An improved low pressure mercury vapor discharge lamp of the fluorescent type wherein a ductile metal is used as the amalgam-forming metal. The improvement comprises using as the amalgam-forming metal an admixture of a silicon-aluminum alloy or a beryllium-aluminum alloy with said ductile metal. The ductile metal is one with which the said aluminum alloy is not substantially in solid solution at the operating temperature of the lamp. The preferred ductile metal is indium or a ductile indium alloy.
3,890,531

LOW PRESSURE MERCURY VAPOR DISCHARGE LAMP WITH AMALGAM

BACKGROUND OF THE INVENTION

This invention relates to low pressure mercury vapor discharge lamps having high electrical and/or thermal loading of the fluorescent type. The lamps contain an amalgam which is formed from the mercury and an amalgam-forming ductile metal.

It is well known that the location of the amalgam-forming metal and of the amalgam within the lamp affects the functioning of the lamp as far as it relates to the amalgam. Similarly, the composition of the amalgam, both in relation to the selection of the amalgam-forming metal and the relative quantities of the amalgam-forming metal and the mercury affect the said function of the lamp. Similarly, the selection of the amalgam-forming metal or metals and the composition of the amalgam or amalgams are influenced by their respective locations. The temperature prevailing during operation of the lamp at the location of the amalgam is of decisive importance. The lamp may also contain several amalgams which have different functions. The main amalgam, as is well known, determines the mercury vapor pressure during operation of the lamp. One or more other amalgams may be utilized to shorten the run-up period of the lamp.

It has been known to use very ductile amalgam-forming metals such as indium and gallium, and their alloys with thallium, zinc, bismuth, tin and others for the various amalgams in the lamp, as disclosed in U.S. Pat. Nos. 3,007,071 and 3,629,641. The aforesaid alloying metals form a solid solution with the main amalgam constituents, i.e., the mercury, and the indium or gallium. Amalgams containing the aforesaid main metals together with one or more of the aforesaid alloying metals result in a reduction of the vapor pressure in the lamp or effect a shortening of the run-up period.

U.S. Pat. No. 3,574,033 discloses a specific process for preparing the amalgam wherein the amalgam-forming metal is indium containing an addition of germanium and/or aluminum. This is used for the purpose of increasing the adhesion and the thermal stability within the lamp during operation.

Processing of most of the metals and alloys which are the amalgam-forming metals is extremely difficult due to their being very ductile. It is only with great effort that they can be positioned in the lamp in any form. This ductility is especially apparent when the amalgam-forming metal in the lamp is prepared from a wire, ribbon or the like. The ductile metal or alloy is frequently supplied as a coil of wire on a reel. When transporting the wire coil, fusing between adjacent wires occurs so that when the wire is unwound from the coil, it is often expanded plastically and during further processing, differences in diameter result. It is also often torn. Because of these differences in wire diameter due to its deformation, inaccuracy in the amount of amalgam-forming metal applied to the lamp results. This entails the possibility that the optimum mercury vapor pressure for which the lamp was designed will not be attained and, consequentially, the optimum designed lamp characteristics, such as luminous efficacy and thermal performance, are not attained.

It is an object of the present invention to provide ductile amalgam-forming metals which are more readily processed and to provide improved lamp and lamp components containing said improved ductile amalgam-forming metals and improved amalgams.

SUBJECT MATTER OF THE INVENTION

The present invention provides improved low pressure mercury vapor discharge lamps of the fluorescent type which have a high electrical and/or thermal loading. These lamps utilize an amalgam which is formed from a ductile metal. The improvement in the present lamps comprises using as the amalgam-forming metal a composition comprising the said ductile metal together with an addition of an aluminum alloy selected from silicon-aluminum and beryllium-aluminum. The said aluminum alloy is present in said ductile metal as a distinct phase at the operating temperature of the lamp i.e., it is not primarily in solid solution in the ductile metal or in the amalgam formed by the mercury and the ductile metal composition.

The present invention also provides lamp components, i.e., electrode supports and the electrode housing containing the improved ductile metal composition.

The reference to "metal" in the term "ductile amalgam-forming metal" refers to both elemental metals and alloys. The preferred ductile metals are germanium and indium. These metals may contain alloying elements which result in the consequent amalgam having a lower vapor pressure. The preferred alloying elements are thallium, zinc, bismuth and tin. Indium and its alloys with the aforesaid alloying elements are the preferred ductile amalgam-forming metal.

The aluminum-forming alloy which is the non-ductile substantially insoluble component of the ductile metal composition is preferably silicon-aluminum or beryllium-aluminum in amounts between 0.05% and 25% and preferably between 0.5 and 5% by weight of the ductile amalgam-forming metal. The weight ratio of silicon to aluminum is from 1:10 to 1:5, i.e., the silicon is between about 10% and 20% of the said silicon-aluminum. The silicon-aluminum has the advantage of being particularly inexpensive.

The characteristics of the ductile amalgam-forming metals and the amalgams formed therefrom, including the soft and relatively pliable characteristics, are advantageously affected by the addition of the said aluminum alloys which are insoluble in the ductile metals. The aluminum alloy additives are dispersed throughout the ductile metal composition and the consequent amalgam, and remain in a distinct phase, i.e., they are substantially insoluble in the ductile amalgam-forming metal and in the mercury at the operating temperature of the lamp. The presence of the aluminum alloys as a phase dispersed throughout the ductile amalgam-forming matrix results in the said ductile metal composition having a strengthened structure. If the aforesaid aluminum alloys were soluble to the extent of forming solid solutions with the ductile amalgam-forming metal and/or with the amalgam, they would not be useful for the purpose of the present invention. If they dissolved in mercury, the mixed phase equilibrium between the amalgam-forming metal and the mercury would be changed. This would change one of the fundamental characteristics of the lamp and would impair the desired functioning of the low pressure mercury vapor discharge lamp of the present invention. However, the aluminum alloys of the present invention do not affect the mercury vapor pressure which is optimal for opera-
tion of the lamp because of their insolubility in mercury and the ductile metal.

The ductile metal composition utilized as the amalgam-forming constituent of the lamps of the present invention are prepared by heating and admixture of the components of said composition until all of the components are molten and then when a homogenous mixture is attained, cooling to form the ductile metal composition containing the aluminum alloy as a dispersed phase. The melting point of the said aluminum alloy non-ductile insoluble component of the said composition should not be too high because of the requirements of the aforesaid preferred process for preparing said composition.

The said ductile metal composition may be prepared in the form of wire or rod from the composition prepared as described in the preceding paragraph. The mechanical properties of said ductile metal composition are noticeably improved when compared with the corresponding ductile metal amalgam-forming alloy which does not contain the said aluminum alloy component. Indium compositions in wire form containing the silicon-aluminum additive of the Example herein have a tensile strength of about three times greater than that of the corresponding indium wire which does not contain the silicon-aluminum alloy. The said alloyed wire also has a greatly decreased tendency to cold fuse. The annealing and tempering temperatures of the said alloyed indium wire composition are also less critical than the corresponding temperatures of pure indium wire. The cost of the said alloyed composition in wire form does not differ greatly from that of pure indium wire.

An embodiment of the lamp according to the invention is illustrated in the accompanying drawing wherein:

The sole FIGURE of the drawing is a partial sectional view of the fluorescent lamp of the present invention. The lamp comprises an elongated transparent envelope 1. The interior surface of said envelope 1 is coated with a phosphor coating 2. An electrode foot (or support) 3 is sealed in each end of the lamp. The electrode foot 3 consists essentially of a flare stem 4 and a stem press (or pinch) 5. The lead-in wires 6 and 7 pass through said electrode foot. The electrode coil 8 is attached to the inner ends of the lead-in wires 6 and 7.

The amalgam-forming ductile metal composition of the present invention is applied, preferably in the form of an annulus 9 on the portion of the flare stem 4 which approaches the stem press 5. The ductile metal-forming composition is one prepared from indium and a silicon-aluminum solder which is 88.3% by weight of aluminum and 11.7% by weight of silicon. This is the eutectic composition with a melting point of about 577°C. The ductile metal composition contains 2% by weight of this silicon-aluminum alloy resulting in a composition composed of 98% by weight of indium, 1.77% by weight of aluminum, and 0.23% by weight of silicon. The annulus 9 has a width of three mm. The amount of ductile metal composition applied is 55 mg. The ratio of indium to mercury in the amalgam in the lamp is 5.5:1.

The electrode coil 8 is surrounded by a sheet iron annular cap 10. Cap 10 is supported by wire 11. Cap 10 has positioned thereon an amalgam-forming metal 12 which forms an amalgam that facilitates run-up (starting time) of the lamp. Another amalgam-forming metal composition and consequent amalgam which also facilitates run-up of the lamp is provided on stem press 5. Both of the said amalgam-forming metals 12 and 13 are the same indium composition containing the said aluminum alloy as the main amalgam-forming metal composition which is coated on the flare stem 4.

We claim:

1. In a mercury vapor discharge lamp of the fluorescent type comprising an elongated transparent envelope having electrodes sealed into its ends, at least one of said electrodes being connected to an electrode positioning means, said electrode positioning means containing on its surface at least one ductile metal composition as the amalgam-forming metal, the improvement comprising utilizing as said ductile metal composition, a ductile amalgam-forming metal and at least one aluminum alloy selected from the group consisting of silicon-aluminum and beryllium-aluminum, said aluminum alloy being a separate solid phase dispersed throughout said ductile amalgam-forming metal at the operating temperature.

2. The lamp of claim 1, wherein said ductile metal composition contains between about 0.05% and 25% by weight of said aluminum alloy based on the weight of said ductile amalgam-forming metal.

3. The lamp of claim 2, wherein said ductile amalgam-forming metal is selected from the group consisting of indium and gallium and alloys thereof and wherein said ductile amalgam-forming metal is an alloy of indium or gallium, the alloying metal or metals forming solid solutions with said indium or gallium; and wherein said aluminum alloy is a silicon-aluminum alloy.

4. The lamp of claim 3, wherein said ductile amalgam-forming metal is indium or an alloy of indium with at least one metal selected from the group consisting of thallium, zinc, bismuth and tin.

5. The lamp of claim 4, wherein said silicon-aluminum alloy contains between 10% and 20% by weight of silicon.

6. The lamp of claim 5, wherein said ductile metal composition contains between about 0.5% and 5% by weight of said silicon-aluminum based on the ductile amalgam-forming metal.

7. The lamp of claim 1, wherein said aluminum alloy is a silicon-aluminum alloy containing between 10% and 20% of silicon.

8. The lamp of claim 1, wherein said ductile metal composition contains between about 0.5% and 5% of a silicon-aluminum alloy based on the ductile amalgam-forming metal.

9. The lamp of claim 3, wherein said silicon-aluminum alloy contains between 10% and 20% of silicon.

10. The lamp of claim 1, wherein said aluminum alloy is beryllium-aluminum.

11. An electrode support for fluorescent lamps comprising a flare stem and a stem press and containing on at least one portion of its surface a ductile metal composition comprising at least one ductile amalgam-forming metal and at least one aluminum alloy selected from the group consisting of silicon-aluminum and beryllium-aluminum, said aluminum alloy comprising between about 0.05% and 25% by weight of said ductile amalgam-forming metal.

12. The electrode support of claim 11, wherein said ductile metal composition comprises about 98% indium, 1.77% aluminum and 0.23% silicon.