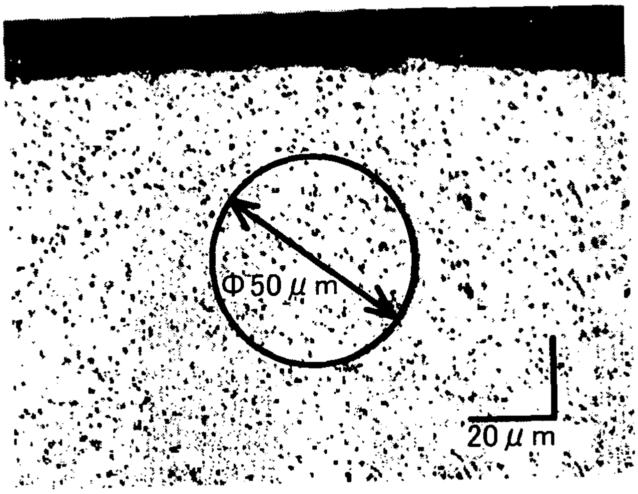


FIG.6A

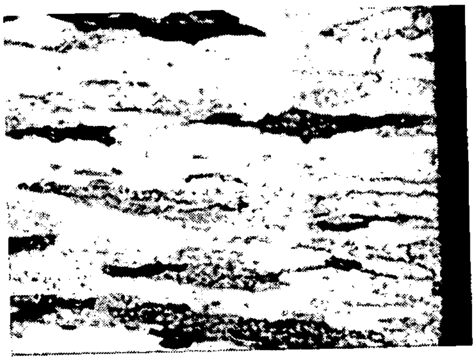


FIG.6B

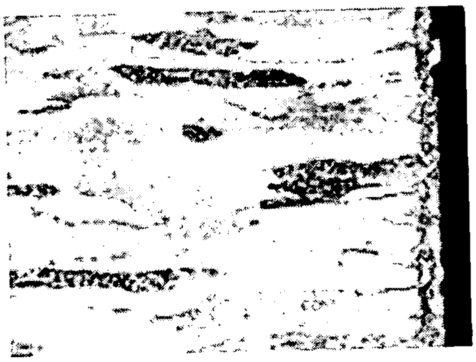


FIG.7A

FIG.7B

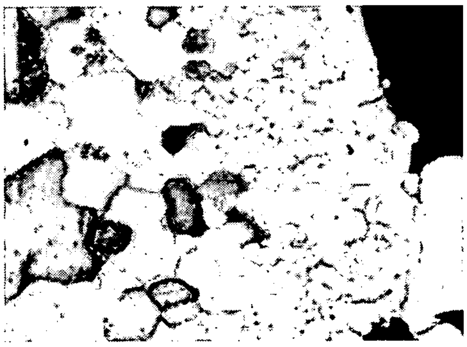


FIG.8

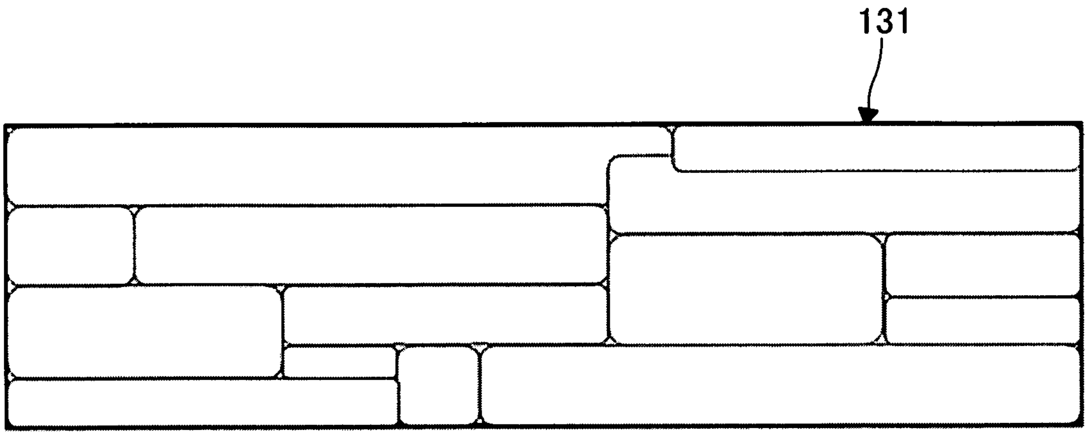
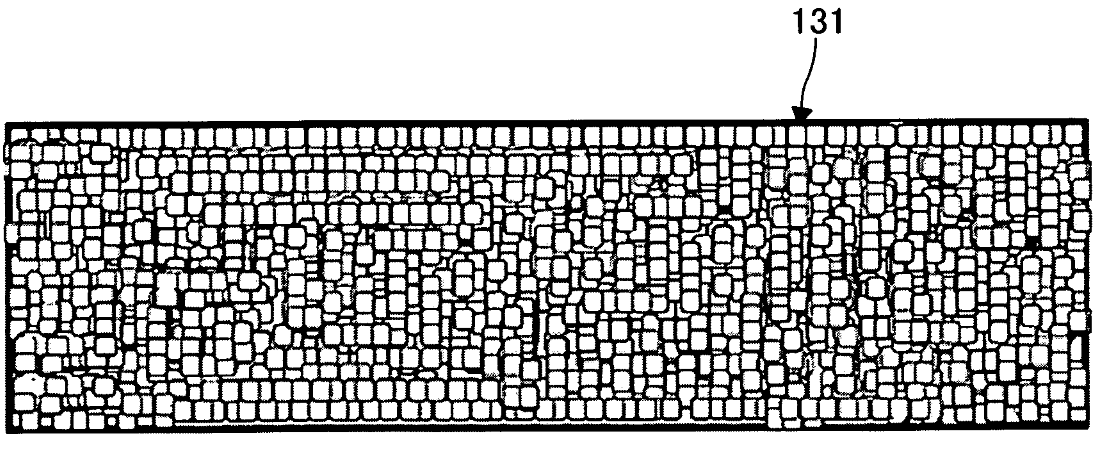


FIG.9



REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2007179849 A **[0002] [0002] [0007]**