DARK COATED HEATER FOR VACUUM TUBE CATHODE

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Related U.S. Application Data


ABSTRACT

A tungsten heater has a first coating of an insulating oxide covering its entire body and extending onto its legs and a second coating of elemental tungsten, reduced in situ, covering substantially all the first coating except for a short span on the legs.

3 Claims, 3 Drawing Figures
FIG. 1

FIG. 2

FIG. 3

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This is a division of application Ser. No. 419,440, filed Dec. 18, 1964.

This invention relates to coated heaters and, particularly, to dark coated insulated heaters utilized in indirectly heated cathodes in vacuum tubes.

Conventional heaters are normally made of tungsten wire and coated with an insulating coating, usually aluminum oxide, to electrically insulate the turns of the heater wire from each other and from the cathode in which it will be disposed. The aluminum oxide coating is normally white, however, it is advantageous to have a gray or black colored coating on the heater. The higher emissivity of the dark coating results in better heat transfer to the cathode. Therefore, for the necessary cathode temperature and adequate electron emission, a dark coated heater would operate at a lower temperature than a white coated heater. The advantages resulting from this lower heater temperature are longer life, better current stability of the heater and lower heater-cathode electrical leakage.

Heater coils are an essential element in most vacuum tubes. These coils are placed inside thin walled, nickel sleeves which are coated on the outside with carbonates of barium, calcium, and strontium. After a coil is inserted in a cathode sleeve, the assembly is heated in a vacuum to reduce the carbonate to their corresponding oxides. When properly activated, electrons will be emitted and the coated sleeve will act as a cathode. Connection of the coil to a power supply will furnish heat to the sleeve to activate the oxides.

Conventional processes for obtaining a dark coating on the heaters are by direct use of a coating suspension that incorporates insoluble metallic oxide powders, such as chromium or titanium, which will impart a dark color to the coating, after the coated heater has been fired. The major disadvantage to this process is that these metallic oxides have poorer electrical insulation characteristics at normal heater operating temperatures than the white aluminum oxide coating, and therefore, have higher heater-cathode electrical leakage, which results in a poorer quality of short-life tube.

Another method of obtaining a dark coated heater is to directly deposit a dark coating over a conventional white coated heater. In this process, the heater is conventionally coated with the white aluminum oxide. It may then, although not necessarily, be fired at a high enough temperature to sinter the coating. The sintered, coated coil is then electroplated or dip coated in a suspension of fine tungsten powder to incorporate the metal and produce a dark coating.

According to our invention, the heater coil is coated with aluminum oxide such as disclosed in the U.S. Pat. of Dolan, No. 3,049,482. Following the manufacture, the coated coil is dipped in a solution of a soluble high tungsten containing compound. After dipping, the coated coil is sintered at an elevated temperature in a reducing atmosphere and the ionized tungsten is reduced to a tungsten metal, thereby imparting the dark coloration.

Accordingly, the primary object of our invention is darkening an insulating coating on heater coils.

Another object of our invention is increasing the emissivity of the coating on the heater coil, hence, resulting in better heat transfer without decreasing the insulating characters.

The many other objects, features and advantages of the present invention will become manifest to those conversant with the art upon reading the following specification and drawings wherein the specific embodiments of a method of placing a dark over-coat on the insulating coating are shown and described.

Of these figures:

FIG. 1 is an elevational view of a reverse helix heater coil coated with alumina and tungsten.

FIG. 2 is an elevational view of a hair-pin shaped heater coil coated with aluminum and tungsten.

FIG. 3 is a cross-sectional view taken along the lines 3—3 of FIGS. 1 and 2.

A tungsten heater-coil having the general shape of a reverse helix of a hair pin is electrophoretically coated with a white insulating oxide such as aluminum according to well known and conventional techniques in the art. Following the coating, the cathode is heated and dried. When dry, it is dipped to a predetermined height in a solution of a soluble tungsten compound. Preferably, the entire white coating is not covered and a small gap is left on the aluminum oxide between the legs of the coil and the tungsten coating. Such gaps minimize heater-cathode leakage. Preferably, the tungsten coating solution is saturated with the compound but contains at least greater than about 0.25 gram atoms of tungsten per liter of solvent. After coating with tungsten containing solution, the heater is fired at a high temperature, usually greater than 1,300° C., in a reducing atmosphere such as hydrogen. The firing and the reducing atmosphere reduces the ionic tungsten to the metal and darkens the coating.

This process is highly advantageous because deposition through solution is easy to control. Since the tungsten is in ionic form in the solvent, vigorous agitation is not required to maintain a suspension. The heater coils which are produced are more uniform in color and therefore are more uniform in electrical characteristics. Heater-cathode leakage is lower and therefore better quality, longer life tubes can be attained.

As sources of the tungsten compound, we can use any heteropoly tungstic acid such as phosphotungstic acid, aluminotungstic acid or preferably tungstosilicic acid. These sources of tungsten can be suspended in any suitable polar solvent such as methyl or ethyl alcohol, water, acetone, etc. Any heteropoly tungstic acid which has adequate solubility in polar solvents can be used provided that the hetero atom, that is, as described above, the silicon, the aluminum or the phosphorus, would sublime completely during the firing process or be rendered sufficiently inert to maintain good electrical insulation in the quantity present. For example, such non-conductive, hetero molecules would be aluminum oxide or silicon dioxide. The phosphorus in phosphorus based materials would sublime. Other sources of tungsten which met these criteria are, for example, ammonium metatungstate in which ammonia would evanesc during firing and leave the tungsten metal.

Referring now to FIG. 1 of the drawing, the heater coil 1 is coated with aluminum oxide and covered with tungsten metal particles. Each coil is made of tungsten metal and coated with aluminum oxide 3. When coated, the coil 1 is dipped in the tungsten-iron containing solution and a darkened coating will appear after
firing in a reducing atmosphere. A small gap 5 is left between the legs 4 of the coil and the tungsten impregnates aluminum oxide coating to prevent leakage. The shape of the coil is immaterial to the invention and many other designs are possible such as shown in FIG. 2. A hairpin shape having a similar aluminum oxide coating 6 upon the coil 7 may be successfully darkened with an overcoat 8 of tungsten. A small gap is left between the tungsten overcoat 8 and the coil 7 to prevent leakage.

As shown in FIG. 3, the tungsten wire 9 has an aluminum oxide layer 10 coated thereupon. The tungsten overcoat 11 impregnates only partly through the coating 10 to the wire 9, preferably.

As a specific examples of our invention we cite the following: a tungsten heater coil having a hair pin shape is electrophoretically coated with white aluminum oxide and leaving the legs uncoated. The coated heater is dried and then dipped into a solution containing 100 gms of tungstosilicic acid in 500 ml of methol alcohol. The heater is then fired at 1,550°C in a hydrogen atmosphere and the coating of metallic tungsten appears on the outside.

It is apparent that modifications and changes may be made within the spirit and scope of the instant invention. It is our intention, however, to be limited only by the appended claims.

As our invention we claim:

1. A heater for indirectly heated vacuum tube cathodes comprising: a tungsten heater having a body and two legs; an insulating coating of aluminum oxide covering said body and only part of said legs; a dark coating of tungsten atoms covering all of said aluminum oxide coating on the body of the heater and only part of the aluminum oxide coating on the legs of the heater.

2. The heater of claim 1 wherein said tungsten coating penetrates into said aluminum oxide coating part way only.

3. The heater of claim 1 wherein said tungsten atoms are reduced in situ from an ionic form to the elemental form.