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(54) COMPOUND HID ELECTRIC ARC TUBE

(57) A compound HID electric arc tube includes a discharge tube and two lead-out tubes. The discharge tube has an envelope of blown melted quartz glass or Vycor-type quartz glass with a semitranslucent polycrystalline aluminum oxide (PCA) layer applied to the inside surface thus forming a double-layer envelope. The lead-out tubes are made of melted quartz glass or Vycor-type quartz glass and, near the two ends of the arc tube, are partially coated on their inside surfaces with a polycrystalline aluminum oxide (PCA) layer. After high temperature sintering of the electric arc tube, a two-stage method is used to seal the electrodes. A glass solder seal is used in the first section of the lead-out tube having the inner coating of PCA, and a molybdenum foil press seal is used to seal the quartz glass second section.

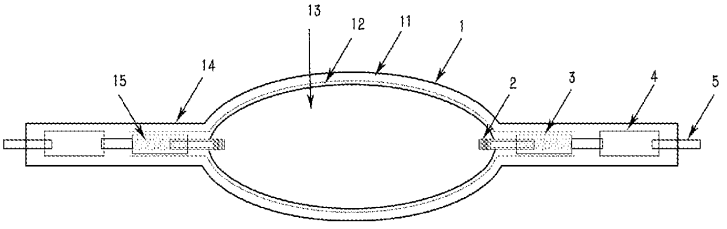

Fig.1

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Description

Field of the Invention

[0001] The invention relates to arc tubes used in the lighting equipment, especially to composite High Intensity Discharge (HID) arc tubes used in HID lamps.

Background of the Invention

[0002] Conventionally, quartz is chosen as the material for HID arc tubes because quartz can withstand high pressure of about 200-300 times of the atmospheric pressure; on the other hand, arc tubes made of quartz is easy to be encapsulated or sealed. However, quartz materials also have apparent disadvantages; i.e. on one hand, the dimension of the inner chamber of the quartz arc tube has uncontrollable tolerance, since the quartz arc tube is formed by molding hot melt at a high temperature by pressing outer mold against the inner chamber while blowing highly pressurized gas into the inner chamber; on the other hand, when the quartz arc tube operates at a high temperature, the color rendering property deteriorates with reduced luminous efficacy and stability, and the lost of sodium in the lamp is severe.

[0003] In recent years, quartz arc tubes, especially low power lamps used for exhibition lighting, are replaced by polycrystalline alumina (PCA) ceramic arc tube to significantly enhance the consistency and stability of light color. The replacement of quartz arc tube by ceramic arc tube improves the color consistency of metal halide lamp (MH), one reason is that the base body used to make ceramic arc tube is shaped by molding or grout molding at an ordinary temperature, so that its dimension is well controlled; and another reason is that ceramic arc tube increases the operation temperature of the tube wall. Thus, in case that the temperature of the tube wall is high, a minimal value can be observed in the curve of correlated color temperatures versus temperatures of the tube wall. Ceramic arc tube is adapted to operate in a region around the corresponding color temperature minimal value (by contrast, for quartz arc tube, such minimal value area is above the appropriate endurable operation temperature of quartz glass), especially when the filling agent is halides of sodium and rare earth element, a higher operation temperature enables the lamp to have a better color rendering property (Ra>80) and higher luminous efficacy (> 901m·W^{-1}). Another benefit of the structure of polycrystalline alumina is in its lifetime, the loss of sodium within the lamp is greatly reduced, ensuring that the color rendering property is more stable than conventional metal halide lamp using quartz arc tube.

[0004] Chinese Patent No. 98115658.4 discloses a ceramic shell component of high intensity discharge lamp, which has a shell structure of PCA shell, and specially designed multi-layer structure of axially delaminated aluminum oxide-metal ceramic. The terminal therein provided with multiple elements has its last element directly sintered to the corresponding feed-through wire without any sealing material, while keeping a certain thermal expansion coefficient. However, in fact, due to high operation temperature and intense corrosion due to fused metal halide and steam of the lamp, such sealing methods cannot provide long-term reliable sealing and a longer lifetime.

[0005] US patent US 6,313,582B1 also discloses a ceramic lamp, in which the discharge tube is made of translucent ceramic, and the tube sealing part is terminally encapsulated by means of Dy_2O_3-Al_2O_3-SiO_2 based sealing material. It is in fact very difficult to encapsulate the electrode of such arc tube made of ceramic due to poor pressure resistance of PCA itself (it can only withstand about 3-5 times of the atmospheric pressure). In the actual state of air exhaust, it is not easy to fill metal halide balls, inject mercury, inflate various inert gases into the arc, and maintain gas sealing between the outer lead of electrode and ceramic material by filling glass solders. The last step of manufacturing arc tube frequently fails, so that all the previous steps were wasted, and the yield rate of arc tube is seriously affected, thus the costs cannot be lowered. Moreover, the technique in the art can only enable arc tube with power of 150W or lower, arc tube with high power of 250W or up to several KW is not commercially applicable yet. Therefore, such advanced technique of manufacturing lamp is not widely used.

[0006] The technical solutions of above patent documents are incorporated here as background for reference.

Summary

[0007] Therefore, with respect to the advantages and the disadvantages of quartz material and translucent polycrystalline alumina, as well as the problems in terms of sealing, the invention proposes a new arc tube which combines the advantages of these two materials and compensates the respective disadvantages of these two materials.

[0008] An obj ect of the invention is to provide a composite HID arc tube, which is characterized in that a layer of translucent polycrystalline alumina is applied on an arc tube manufactured by blow-molding quartz glass or Vycor quartz glass, then the arc tube is heated at high temperature and molded, so as to form a composite HID arc tube made of fused quartz glass and translucent polycrystalline alumina, or Vycor quartz glass and translucent polycrystalline alumina. Such composite HID arc tube maintains the advantages of quartz glass including ease of encapsulation or sealing, and endurance to high working pressures; while the translucent polycrystalline alumina is applied on the inner casing with grout-molding, a strict control of the dimension of the inner chamber of the arc tube is resulted, thus the working temperature of the inner wall of the arc tube is increased and sodium penetration is prevented effectively. By using such a

composite HID arc tube, the inflation pressure in the lamp can be increased by 20%-50% of that of ceramic metal halide lamp made of ordinary polycrystalline alumina. Therefore, the luminous efficacy can be enhanced by about 25%, and particularly, such a composite HID arc tube can be employed to manufacture the arc tube of light source like Ultra High Pressure Mercury Discharge lamp (UHP) to effectively overcome the problem that the pressure resistance of quartz glass arc tube of UHP being reduced due to re-crystallization and devitrification of the inner wall caused by too high temperature of the inner wall, and thus results in an early failure.

[0009] A composite HID arc tube according to the invention comprises a discharge tube and two outwardly extending tubes, characterized in that

said discharge tube is a composite two-layer shell formed of an outer shell manufactured by blow-molding fused quartz glass or Vycor quartz glass, and applying a layer of translucent polycrystalline alumina on the outer shell; and

said outwardly extending tubes are made of fused quartz glass or Vycor quartz glass, wherein a layer of polycrystalline alumina is applied at the ends of said outwardly extending tubes close to arc chamber.

[0010] According to one aspect of the invention, in the above composite HID arc tube, the arc chamber of the discharge tube is in the shape of olive or ellipse.

[0011] According to another aspect of the invention, in the above composite HID arc tube, an inner wall of the arc chamber as well as inner walls of segments of the outwardly extending tubes close to the arc chamber of 3~8mm long are uniformly applied with a layer of translucent polycrystalline alumina of a thickness of 0.2~0.5mm.

[0012] According to another aspect of the invention, in the above composite HID arc tube, two different sealing methods are used at each of the outwardly extending tubes.

[0013] According to still another aspect of the invention, in the above composite HID arc tube, glass solder made of a mixture of Al_2O_3, Dy_2O_3, SiO_2 is used to seal a region of said outwardly extending tube applied with the layer of polycrystalline alumina, a region of said outwardly extending tube made of quartz glass is heated by coal-oxygen fire and then sealed under pressure.

[0014] Furthermore, in the composite HID arc tube of the invention, the layer of polycrystalline alumina is applied by the following steps: an inserted body made of heat-resistant silica gel is inserted into the arc chamber of the discharge tube and the outwardly extending tube, air under a certain pressure is injected such that the inserted body made of silica gel turns into a sophisticated inner lining film; and ceramic powder slurry is injected into the gap between the inner lining film and the outer shell, wherein the ceramic powder slurry is obtained by uniformly mixing highly-pure aluminum oxide powder, a small amount of adhesive, grain generation inhibitor, and plasticizer; after grouting and molding, cures at room temperature and then performs mould unloading; then, heats under pressure at low temperature of 500°C~600°C and pre-heats under medium temperature of 1000°C; and then a fine aluminum oxide outer mold and a sleeve of the inner lining film are applied so as to prevent quartz glass from deforming under high temperature; after being calcinated in vacuum for 3-4 hours under 1800°C, the article is rapidly removed from the high temperature furnace and then cooled down by strong wind.

[0015] Compared with the prior art, the effects of the invention are positive and axiomatic. Specifically, compared with the poor high-temperature resistance, ease of loss of sodium of quartz glass, as well as poor pressure resistance and thus poor sealing capability of polycrystalline alumina, the composite HID arc tube of the invention maintains the advantages of quartz glass of ease of molding, ease of sealing, good pressure resistance and high operating pressure, and also has the advantages of polycrystalline alumina (PCA) arc chamber of dimension regularization, high temperature resistance and good sodium penetration resistance. Thus, the composite HID arc tube of the invention enhances the working pressure and working temperature, prevents sodium penetration and deformation resulted from the liquid-state silicon film on the surface of the electrode, improves the stability of color rendering and luminous efficacy of HID, especially MH lamp, and extends the lifetime of the lamp.

[0016] The objects, features and advantages of the invention will be described in detail with respect to the embodiments and in connection to the figures.

Brief Description of the Drawings

[0017] Figure 1 is a schematic diagram of a composite HID arc tube of the present invention.

Detailed Description of the Preferred Embodiment

[0018] The invention is described in detail with respect to the figures below. As illustrated in Figure 1, the composite HID arc tube of the invention has a discharge tube 1, electrodes 2, molybdenum leads 3, molybdenum foils 4, and molybdenum outer leads 5, wherein the electrodes 2 are arranged within an arc chamber 13 of the discharge tube 1, and the molybdenum leads 3, molybdenum foils 4 and molybdenum outer leads 5 are sequentially connected to the electrodes 2, which are respectively disposed in two outwardly extending tubes 14 at the two ends of the discharge tube 1. The outer shell of the discharge tube 1 is made of blow-molded fused quartz glass or Vycor quartz glass 11, and applying a layer of translucent polycrystalline alumina 12 on the outer shell to form a composite two-layer shell. Each of both sides of the arc chamber 13 of the discharge tube 1 are provided with a long and thin outwardly extending tubes 14, and a translucent polycrystalline alumina layer 12 is also applied on one end of the outwardly extending tubes 14

close to the arc chamber 13. The electrode 2, the molybdenum lead 3, the molybdenum foil 4 and the molybdenum outer lead 5 are sequentially arranged in a direction away from the arc chamber 13. The region of the outwardly extending tube 14 corresponding to the molybdenum lead 3 is a region applied with polycrystalline alumina 12, and the glass solder 15 mainly made of mixture of Al_2O_3, Dy_2O_3, SiO_2 is used for sealing. The region of the outwardly extending tube 14 corresponding to the molybdenum foil 4 is a region of a single-layer glass tube which is made of quartz glass 11 heated by coal-oxygen fire and then sealed under pressure. The discharge tube 1 can be filled with different kinds of metal halides, mercury or its alternatives, high purity argon, mixture gas of argon and neon, or xenon depending on its lamp type.

[0019] Furthermore, in the composite HID arc tube of the invention, the arc chamber 13 of the discharge tube 1 is in a shape of olive or ellipse, and the inner wall of the arc chamber 13 as well as the inner wall of the 3~8mm long segment of the outwardly extending tube 14 close to the arc chamber 13 are uniformly applied with a layer of translucent polycrystalline alumina 12, which has a thickness of 0.2~0.5mm.

[0020] Moreover, in the composite HID arc tube of the invention, the electrode 2 is sealed a way such that a first segment and a second segment are separately sealed segment by segment.

[0021] Moreover, in the composite HID arc tube of the invention, the inner wall of the arc chamber 13 of the discharge tube 1 as well as the inner wall of the 3~ 8mm long segment of the outwardly extending tube 14 close to the arc chamber 13 are uniformly applied with a layer of translucent polycrystalline alumina 12. During the application of the layer of translucent polycrystalline alumina 12, an inserted body made of heat-resistant silica gel is inserted into the arc chamber 13 of the discharge tube and the outwardly extending tube 14, air under a certain pressure is then injected such that the inserted body made of silica gel turns into an sophisticated inner lining film; and then ceramic powder slurry is injected into the gap between the inner lining film and the fused quartz glass or Vycor quartz glass shell 11 of the discharge tube 1, wherein the ceramic powder slurry is obtained by uniformly mixing high pure aluminum oxide powder, a small amount of adhesive, grain generation inhibitor, and plasticizer.

[0022] Moreover, in the composite HID arc tube of the invention, the inner wall of the arc chamber 13 as well as the inner wall of the 3~8mm long segment of the outwardly extending tube 14 close to the arc chamber 13 are uniformly applied with a layer of translucent polycrystalline alumina 12. After grouting and molding, curing at room temperature and then mould unloading; then, heating under pressure at low temperature of 500°C~600°C and pre-heating under medium temperature of 1000°C; and then a fine aluminum oxide outer mold and a sleeve for the inner lining film are applied so as to prevent quartz glass 11 from deforming under high temperature. After being calcinated in vacuum for 3-4 hours under 1800°C, the article is rapidly removed from the high temperature furnace and then cooled down by strong wind, so that the quartz glass shell 11 is prevented from devitrifying.

[0023] Moreover, in the composite HID arc tube of the invention, the electrode 2 is sealed in a way such that a first segment and a second segment are separately sealed segment by segment. A segment of both of the outwardly extending tube 14 is designated as the first segment which is about 3~8mm long and close to one end of the arc chamber 13; and another segment of both of the outwardly extending tube 14 is designated as the second segment which is about 10~20mm long and extends outwardly from the first segment. Similar to the inner wall of the arc chamber 13, the inner wall of the first segment of the outwardly extending tube 14 is also applied with a layer of translucent polycrystalline alumina 12; and sealed by glass solder 15 mainly made of mixture of Al_2O_3, Dy_2O_3, SiO_2. The second segment is quartz glass or improved quartz glass 11, such as Vycor quartz glass or molybdenum resistance glass; and the molybdenum foil 4 is used to seal in an uncomplimentary manner, or directly use a molybdenum bar to seal in a complimentary manner, so as to enhance the airtightness of the lamp under super high pressure such as 100~200atm.

[0024] In the example as illustrated in figure 1, preferably, the discharge tube 1 uses an elliptical arc tube shell 11, which is manufactured by blow-molding high pure quartz glass with a hydroxy content of no more than 10ppm. The maximal diameterφ of the elliptical arc tube shell 11 is 18.5mm, the average thickness of the wall of the elliptical arc tube shell 11 is 1.8mm, and the thickness of the thinnest part of the wall of the elliptical arc tube shell 11 is no less than 1.5mm. The layer of translucent polycrystalline alumina (PCA) 12 is applied and sintered within the elliptical arc tube shell 11. The average thickness of the layer of translucent polycrystalline alumina 12 is 0.2mm, the thickness of thinnest part of the layer of translucent polycrystalline alumina 12 is no less than 0.15mm, and the thickness of thickest part the layer of translucent polycrystalline alumina 12 is no more than 0.25mm. The electrode 2 is made of materials of thorium and tungsten and thus has good emissive property. ScI3-CeI3-1nI3-TlI-NaI is selected as the metal halide filler of the lamp, so that the load Ws of the tube wall is about 20W/cm^2, and the nominal power of the lamp is 150W.

[0025] In case that the lamp is used with an electronic ballast which employs high-frequency square wave current and voltage and outputs a constant power, the test results are as follows: the initial luminous efficacy is no less than 1101m/W, the average luminous efficacy is 95 1m/W, the color rendering index Ra ≥ 85, the color temperature is 4200K, and the lifetime is 20,000 hours; the color consistency in the lifetime of the lamp is greatly improved when compared with quartz scandium sodium lamp.

[0026] According to the embodiments of the invention,

molybdenum lead wire and molybdenum foil are used for electrically connecting the electrode, however, the invention is not limited to molybdenum, and any other suitable metal or alloy can be used alternatively.

[0027] The arc tube of the invention can be used to manufacture ceramic metal halide lamp, conventionally in a double-end manner or in a single-end manner. In the double-end manner, both sides of the outer shell of the lamp are provided with conducting wires connecting both sides of the arc tube, and the shape of the outer shell of the lamp can be cylindrical or conical. In the single-end manner, only one side of the outer shell of the lamp is provided with conducting wire, through which the leads of both sides of the arc tube are connected to the outside, and the shape of the outer shell of the lamp can be spherical or elliptical.

[0028] The above-mentioned patents as a whole are all incorporated here as references. The principle of the present invention and its implementations are explained using illustrative examples, however, the above mentioned embodiments are only used to assist in understanding the method of the invention as well as its key concept. The scope of the present should not be limited to the specific content of the specific examples. It should be pointed out that the persons skilled in the art could make many modifications and variants to the invention without departing from the principle of the present invention, and these modifications and variants are intended to be included within the scope as defined by the accompanying claims of the present invention.

Claims

1. A composite HID arc tube comprising a discharge tube (1) and two outwardly extending tubes (14), **characterized in that**
said discharge tube is a composite two-layer shell formed of an outer shell (11) manufactured by blow-molding fused quartz glass or Vycor quartz glass and applying a layer of translucent polycrystalline alumina (12) on the outer shell; and
said outwardly extending tubes are made of fused quartz glass or Vycor quartz glass, wherein a layer of polycrystalline alumina is applied at both ends of said outwardly extending tubes close to arc chamber.

2. A composite HID arc tube as claimed in claim 1, **characterized in that** the inner wall of the arc chamber as well as the inner wall of segments of the outwardly extending tubes close to the arc chamber of 3 ~ 8mm long are uniformly applied with a layer of translucent polycrystalline alumina of thickness of 0.2~0.5mm.

3. A composite HID arc tube as claimed in claim 1 or 2, **characterized in that** the arc chamber of the discharge tube is in the shape of olive or ellipse.

4. A composite HID arc tube as claimed in claim 1 or 2, **characterized in that** two different sealing methods are used at each of the outwardly extending tubes.

5. A composite HID arc tube as claimed in claim 3, **characterized in that** two different sealing methods are used at each of the outwardly extending tubes.

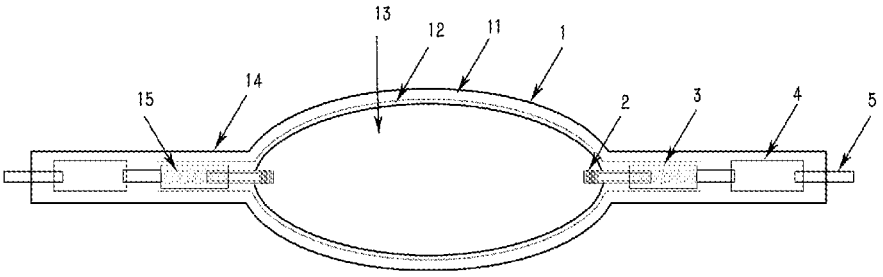

Fig.1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2008/001304

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01J61/00, 61/30, 61/35, 61/36, 61/34, 61/33, 61/32, 61/073, 61/06, 61/04, 61/02

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNKI, CNPAT, WPI, EPODOC, PAJ, compound, HID, electric, arc, tube, quartz, glass, shell, alumin+, oxide, high w intensity w discharge

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP10208700A（IWASAKI ELECTRIC CO LTD）07 Aug.1998(07.08.1998), Description paragraph [0015] to paragraph [0023], Fig.1	1-5
Y	JP2006-99966A（HITACHI SHOMEI KK）13 Apr.2006 (13.04.2006), Description paragraph [0009] to paragraph [0014], Fig.1.	1-5
A	JP2004-55226A（USHIO INC）19 Feb.2004（19.02.2004）The whole document	1-5
A	JP2002-157974A（USHIO INC）31 May.2002（31.05.2002）The whole document	1-5
A	US7187128B2（NGK INSULATORS LTD）06 Mar.2007（06.03.2007）The whole document	1-5
A	US7362053B2（OSRAM SYLVANIA INC）22 Apr.2008（22.04.2008）The whole document	1-5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 Dec.2008 (30.12.2008)	**08 Jan. 2009 (08.01.2009)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer ZHANG Chunwei Telephone No. (86-10)62414346

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2008/001304

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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JP2006-099966A	13.04.2006	None	
JP2004-55226A	19.02.2004	None	
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Form PCT/ISA/210 (patent family annex) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2008/001304

A. CLASSIFICATION OF SUBJECT MATTER:

H01J 61/00(2006.01)i

H01J 61/35(2006.01)i

H01J 61/36(2006.01)i

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REFERENCES CITED IN THE DESCRIPTION

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- CN 98115658 **[0004]**
- US 6313582 B1 **[0005]**