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METAL HALIDE DISCHARGE LAMPS WITH RARE-EARTH METAL OXIDE USED AS ELECTRODE EMISSION MATERIAL

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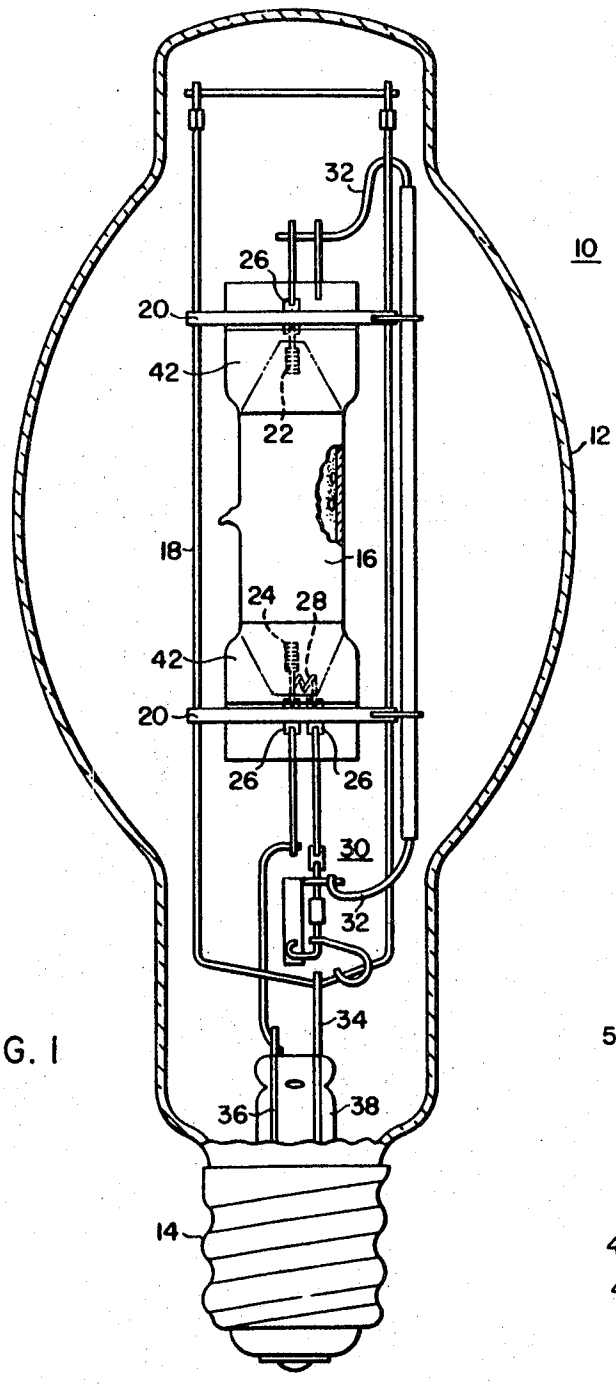


FIG. 1

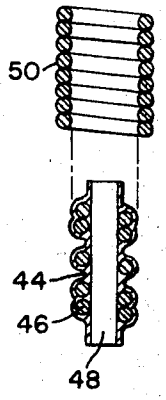


FIG. 2

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METAL HALIDE DISCHARGE LAMPS WITH RARE-EARTH METAL OXIDE USED AS ELECTRODE EMISSION MATERIAL

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ABSTRACT OF THE DISCLOSURE

Rare-earth metal oxide used as the electrode emission material in a metal halide additive arc discharge device. The rare-earth metal oxide is particularly resistant to attack by the reactive rare-earth metal halide. The rare-earth metal component of the emission material may be the same as the rare-earth metal component of the discharge-sustaining filling.

BACKGROUND OF THE INVENTION

The so-called additive type mercury discharge lamp containing metallic halide compounds has become an important commercial lighting source. The use of rare-earth metal halide additives has been particularly effective in improving the color rendition of the light produced. A continuing problem however is presented by the reactive nature of rare-earth metal halides with respect to cathode emission material at the operating temperatures of the lamps. Also, the standard electron emissive materials used in low pressure and medium pressure mercury discharge lamps, such as alkaline-earth oxides and alkaline-earth tungstates, display some tendency to deteriorate in the reactive rare-earth metal halide atmosphere. For this reason, plain coiled tungsten electrodes have sometimes been utilized. While tungsten electrodes are relatively chemically stable, it has been observed that the work function of tungsten increases in an operating rare-earth metal halide atmosphere.

The use of thoria silvers, which are retained by the electrode coils, to increase the electrode emissivity is well known in the art. Rare-earth metal oxides have found some use when added in small amounts to the usual alkaline-earth oxides in low pressure fluorescent discharge lamps.

One of the most successful additive type lamps utilizes dysprosium iodide as a major metallic halide additive. A thallium iodide-dysprosium iodide-mercury lamp exhibits superior color output that is further extending the usefulness of such lamps into new lighting applications, and such a lamp is disclosed in copending application Ser. No. 599,133, filed Dec. 5, 1966, now Pat. No. 3,452,238, and owned by the present assignee.

SUMMARY OF THE INVENTION

It is an object of this invention to provide in combination with metal halide-additive, mercury-discharge lamp, an improved electron emissive portion of the electrodes that resists attack of the metal halide and provides efficient long-life operation.

The aforementioned object, and others that will become apparent as the description proceeds, are accomplished by utilizing rare-earth metal oxide as the principal constituent of the emision material which forms a portion of the electrodes of a high-pressure, mercury-vapor additive type lamp. For a lamp containing dysprosium iodide as a primary discharge sustaining constituent, the preferred emission material substantially comprises dysprosium oxide.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can best be understood by referring to the accompanying drawings, in which

FIG. 1 is a side elevation, with part of the outer envelope broken away, of a discharge lamp constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The lamp, generally designated **10**, in FIG. 1, includes a radiation transmitting, sealed outer envelope **12** of a material such as glass, to which is fixed a standard mogul base **14**. Mounted within the outer envelope **12** and spaced therefrom is an inner envelope or arc tube **16** of a material such as quartz, or other high temperature light transmissive material such as polycrystalline alumina. The volume between the outer envelope **12** and the arc tube **16** is preferably evacuated or can be filled with an inert gas such as nitrogen. The arc tube **16** is mounted within the outer envelope **12** by conventional frame **18** and straps **20**. Sealed within the arc tube **16** and disposed at opposite ends thereof are electrodes **22** and **24**. Electrodes **22** and **24** are connected respectively to the conductive lead-ins **32** and **40** which are sealed through the opposite press-sealed ends of the arc tube **16** by means of conventional ribbon seals **26**. An auxiliary starting coil **28** is connected to electrode **24** to facilitate starting the device as is now well known in the art. A bi-metal starting switch mechanism **30** is provided for the operation of the starting coil **28**. The starting mechanism **30** is specifically described in U.S. Pat. No. 3,307,069, dated Feb. 28, 1967. A pair of lead-in conductors **34** and **36** connect the lamp through a re-entrant stem **38** to the base **14**. Lead-in conductor **34** connects through the frame **18** to the starting switch mechanism **30** while lead-in conductor **36** connects directly through a lead **40** to electrode **24**.

A heat retaining coating **42** of zirconium dioxide silicon dioxide is adhered to the outside of the end portions of the arc tube **16**. The coating **42** prevents an extreme temperture gradient from occurring in the electrode area of the arc tube **16**. The operation of the above-described arc discharge device is more particularly described in the aforementioned copending application Ser. No. 599,133. For an arc tube **16** enclosing a volume of about 14 cc., a suitable dosing charge comprises inert, ionizable starting gas, such as argon at a pressure of about 20 to 25 torrs, a quantity of mercury between 32 and 40 milligrams, a charge of 5 milligrams of thallous iodide, about 3 milligrams of dysprosium metal, and about 12 milligrams of mercuric iodide. When initially operated, the dysprosium metal converts to the iodide. Electrodes **22** and **24** are doubly coiled tungsten members having an inner and outer coil wound about a tungsten support rod. The coil portion of the electrodes **22** and **24** is formed of approximately 15 mil tungsten wire. The coiled portions are wound about the tungsten support rod, which is approximately 30 mil tungsten wire, for a distance of about 5 millimeters. Electrodes are spaced within the arc tube to provide an arc length of approximately 5 centimeters.

In the aforementioned copending application Ser. No. 599,133, the electrodes are bare coiled tungsten members. Pursuant to the present invention, it has been found particularly advantageous to apply a particular electron emissive coating **44** to at least one of the partially fabricated electrodes. In FIG. 2, the inner coil **46** of tungsten has spaced turns and is wound about the support rod **48**, also of tungsten. The end of the support rod with

the coil thereabout is then coated with the emissive coating **44**, which for the lamp containing dysprosium iodide is preperably dysprosium oxide. In applying the coating **44**, dysprosium oxide is reduced to finely divided status and mixed with a sufficient amount of acetone or alcohol to form a thick slurry into which the partially fabricated electrode **22**, **24** is dipped before overfitting the outer coil **50**. The single-coiled electrode portion is dipped into the slurry and after removal can be heated moderately to speed drying and to drive off the acetone or alcohol. As an example, the resultant electrodes **22**, **24** of the above-described dimensions will have approximately 20 milligrams of dysprosium oxide coated thereon. The dysprosium oxide coating **44** acts as an efficient source of electrons for sustaining the discharge, while at the same time being particularly resistant to attack by the metallic iodides contained in the lamp.

After overwinding the outer coil **50** to complete the electrodes **22**, **24**, it is preferable to bake the electrode under vacuum, at for example about 1000° C. prior to incorporating the electrode into the arc-tube, or while mounted in the arc-tube prior to dosing and sealing. This bake-out will help prevent contamination of the arc-tube during operation.

While a very simple method of including the dysprosium oxide as the electrode emission material has been described, this is given only by way of example and other known methods of including an oxide emission material may be used. Also, while a coiled tungsten support member is specified in the example, other non-reactive metals and alloys familiar in the art such as rhenium can be utilized as the support member to be coated with the rare-earth metal oxide. The coiled electrode configuration can be modified and other designs can be utilized.

The dysprosium oxide, while described here as being coated on the tungsten support, can be pelletized with or without a binder or small amounts of selected metals and then fitted between the electrode support and the overwound coil portion, much like the prior art practice of including thoria silvers.

In another embodiment of the invention the basic lamp structure is as shown in FIG. 1 and described above except that a larger volume arc-tube is employed, a different discharge sustaining filling is used, and the preferred emission material comprises yttrium oxide. Specifically, the arc-tube **16** is about 28.8 cc. in volume and the discharge-sustaining filling comprises about 117 milligrams of mercury, about 24 milligrams of sodium iodide, 5 milligrams of thallous iodide, 20 milligrams of thallium metal, and the arc-tube is filled to a pressure of about 20 torr with argon. This lamp is more fully described in copending application Ser. No. 516,200, filed Nov. 29, 1965 and owned by the present assignee. It has been found that yttrium oxide emission material provides long-life emission in this reactive metal halide discharge device. The yttrium oxide is incorporated into the lamp as the emission material was the dysprosium oxide in the previous example. The yttrium oxide is reduced to finely divided status and mixed with acetone or alcohol to form a thick slurry into which the inner coil **46** wound about the support rod **48** is dipped. About 20 milligrams of yttrium oxide is preferably coated on the tungsten support. The electrode is again preferably degassed by thoroughly baking in a vacuum environment prior to incorporation into the arc-tube. Other rare-earth metal oxides can be substituted for the yttrium oxide in this example in whole or in part.

The rare-earth oxides of particular importance as emission material because of their relatively low work functions are yttrium, dysprosium, gadolinium, and terbium. The rare-earth metal oxides in terms of decreasing approximate resistance to reactivity with iodine are, yttrium, neodymium, praseodymium, cerium and lathanum. The rare-earth metal oxides in terms of increasing volatility in vacuum are, yttrium, gadolinium, dysprosium, terbium, erbium, lanthanum, holmium, lutetium, praseodymium, neodymium and cerium.

Numerous other metallic halide containing arc-discharge devices have been suggested in the prior art and the rare-earth oxide emission material of the present invention can be successfully employed as a long-life source of electrons in these devices. In any particular metallic halide additive discharge lamp the particular rare-earth oxide selected for use will be determined by the work function, reactivity of the oxide with the halide, the volatility of the oxide, and the desire for having a particular rare-earth metal present to act as a reservoir of that metal.

In a lamp utilizing polycrystalline alumina envelopes, rare-earth metal oxides are being used to form a seal material between the envelope and the metallic lead-ins. The rare-earth metal oxide used as emission material in the lamp should have a lower work function than the work function of the seal rare-earth metal oxide to insure that the discharge is directed to the electrode and not the seal.

Pursuant to the present invention, the rare-earth metal oxides display superior maintenance characteristics in a discharge device containing rare-earth metal halide as a discharge sustaining constituent. In the preferred lamp described hereinbefore, dysprosium oxide is the preferred emission material to be used with the dysprosium iodide containing discharge device. The dysprosium oxide emission material insures that if any electrode material would sputter into the arc it would not adversely change the spectral light output of the lamp.

Numerous other rare-earth metallic halide additive lamps including yttrium, lanthanum, gadolinium and terbium halides have been suggested in the prior art. In accordance with the present invention the particular rare-earth metal used in the discharge can serve in oxide form as the substantial portion of the emissive portion of the electrode members. In this way, the preferred emission material for the yttrium halide containing lamp is yttrium oxide, gadolinum oxide for the gadolinium halide containing lamp, etc. The discharge sustaining material generally contains a combination of metal halides, so that it may also contain a combination of rare-earth metal halides. The emission material may likewise include a combination of rare-earth metal oxides, and when a combination of rare-earth metal halide comprises the discharge sustaining material preferably the same rare-earth metal combination in oxide form comprise the emission material. While it is preferred to match the emission material rare-earth metal oxide to the discharge sustaining rare-earth metal halide, the rare-earth metal oxide or combinations thereof can be used in metallic halide discharge lamps generally.

In the specific example the dysprosium oxide and yttrium oxide emission material can each be substituted for in whole or in part by one or more of the rare-earth metal oxides or mixtures thereof.

It is within the scope of this invention to use an amount of selected metallic oxides in combination with the rare-earth metal oxide, such as have been useful in the low pressure discharge art in combination with alkaline-earth oxides. These metallic oxides include zirconium oxide, scandium oxide, and aluminum oxide. As an example, aluminum oxide can be substituted for up to about half of the yttrium oxide used as the emission material in the sodium iodide lamp described, to enhance the stability of the emission material. Likewise in the example where dysprosium oxide is the emission material, the dysprosium oxide can be substituted for by zirconium oxide in an amount of up to about 50% by weight of the rare-earth metal oxide.

In general, while the improved electron emissive material of the invention substantially comprises rare-earth metal oxide, the rare-earth metal oxide can be substituted for by these selected metallic oxides in an amount of up

to about 50% by weight of the rare-earth metal oxide. Other metallic oxides found useful as emission material additives can be substituted for the rare-earth oxide emission material in amounts up to about 50% by weight of the rare-earth metal oxide. Furthermore, selected metals in small amounts intermixed as powder with the rare-earth metal oxides can be beneficial. For instance, in Example I a small amount of powdered dysprosium metal such as about 2 milligrams can be dispersed in the finely divided dysprosuim oxide. Other metals that can be added as powder to the rare-earth metal oxide in small amounts include tungsten, tantalum, molybdenum, and niobium as well as the rare-earth metals. It is preferred that the metal added is in an amount of not more than about ten percent by weight of the rare-earth oxide.

In a rare-earth metal halide containing lamp when the same rare-earth metal oxide, with or without small amounts of the same rare-earth metal, forms the emission material, the emission material also can act as a possible source of the rare-earth metal in case the rare-earth metal is "gettered" during prolonged lamp operation.

In the specific examples the rare-earth metal halide is formed during manufacture by vaporizing the mercuric iodide and causing the rare-earth metal to react with the iodine in the lamp. While the rare-earth metal iodide can be directly added to the lamp, the method specified is generally more convenient. While in the examples cited metal iodides were specified as discharge material, metal bromides and chlorides can be substituted as is known in the art.

It will be recognized that an improved electron emissive material has been provided for use particularly with rare-earth metal halide additive type lamps. The use of the same rare-earth metal oxide emission material provides an efficient source of electrons and exhibits resistance to attack by the rare-earth metal halide.

While specific embodiments have been given by way of illustration it is to be understood that the invention is not to be limited thereto or thereby.

We claim as our invention:

1. In combination with an arc-discharge device comprising a sealed light-transmissive envelope, a discharge-sustaining filling of preselected materials in predetermined amounts enclosed by said envelope with at least one rare-earth metal halide comprising a portion of said preselected discharge-sustaining filling, lead-in conductors sealed through said envelope, and spaced electrodes comprising refractory metal operatively positioned within said envelope and connected respectively to said lead-in conductors, the improved electron emissive material which is carried on at least one of said electrodes and which substantially comprises an oxide of the same rare-earth metal as is included in halide form as a portion of said discharge-sustaining filling.

2. The combination as specified in claim 1, wherein dysprosium iodide is included in said discharge-sustaining filling, and dysprosium oxide substantially comprises said electron emissive material.

3. The combination specified in claim 1, wherein said discharge-sustaining filling comprises an easily ionizable inert gas, mercury, and preselected metallic halides.

4. The combination specified in claim 3, wherein said discharge-sustaining filling includes dysprosium iodide as an essential constituent.

5. The combination specified in claim 4, wherein said emissive portion of the electrode substantially comprises dysprosium oxide.

6. The combination specified in claim 5, wherein said emissive portion also includes a predetermined proportion of powdered dysprosium metal.

7. In combination with an arc-discharge device comprising a sealed light transmissive envelope, a discharge-sustaining filling of preselected materials in predetermined amounts enclosed by said envelope with metal halide comprising a portion of said preselected discharge sustaining filling, lead-in conductors sealed through said envelope, and spaced electrodes comprising refractory metal operatively positioned within said envelope and connected respectively to said lead-in conductors, the improved electron emissive material which is carried on at least one of said electrodes and which substantially comprises yttrium oxide and/or rare-earth metal oxide.

8. The combination as specified in claim 7, wherein said discharge-sustaining filling includes dysprosium iodide and said emissive material substantially comprises dysprosium oxide.

9. The combination as specified in claim 8, wherein said discharge-sustaining filling includes thallous iodide, and dysprosium metal.

10. The combination as specified in claim 7, wherein said discharge-sustaining filling includes sodium iodide, and thallous iodide, and said electron emissive material substantially comprises yttrium oxide.

11. The combination as specified in claim 7, wherein said electron emissive material includes selected refractory metallic oxides intermixed with said rare-earth metal oxide.

12. The combination as specified in claim 7, wherein said electron emissive portion includes an amount of selected metal powder intermixed with said rare-earth metal oxide.

13. The combination as specified in claim 12, wherein said selected metal powder is rare-earth metal.

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