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[54] **TUNGSTEN-ALLOY ELECTRODE WITH BRAZABLE LEADS INTEGRAL WITH EMITTER HEAD**

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[58] **Field of Search**.....313/332, 346, 336

[56] **References Cited**

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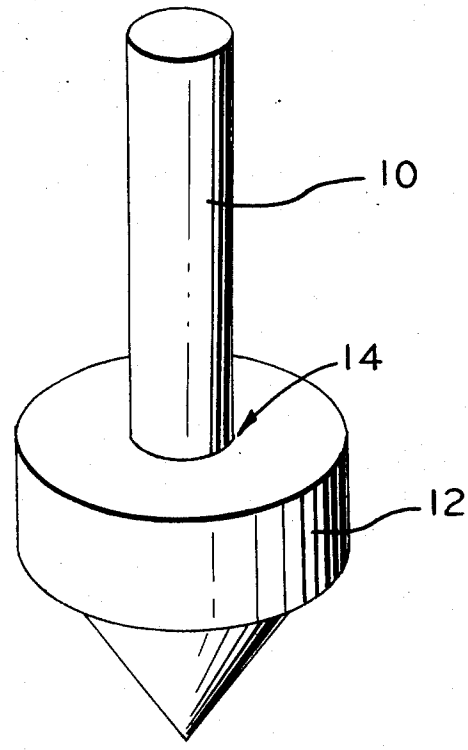
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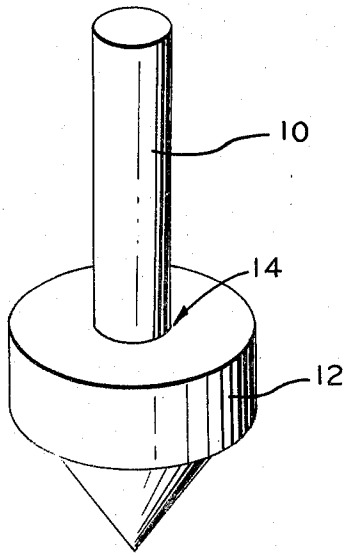
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[57] **ABSTRACT**

An emitter type electrode comprising a head consisting essentially of a moldable emissive electrode material, tungsten, and from about 0.2 to about 7 percent of a group VIII metal additive that lowers the sintering temperature of tungsten at least about 100° C and integral with said head and extending therefrom, an electrically conductive tungsten alloy lead consisting essentially of tungsten and from about 1 to about 30 percent rhenium. In the process for preparing emitter-type electrodes having an integral head and lead by molding, pressing and sintering the improvement comprising adding to the moldable, emissive electrode material and tungsten, that forms the head, prior to pressing and sintering, from about 0.2 to about 7 percent of a group VIII metal additive and inserting into the head prior to pressing and sintering a tungsten alloy lead consisting essentially of tungsten and from about 1 percent by weight to about 30 percent of rhenium.

5 Claims, 1 Drawing Figure




10
14
12

TUNGSTEN-ALLOY ELECTRODE WITH BRAZABLE LEADS INTEGRAL WITH EMITTER HEAD

BACKGROUND OF THE INVENTION

This invention relates to emitter-type electrodes. More particularly, it relates to emitter-type electrodes that have an integral head and lead wherein the lead has many of the desirable properties of tungsten and which lead is resistant to embrittlement.

This invention relates broadly to the art of producing emitter-type electrode structures, which also may be designated as emissive (i.e., electron-emissive) electrode structures. More particularly, it is concerned with the fabrication of an electrode that is especially adapted for use as a high-voltage cold electrode (anode or cathode) element in such devices as, for example, spark-gap assemblies, flash lamps, flash tubes and the like. The scope of the invention includes both article and method features.

Emitter-type electrode heads heretofore were made from powdered materials by techniques that involve pressing and sintering. Typically, the head consists of an emissive (including potentially emissive) material that is dispersed in a porous refractory metal matrix, e.g., tungsten, molybdenum, or mixtures of either or both with other refractory metals; or, alternatively, such electrodes can be described as consisting essentially of a porous refractory metal matrix impregnated or mixed with the emissive material. The emissive material can be, for instance, a compound of an alkaline-earth metal, e.g., an oxide, carbonate, aluminate or orthosilicate either alone or in certain combinations.

It will be understood, of course, by those skilled in the art that by "emitter-type" electrode or electrode structure is meant an electrode that functions during use, more particularly, under high-voltage application, to emit electrons. By "cold" electrode or electrode structure is meant an emitter-type electrode device having an emissive surface that, in use, emits electrons only under high voltage as contrasted with an electrode or electrode structure that, in use, is continuously heated by a filamentary conductor. An example of the latter is, for example, a dispenser cathode.

Sintered electrode heads, specifically sintered cathodes, usually have the general form of a disc. The emitting surface can be, for example, flat, concave, convex or conical. The opposite side is usually flat. One end of a lead (i.e., lead-in conductor) consisting of an electrically conducting rod or wire, having a diameter less than that of the electrode, can be attached to the flat surface of the electrode by brazing. Although tungsten has many desirable properties for leads and the matrix for the head, brazing is difficult.

Because of the close physical relationship between the lead and the electron-emissive surface, this brazing step is a very troublesome operation particularly when tungsten is used. Furthermore, the brazing problems increase as the percentage of alkaline-earth emissive material in the electrode composition (which may be from about 5 percent to about 20 percent by weight thereof) is increased to a percentage near to and above the usual amount of about 10 weight percent of the aforesaid composition. An even more serious problem is often encountered during operation of the article or device, containing the electrode element, as a result of

bleeding of the braze material onto the emissive surface. Such bleeding can cause the device to operate improperly.

To overcome the problems associated with brazing the head and lead, a technique was developed for using metal powders, casting, sintering them to form the head and stem as one integral part. This technique is disclosed in U.S. Pat. No. 3,489,554.

Although the problems with brazing were overcome when tungsten was used as the material for the matrix for the head and the lead, additional problems resulted. These problems resulted partially from the high temperatures used to sinter tungsten and resulted in some cracking of the parts. Use of metal additives in the head to lower the sintering temperature of tungsten in the head resulted in an induced recrystallization and the resultant embrittlement of the tungsten lead frequently results so that relatively slight pressures to the lead causes the part to break.

It is believed, therefore, that an emissive electrode that is not brazed, that has a lead that has the desired properties of tungsten and that can be sintered at a lower temperature or for a shorter time without embrittlement is an advancement in the art.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of this invention to provide an emissive electrode that overcomes the problem of brazing but is structurally more sound than prior electrodes having tungsten leads.

It is a further object of this invention to provide an improved process for providing emissive electrodes having an integral head and lead.

In accordance with one aspect of this invention, there is provided an emissive electrode comprising a head consisting essentially of an emissive material, tungsten, and from about 0.2 to about 7.0 percent of a group VIII metal additive that lowers the sintering temperature of tungsten at least about 100° C and integral with and extending from the head a lead consisting essentially of a tungsten-base alloy consisting essentially of tungsten and from about 1 to about 30 percent of rhenium based upon the weight of the tungsten.

In accordance with an additional aspect of this invention there is provided an improvement to the process for manufacturing parts having a head with a tungsten matrix and a tungsten alloy lead. The improvement comprises incorporating in the material used to form the head, prior to pressing and sintering, tungsten and about 0.5 to about 7.0 percent of an additive that lowers the sintering temperature of tungsten at least 100° C and using a tungsten alloy stem consisting essentially of tungsten and from about 1 to about 30 percent of rhenium.

BRIEF DESCRIPTION OF THE DRAWING

The drawing illustrates a perspective view of an electrode structure embodying this invention.

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims in connection with the above description of some of the aspects of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Briefly described, the article is constructed by pressing a powdered, moldable, emissive, electrode head material hereinafter described about the end of an electrically conducting lead of a particular tungsten alloy hereinafter described. Molding pressures can range from about 10,000 to about 80,000 p.s.i.g. or more as can be used depending upon the particular materials being pressed and structure being fabricated. During subsequent sintering of the pressed assembly, the electrode or head and the lead or stud become fixedly attached or united to each other thereby forming an integral structure.

The electrically conducting lead shown as **10** on the drawing (or stem or stud as it also can be designated) comprises or consists essentially of a particular tungsten alloy as hereinafter described.

In producing the composite structures of this invention, the head shown as **12** on the drawing is formed by

a. a powdered emissive material (examples of which have been given hereinbefore,)
b. a tungsten metal powder generally referred to as the matrix is employed in the approximate weight percentages of from 5–20 percent of the former to from 95–80 percent of the latter, and
c. from about 0.2 to about 7 percent by weight of the tungsten of a group VIII metal additive that lowers the sintering temperature of tungsten at least about 100° C.

These ingredients together with a small amount (e.g., from about 0.5 to about 3 percent of the weight of the primary components) of a temporary organic binder, for instance from 1 to 2 weight percent (on this same basis) of a wax or wax-like substance of natural or synthetic origin, are first thoroughly mixed together. When the organic binder is, for example, paraffin wax (in slivered or other suitable form) sufficient heat is generated during mixing to melt the paraffin thereby facilitating its more uniform dispersion throughout the mix. With higher melting waxes or wax-like substances it may be necessary to heat the mixture while admixing in order to effectively disperse the binder.

Any desired configuration of the head can be pressed, e.g., flat, concave, convex, pointed or conical, etc. Likewise the diameters and lengths of the studs can be varied as desired or as conditions may require.

Although in general any group VIII metal that lowers the sintering temperature of tungsten at least 100° C such as iron, nickel, cobalt, rodium, palladium and the like can be used, iron, cobalt and nickel are preferred and of these nickel is especially preferred. Preferred amounts of the metal additive are from about 0.25 to about 1 present by weight of tungsten.

A tungsten alloy lead consisting essentially of tungsten and from about 1 to about 30 percent of rhenium is used. The use of rhenium apparently creates a resistance to the embrittlement normally induced by the migration of the group VIII metal additive to the usual tungsten lead. In this manner, the benefits of the lower sintering temperatures are attained without the embrittlement experienced heretofore. The tungsten alloy containing rhenium in the amounts herein specified has the desirable electrical and refractory metal properties of tungsten. From about 1.5 percent to about 5.0 percent by weight of rhenium is preferred with about 3 to about 3.5 percent being especially preferred.

After pressing the moldable electrode material onto one end of the lead, as shown as **14** on the drawing the resulting composite is dewaxed, fired (i.e., sintered) in a reducing atmosphere, usually hydrogen. The temperatures employed during the sintering step are below 1,700° C but will be dependent upon the particular metal additives used in the pressed electrode composition of which the head is formed.

Nickel, for example, when used within the 0.2 to 7 percent range can lower the temperature to about 1,550° C and reduce the sintering to about one-half hour. When tungsten alone is the matrix a temperature of about 1,800° C for about 10 hours is required. The improvement of this invention offers appreciable increases in production throughput. In most instances, it is desired to use amounts and types of additives that after dewaxing at 800° for 1½ hours an electrode is formed below 1,600° C in less than 1 hour.

In order to more fully illustrate the subject invention, the following detailed example is presented. All parts, proportions and percentages are by weight unless otherwise indicated.

EXAMPLE 1

1. To a high intensity mixer are charged and therein thoroughly admixed: 450 parts tungsten powder having an average diameter of about 4 microns; 50 parts powdered barium aluminate (200-mesh particle size, U.S. Standard sieve series), and 7.5 parts of silvered paraffin wax and about 5 parts of nickel powder.

2. The resulting substantially homogeneous admixture is removed from the mixer and allowed to become harder.

3. The mixture from step 2 is forced through a 20-mesh screen (U.S. Standard sieve series) to provide a powder that flows freely.

4. The powder is allowed to flow into the cavity of a double-acting die mounted in a rotary mechanical press.

5. Simultaneously with step 4 a tungsten alloy lead in the form of a 1.050 in. long rod containing tungsten and 3.25 percent by weight of rhenium is placed in the upper punch or plunger of the press.

6. The press is actuated such that the powder is pressed about the end of the lead at a pressure of about 40,000 p.s.i.g.

7. After the part has been ejected from the press, it is subjected to a sintering operation. A satisfactory procedure consists of the following sintering and finishing steps:

a. Place the pressed part in ZrO_2 sand contained in a molybdenum tray.
b. Dewax by heating to about 800° C for about 1.5 hours to drive off volatile materials.
c. Stoke the tray into the hot zone of a furnace operating at about 1,550° C under an atmosphere of flowing (ca. 30–40 c.f.h.) hydrogen. After the part reaches the temperature of the furnace, it is maintained at that temperature for about one-half hour.
d. Stoke the tray into the cool zone.
e. Hold the tray in the cool zone for about 1 hour.
f. Remove the tray from the cool zone and remove the finished part from the tray.

g. The collected, sintered parts are tumbled in methanol while in contact with polishing stones for about 1 hour.

The resulting head can not be broken from the lead using finger pressure. It requires the use of two pair of pliers, one gripping the head while the other gripping the lead, to break the cathode.

A composite using a tungsten lead without rhenium is also prepared. The head breaks from the lead by applying finger pressure to the end of the lead while grasping the head in the other hand.

Substantially similar results are achieved when other group VIII elements are substituted for the nickel in substantially similar amounts. For example, use of about 1 percent iron in the lead lowers the sintering temperature to about 1,550° C.

Below about 0.2 percent by weight of the Group VIII metal additive is generally ineffective. Greater than about 7 percent by weight does not result in any appreciable benefits and can alter the properties of the part sufficiently to create some problems, therefore, are not recommended.

While there has been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. An emitter type electrode comprising a head consisting essentially of a moldable emissive electrode material, tungsten and from about 0.2 to about 7 percent by weight of the tungsten of a group VIII metal additive that lowers the sintering temperature of tungsten at least 100° C and integral with and extending from said head a tungsten alloy lead consisting essentially of tungsten and from about 1 to about 30 percent rhenium.

2. An electrode according to claim 1 wherein said metal additive is selected from the group consisting of iron, cobalt, and nickel.

3. An electrode according to claim 2 wherein said additive is nickel.

4. An electrode according to claim 3 wherein said nickel is from about 0.5 to about 4 percent of weight of said tungsten.

5. An electrode according to claim 4 wherein said lead consisting essentially of tungsten and from about 1.5 to about 5.0 percent rhenium.

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