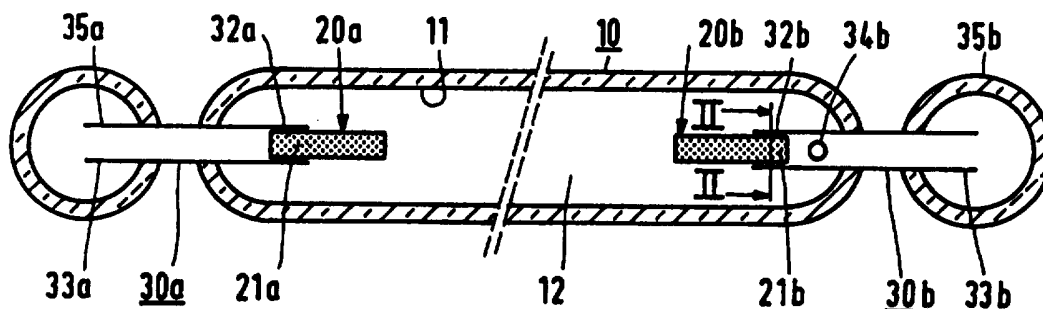




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(21) International Application Number: PCT/IB95/00922 (22) International Filing Date: 25 October 1995 (25.10.95) (30) Priority Data: 94203248.3 8 November 1994 (08.11.94) EP (34) Countries for which the regional or international application was filed: NL et al. (71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 5, Kista, S-164 85 Stockholm (SE). (72) Inventors: WEIJTENS, Christianus, Hermanus, Leopold; A. van Ostadelaan 21, NL-5581 JS Waalre (NL). HENNINGS, Detlev; Hangstrasse 28, D-52076 Aachen (DE). (74) Agent: EVERS, Johannes, H., M.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).		(81) Designated States: CN, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>

(54) Title: LOW-PRESSURE DISCHARGE LAMP**(57) Abstract**

A low-pressure discharge lamp according to the invention is provided with a radiation-transmitting discharge vessel (10) which encloses a discharge space (12) containing an ionizable filling in a gastight manner, and electrodes (20a, 20b) arranged in the discharge space (12) between which a discharge path extends. At least one of the electrodes (20a, 20b) comprises a sintered mixture of metal (23) and ceramic material (22, 24), the proportional quantity of metal (23) in the mixture being small compared with the proportional quantity of ceramic material (22, 24). The sintered mixture comprises smaller ceramic particles (22) with a modal diameter D1 and larger ceramic particles (24) with a modal diameter D2, the ratio D2/D1 being at least 3, while the proportional volume of the smaller ceramic particles (22) is small compared with that of the larger ceramic particles (24). In the lamp according to the invention, the electrodes (20a, 20b) have a comparatively high resistance to temperature variations in spite of the small proportional volume of metal particles.

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Low-pressure discharge lamp.

The invention relates to a low-pressure discharge lamp provided with a radiation-transmitting discharge vessel which encloses a discharge space containing an ionizable filling in a gastight manner, and comprising electrodes arranged in the discharge space between which a discharge path extends, while at least one of the electrodes comprises
5 a sintered mixture of metal and ceramic material, the proportional quantity of metal in the mixture being small in relation to the proportional quantity of ceramic material.

Such a lamp is known from German Patent 529.392. The known lamp has
10 electrodes sintered from a mixture of a metal, such as W or Mo, and a ceramic material, such as an oxide or a silicate of an alkali metal, an alkaline earth, or a rare earth, the proportional quantity of metal being small compared with the quantity of ceramic material. The use of such electrodes has the advantage that a high current density is possible, so that the electrode can be comparatively thin, if so desired. This is of particular importance for
15 lamps having comparatively narrow discharge vessels.

Ceramic materials are comparatively prone to fracture in the case of abrupt temperature changes. Such temperature changes may occur in the electrodes upon switching-on of discharge lamps. The presence of metal, which is comparatively ductile, can considerably increase the resistance to such temperature changes, provided it is present in the
20 ceramic material in a sufficiently continuous structure. The continuity of the metal, however, decreases with a decreasing proportional volume of the metal.

The invention has for its object to provide a lamp of the kind mentioned
25 in the opening paragraph whose electrodes have a construction which has a comparatively high resistance to temperature variations with a comparatively low proportional quantity of metal.

According to the invention, the lamp is for this purpose characterized in that the sintered mixture comprises besides smaller ceramic particles with a modal diameter

D1 also larger ceramic particles with a modal diameter D2, the ratio D2/D1 being at least 3, while the proportional volume of the smaller ceramic particles is small compared with that of the larger ceramic particles. The term "modal diameter" is understood to mean a diameter for which the particle size distribution has a maximum. In the lamp according to the
5 invention, the smaller and the larger ceramic particles together provide a comparatively dense packing because the smaller ceramic particles fill up spaces between the larger ceramic particles. It is possible with comparatively little metal nevertheless to form a highly continuous network in the remaining space between the smaller and larger ceramic particles. The modal diameters D1 and D2 are determined by means of the linear intercept method. In
10 this method, the length distribution of line segments, each segment being defined by the circumference of a particle and lying on a common (arbitrary) line in a cross-section through the sintered mixture, is determined in a microscopic image of said cross-section. The modal diameters D1 and D2 are subsequently calculated from the length distribution thus obtained.

The ceramic particles are preferably made of a material having a low
15 work function. Suitable are, for example, barium and strontium compounds such as BaO and SrO. Favourable compounds are mixed oxides of Ba and/or Sr with one or more of the metals from the series comprising Ta, Ti, Zr, such as Ba₄Ta₂O₉, BaTiO₃, Ba₂TiO₄, BaZrO₃, SrTiO₃, SrZrO₃, Ba_{0.5}Sr_{0.5}TiO₃, Ba_{0.5}Sr_{0.5}ZrO₃, and/or with one or several rare earths (Sc, Y, La, and the lanthanides), such as BaCeO₃. Such compounds do not or hardly react with
20 components from the atmosphere, which simplifies lamp manufacture. The metal used in the sintered electrode preferably has a comparatively low vapour pressure at the operating temperatures obtaining in the electrode. Very suitable are, for example, W, Mo, Re, and Ta. Also suitable are the comparatively expensive metals Os, Ru, and Ir. Metals such as Ni and Fe may also be used in lamps whose ionizable fillings comprise exclusively rare gases.

25 An embodiment of the lamp according to the invention which is comparatively easy to manufacture is characterized in that the modal diameter D1 of the smaller ceramic particles and the modal diameter D2 of the larger ceramic particles lie between 5 and 10 μm and between 20 and 70 μm , respectively. This embodiment has the additional advantage that the reproducibility of the electrical and thermal conductance is great
30 also in the case of comparatively thin electrodes, for example of the order of 0.5 mm. Since the modal diameter of the larger ceramic particles is comparatively small in relation to the electrode diameter, the fraction of the transverse surface area occupied by the larger particles, and thus the electrical and thermal conductance, shows little dispersion.

Preferably, the manufacture of the electrodes starts with metal particles

which have approximately the same size as or are smaller than the smaller ceramic particles. The starting material is, for example, a powder of metal particles having a modal diameter of 0.5 to 1.5 μm . The metal particles may have been fused together in the sintered electrodes.

An attractive embodiment of the low-pressure discharge lamp according to
5 the invention is characterized in that the proportional volume of the smaller ceramic particles divided by the proportional volume of metal lies between 1 and 4, and in that the proportional volume of the larger ceramic particles divided by the joint proportional volume of the smaller ceramic particles and the metal lies between 2 and 10. This embodiment has the advantage that the electrode is sufficiently electrically conductive also with the use of
10 insulating ceramic materials, while nevertheless the heat conduction is comparatively low. A comparatively low heat conduction is favourable for realising a temperature of the electrode tips which is sufficiently high for thermal emission with comparatively low thermal losses.

A further attractive embodiment of the low-pressure discharge lamp according to the invention is characterized in that the smaller ceramic particles are made of a
15 semiconducting ceramic material such as doped barium titanate or strontium titanate (for example, doped with a rare earth). This renders possible a reduction of the proportional quantity of metal in the mixture, and thus a further increase in the heat resistance of the electrodes, while the electrical resistance thereof can remain at least substantially unchanged.

Preferably, the smaller and the larger ceramic particles of the mixture
20 have approximately the same coefficient of expansion. This enhances the temperature resistance of the electrodes. A favourable embodiment of the low-pressure discharge lamp according to the invention is therefore characterized in that the smaller and the larger ceramic particles are substantially made of the same material.

An advantageous embodiment of the low-pressure discharge lamp
25 according to the invention is characterized in that an end portion of the electrode is fastened in an end of a metal tube. Preferably, the electrode is fastened in the tube with a soldered joint. A reliable electrical and mechanical connection between the electrode and the metal tube is obtained thereby. Alternatively, the end portion of the electrode may, for example, be clamped in an end of a metal tube. The assembly of the electrode and the metal tube may be
30 readily mounted in the discharge vessel.

The metal tube is, for example, welded or soldered at the opposed end to a metal pin which issues from the discharge vessel to the exterior and serves as a current supply conductor. The discharge vessel may be evacuated and filled through an exhaust tube integral with the discharge vessel and subsequently closed by fusion.

Preferably, however, the tube extends to outside the discharge vessel. The tube may then act as the current supply conductor. It is favourable when the tube is provided with an opening in the discharge space, so that it can then act as an exhaust tube during manufacture. The opening in the tube is realised, for example, in that there is a clearance
5 over a portion of the circumference between the electrode and the metal tube. The tube may be closed off with glass at the end remote from the electrode. Alternatively, the tube may be, for example, closed by welding at that end.

In another embodiment, for example, the electrode is sintered to a metal pin which is passed through the wall of the discharge vessel.
10

These and other aspects of the low-pressure discharge lamp according to the invention will be explained in more detail with reference to a drawing, in which Fig. 1 diagrammatically shows a first embodiment. Fig. 2 shows a cross-section taken on the line
15 II-II in Fig. 1 in more detail. A second and a third embodiment are shown in Figs. 3 and 4, respectively.

The low-pressure discharge lamp shown in Fig. 1 is provided with a
20 tubular discharge vessel 10 of 5 mm internal diameter which is provided with a luminescent layer 11 on an inner surface and which encloses a discharge space 12 in a gastight manner, said space containing an ionizable filling, here of mercury and argon. The discharge vessel 10 is made of lime glass which transmits the visible radiation generated in the luminescent layer 11. Electrodes 20a, 20b of 0.5 mm diameter and 10 mm length are arranged in the
25 discharge space 11. An end portion 21a, 21b of each electrode 20a, 20b is soldered by means of nickel 31b (shown dotted in Fig. 2) in an end 32a, 32b of a metal tube 30a, 30b extending to outside the discharge vessel 10. The tubes 30a, 30b serve as current supply conductors. One of the tubes 30a, 30b is provided with an opening 34b in the discharge space 12. The end 33a, 33b of each tube 30a, 30b remote from the electrodes 20a, 20b is
30 closed off with glass 35a, 35b. The electrodes 20a, 20b are sintered from a mixture of ceramic materials 22, 24 and metal 23, the metal 23 being shown in black in between the ceramic particles 22, 24, the proportional quantity of metal being comparatively small. In the embodiment shown, the proportional volume of the metal is 3%. The sintered mixture comprises smaller ceramic particles 22 with a modal diameter $D1$ of 7 μm and larger

ceramic particles 24 with a modal diameter D2 of 50 μm . The ratio D2/D1 is 7.1, *i.e.* is at least 3. The diameters D1 and D2 were determined by the linear intercept method. The particles 22, 24 are shown larger in the drawing for the sake of clarity than would be the case if the drawing were true to scale. The proportional volume of the smaller ceramic particles 22 is 9%, *i.e.* small compared with the proportional volume of the larger ceramic particles 24, which is 88%.

The proportional volume of the smaller ceramic particles (9%) divided by the proportional volume of metal (3%) is 3 and lies between said limits of 1 and 4. The proportional volume of the larger ceramic particles (88%) divided by the joint proportional volume (9%+3%) of the smaller ceramic particles and the metal is 7.3, and lies between the limits 2 and 10.

The smaller and the larger ceramic particles 22, 24 of the mixture are both of semiconducting Y-doped BaTiO_3 . W is used as the metal 23.

The electrodes 20a, 20b were obtained as follows. W-powder (modal particle diameter 1 μm) and BaTiO_3 powders (modal particle diameters 1 μm and 50 μm , respectively) were mixed in the desired proportions. (The modal particle diameters of the powders were determined by sedimentation). Then the mixture was isostatically compressed and subsequently heated for some time in a reducing N_2/H_2 atmosphere. Particles of the BaTiO_3 powder of 1 μm modal particle diameter grew together during this step, whereby particles with a modal diameter of 7 μm were formed. The electrodes were manufactured from the material thus obtained through sawing. Alternatively, said powders may be mixed with a binder and subsequently extruded, fired for removing the binder and, for example, heated in a reducing N_2/H_2 atmosphere. The rod thus obtained may be sawn into pieces of the length desired for the electrode application. A high porosity of the larger ceramic particles contributes to a low heat conductance, which is favourable for electrode operation.

The larger ceramic particles may be obtained, for example, by pre-sintering from a powder of finer particles.

In Fig. 3, components corresponding to those of Fig. 1 or Fig. 2 have reference numerals which are 100 higher. In the embodiment of the lamp according to the invention shown in Fig. 3, an end portion 121a, 121b of each electrode 120a, 120b is clamped in an end 132a, 132b of a metal tube 130a, 130b. A metal pin 136a, 136b is fastened by welding to the opposed, closed end 133a, 133b of each tube 130a, 130b. The pin 136a, 136b issues through the wall of the discharge vessel 110 to the exterior and serves as a current supply conductor. The discharge vessel 110 was evacuated and filled through an

integral exhaust tube 113. The exhaust tube 113 was subsequently tipped.

In Fig. 4, components corresponding to those of Fig. 1 or Fig. 2 have reference numerals which are 200 higher. Components corresponding to those of Fig. 3 have reference numerals which are 100 higher. Fig. 4 shows an embodiment of the lamp
5 according to the invention in which the electrodes 220a, 220b are each fixed by sintering to a metal pin 236a, 236b which issues through the wall of the discharge vessel 210 to the exterior.

CLAIMS:

1. A low-pressure discharge lamp provided with a radiation-transmitting discharge vessel (10) which encloses a discharge space (12) containing an ionizable filling in a gastight manner, and comprising electrodes (20a, 20b) arranged in the discharge space (12) between which a discharge path extends, while at least one of the electrodes (20a, 20b)
5 comprises a sintered mixture of metal (23) and ceramic material (22, 24), the proportional quantity of metal (23) in the mixture being small in relation to the proportional quantity of ceramic material (22, 24), characterized in that the sintered mixture comprises besides smaller ceramic particles (22) with a modal diameter D1 also larger ceramic particles (24) with a modal diameter D2, the ratio D2/D1 being at least 3, while the proportional volume
10 of the smaller ceramic particles (22) is small compared with that of the larger ceramic particles (24).
2. A low-pressure discharge lamp as claimed in Claim 1, characterized in that the modal diameter D1 of the smaller ceramic particles (22) and the modal diameter D2 of the larger ceramic particles (24) lie between 5 and 10 μm and between 20 and 70 μm ,
15 respectively.
3. A low-pressure discharge lamp as claimed in Claim 1 or 2, characterized in that the proportional volume of the smaller ceramic particles (22) divided by the proportional volume of metal (23) lies between 1 and 4, and in that the proportional volume of the larger ceramic particles (24) divided by the joint proportional volume of the smaller ceramic
20 particles (22) and the metal (23) lies between 2 and 10.
4. A low-pressure discharge lamp as claimed in Claim 1, 2 or 3, characterized in that the smaller ceramic particles (22) are made of a semiconducting ceramic material.
5. A low-pressure discharge lamp as claimed in Claim 1, 2, 3 or 4,
25 characterized in that the larger ceramic particles (24) are substantially made of the same material as the smaller ceramic particles (22).
6. A low-pressure discharge lamp as claimed in any one of the preceding Claims, characterized in that an end portion (21a, 21b) of each electrode (20a, 20b) is fastened in an end (32a, 32b) of a metal tube (30a, 30b).

7. A low-pressure discharge lamp as claimed in Claim 6, characterized in that the metal tube (30a, 30b) extends to outside the discharge vessel (10).
8. A low-pressure discharge lamp as claimed in Claim 7, characterized in that the metal tube (30b) is provided with an opening (34b) in the discharge space (12).

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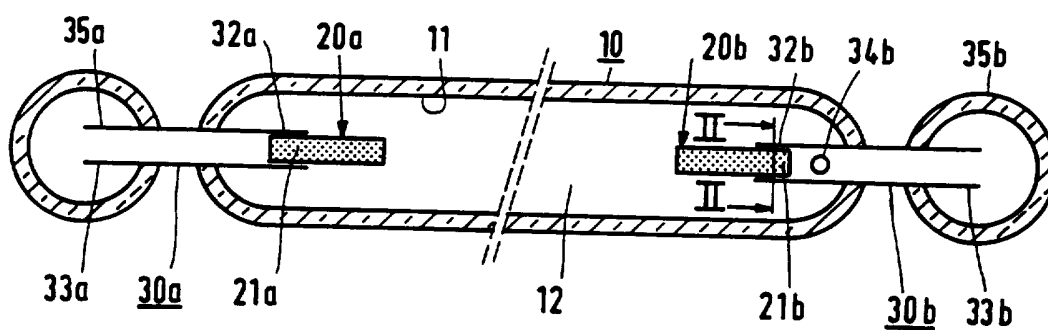


FIG. 1

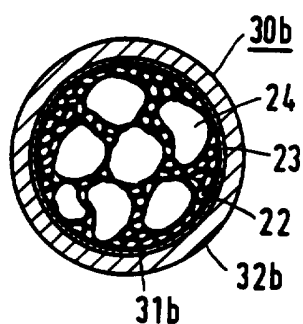


FIG. 2

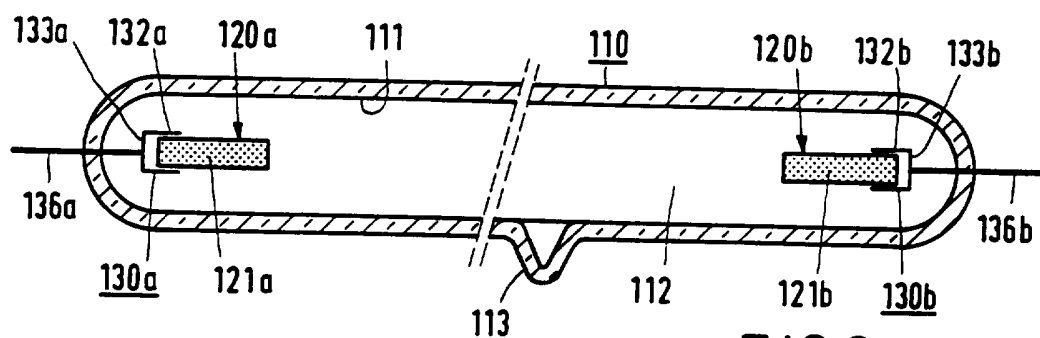


FIG. 3

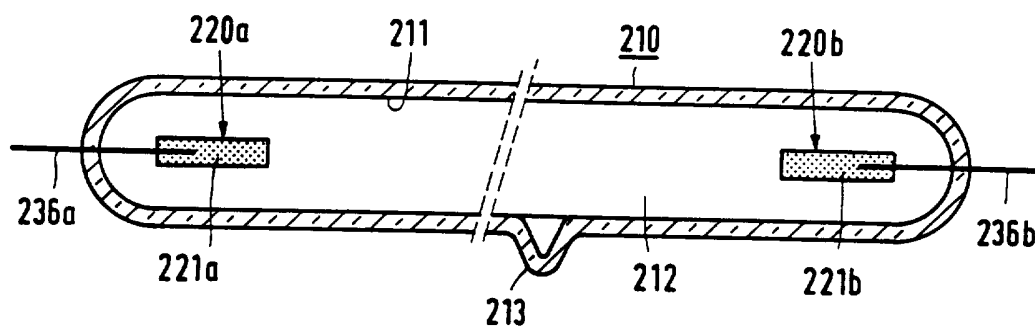


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 95/00922

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01J 61/067

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)

IPC6: H01J

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0489463 A2 (N.V. PHILIPS 'GLOEILAMPENFABRIEKEN), 10 June 1992 (10.06.92) --	1-8
A	EP 0584858 A1 (PHILIPS ELECTRONICS N.V.), 2 March 1994 (02.03.94) -- -----	1-8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

05/02/96

International application No.

PCT/IB 95/00922

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A2- 0489463	10/06/92	CN-A- 1062056 DE-D, T- 69105103 JP-A- 4269440 US-A- 5138224	17/06/92 24/05/95 25/09/92 11/08/92
EP-A1- 0584858	02/03/94	NONE	