106. COMPOSITIONS, COATING OR PLASTIC

Cross Reference

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FILAMENT FOR HEATER TYPE VACUUM TUBES

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This invention relates to vacuum tubes and particularly to that type of vacuum tube which has a cathode adapted to be heated by an independent heater. The invention is an improvement over my co-pending applications entitled, "Electron emission element," Serial No. 164,119 filed January 27, 1927, and "Electron discharge device," Serial No. 205,024 filed July 11, 1927.

In a vacuum tube of the heater type a cylindrical cathode is usually employed, through which the filament extends which is adapted to be energized by a current of electricity in order to heat the cathode. Such filaments are separated from the cathode either by vacuous space or by an insulating material so that the filament is prevented from touching the cathode and the heat is transmitted to the cathode either by radiant heat alone or by radiant heat and conduction through the insulation. In using a cathode which is separated from the heater by vacuous space it is necessary to have enough clearance between the filament and cathode to prevent the filament from touching the cathode due to movement caused by temperature changes in both the cathode and the filament and also to permit convenient manufacture of the same in quantities. This clearance between the filament and cathode considerably increases the heat loss, as the heat radiated from the filament to the cathode is inversely proportional to the square of the distance the two are apart and the danger is always present that some distortion will cause the filament and cathode to touch, thereby rendering the tube useless.

For tubes of the type in which a solid dielectric is used between the filament and cathode it has been difficult to find such a dielectric which is inexpensive and which permits close proximity of cathode and heater. One of the best substances to use for such a solid dielectric is quartz, which must necessarily have considerable thickness in order to stand up of itself and prevent fracture due to vibration and temperature changes. The necessary thickness of the solid dielectric also tends to increase the heat loss due to the distance which the heat must travel through the insulation and very appreciably increases the time lag so that an element of time lapses between temperature variations of the filament and the corresponding variations of the cathode.

It is one of the objects of the present invention, therefore, to provide a method of applying an insulating coating directly to the filament of a vacuum tube which will have a greater dielectric strength than any solid dielectric heretofore used and which will be exceedingly thin so that the heat loss between the filament and cathode is materially reduced.

Another object of the invention is to provide a filament having a high dielectric coating which is so closely associated with the filament as to resist the effects of thermal mechanical movement.

Another object of the invention is to provide a filament having a coating which has an extremely high dielectric strength at high temperatures and which is also an excellent conductor of heat and a radiator of heat.

Another object of the invention is to provide a method of coating the filament wire with an insulating material having a high dielectric strength, whereby such coating may be continuously applied to a long wire which may be wound upon a spool and thereafter cut into the desired filament lengths as used.

Other objects of the invention will be apparent as the description thereof proceeds.

In carrying out the invention I prefer to use a filament of tantalum wire for the reason that tantalum has the property of absorbing gases when heated, which assists in maintaining the vacuum in the tube and because tantalum also has a high specific resistance. It is to be understood, however, that other materials such as nickel or tungsten might be used if desired. The tantalum wire is first placed in an oxidizing atmosphere and subjected to a temperature of about 600° C. until a dense coherent white coating of tantalum pentoxide (Ta_2O_5) is formed. The wire is then covered with a mixture of finely divided silicon dioxide (SiO_2) which is suspended in a very weak solution of sodium silicate, such suspension being more in the nature of a pasty mixture. The sodium silicate is used merely as a binder to hold the particles of silicon dioxide together on the filament until the same has been dried and heated. The silicon dioxide solution may best be prepared by grinding the silicon dioxide in a ball mill with the binder solution until a paste of the desired smoothness is obtained.

This coating of silicon dioxide quickly dries and remains on the filament until the filament is used. When the filament is mounted in a vacuum tube and the tube evacuated, it is heated to about 1600° C., which expels all occluded and chemically formed gases or volatile products from the coated filament and the heat also produces two important effects on the silicon dioxide coating. In the first place, there is a tendency

for the silicon dioxide to combine chemically with the tantalum pentoxide so that the silicon dioxide coating not only becomes firmly attached to the filament by reason of the fact that it hardens against the roughened oxide surface but the tendency to combine chemically makes an integral connection between the two which cannot be impaired, due to differences of the coefficients of expansion of the metal and coatings. Another result produced by this temperature is that the particles of silicon dioxide at the outer surface thereof sinter or fuse together to form an extremely hard surface of silica which increases the dielectric strength of the coating and also provides a better radiating surface for the heat, which is desirable, as no matter how close the cathode is placed with respect to the filament, there will always be some places which do not touch and which will then depend on radiated heat for energization.

The coating on the filament has an extremely high dielectric strength and is also exceptionally thin, the thickness thereof not necessarily exceeding .05 millimeters. The filament so coated may be placed inside of a cathode tube which is just sufficient in diameter to permit the filament to be slipped thereinto and which will closely engage the sides of the filament with no danger at all of the insulating coating breaking down with differences of potentials commonly used between the filament and cathode.

While I have described the use of silicon dioxide in a solution of sodium silicate, other substances may be used with good results, if desired. For instance, aluminum magnesium or boric oxides may be used, but silicon, having a very high dielectric strength, is preferable. Also, the binder of sodium silicate is preferred because it requires a very small concentration to bind the particles of silicon dioxide together and it releases a minimum of gas vapors during the life of the tube. Other binders, however, could be used, such as resinous or organic types, the necessary feature being merely that the binder hold the particles of silicon dioxide to the oxide coating of the filament until the filament is ready to be used.

The surface of the metal filament is best prepared to receive the silicon dioxide by forming an oxide upon it, as indicated above. It is possible, however, to place the silicon dioxide directly upon the metallic filament without forming the oxide, but I have found that in so coating the filament the silicon dioxide cannot be as uniformly distributed, nor will it adhere to the surface as well, due to surface tension and other effects, and the resulting coating is liable to chip and peel when the filament expands and contracts under temperature changes. It is within the spirit of the invention, however, to include the use of the dielectric applied directly to the filament.

It is evident from the above description that I have provided an insulated coating for a filament wire which may be easily applied to the wire and which produces an insulation having a very high dielectric strength which will not break down under differences in potential of the cathode and filament which are ordinarily used in vacuum tubes, and which coating is so thin that the cathode may be positioned in close proximity to the filament, thus reducing the heat losses to a minimum.

The coating has in effect a homogeneous structure ranging from the metal core at the center to pure silica at the surface, the particles being either chemically combined or physically closely adherent.

While I have described the invention in connection with certain specific substances, it is evident that many changes may be made in the materials and combinations of materials used, so that I do not desire to limit myself to the specific substances described but to interpret the invention broadly within the scope of the appended claims.

Having thus described my invention, what I desire to claim is:

1. The method of insulating a heater element for an indirectly heated cathode in an electron discharge tube which comprises forming an oxide on the surface of said element, immersing said element, in finely divided silicon dioxide suspended in a liquid binder, the silicon dioxide being greatly in excess of the amount of solid material in said binder, and heating said element to harden said silicon dioxide and effect the combination of said oxides.

2. The method of insulating a metal filament which comprises heating said filament in an oxidizing atmosphere to form an oxide thereon, coating said oxide with finely divided silicon dioxide suspended in a very weak solution of sodium silicate and heating said filament to harden said silicon dioxide.

3. The method of insulating a filament which comprises heating said filament in an oxidizing atmosphere, coating said filament with finely divided silicon dioxide suspended in a very weak solution of sodium silicate and heating said filament, whereby the surface of said silicon dioxide is fused.

4. A heater element for an indirectly heated cathode in an electron discharge tube, a coating of oxide on said element and a second coating on said oxide of an electrical insulating substance having a greater dielectric strength than said oxide, said second coating having a tendency to combine chemically with said oxide and thereby obtain integral connection of said coating with the heater element through the agency of said oxide coating.

5. A heater element for an indirectly heated cathode in an electron discharge tube, an oxide forming a coating on said element and a second coating on said oxide comprising an electrical insulating substance having a higher dielectric strength than said oxide and combined therewith.

6. A heater element for an indirectly heated cathode in an electron discharge tube, an oxide coating on the surface of said element and a second coating of finely divided silicon dioxide closely associated with said first coating.

7. A metallic heater element for an indirectly heated cathode in an electron discharge tube, an oxide formed on the surface of said element and a coating of silicon dioxide physically and chemically associated with said oxide.

8. A metal heater element for an indirectly heated cathode in an electron discharge tube, an oxide formed on the surface of said element and a coating on the surface of said oxide comprising finely divided silicon dioxide with a binder of a relatively much smaller amount of sodium silicate.

9. A tantalum heater element for an indirectly heated cathode in an electron discharge tube adapted to be used in a vacuum tube, a coating

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of tantalum pentoxide on said element, a coating of silicon dioxide physically and chemically combined with said oxide coating and a hard, fused surface on said silicon dioxide.

10. The method of insulating a heater element for an indirectly heated cathode in an electron discharge tube which comprises forming an oxide coating on the surface of a filament of metal having a melting point above 1600° C., coating such oxidized surface with material consisting very largely of an oxide having a melting point above 1600° C. and high dielectric strength and a relatively much smaller amount of a binder and heating sufficiently to bring about partial chemical reaction between the materials of said coatings and adhesion between such materials and the metal of the filament.

11. The method as in claim 10 in which the metal of the filament consists chiefly of tantalum and the first oxide coating is formed by oxidizing the metal of the filament.

12. The method as in claim 10 in which the second oxide coating consists very largely of free silica.

13. The method as in claim 10 in which the binder consists chiefly of a relatively readily fusible silicate.

14. The method as in claim 10 in which the metal of the filament consists chiefly of tantalum.

15. The method of insulating a heater element for an indirectly heated cathode in an electron discharge tube, which comprises heating a filament consisting chiefly of tantalum in an oxidizing atmosphere to produce a layer of tantalum pentoxide, coating the oxidized surface with silicon dioxide mixed with a relatively much smaller amount of alkali silicate and heating sufficiently to bring about partial chemical reaction between the materials of said coatings and adhesion between such materials and the metal of the filament.

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