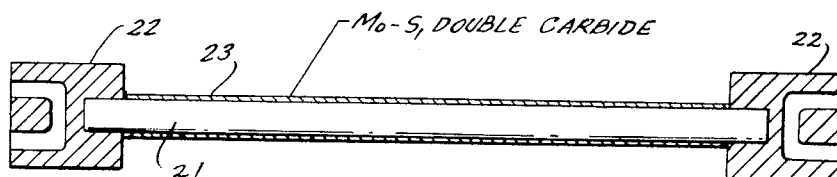


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ELECTRIC RESISTOR
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ELECTRIC RESISTOR

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5 Claims. (Cl. 201—75)

This invention relates to electric resistor heater bodies, and more particularly to such bodies which are formed with molybdenum disilicide, and to the production of such heater bodies.

It has long been known that molybdenum disilicide MoSi_2 has unusually desirable properties which would make it an ideal material for electric resistor heater bodies.

However, in the past, electrical heater rod bodies for electric furnaces and the like have as a rule, been made out of silicon carbide cemented with nickel carbide, such heater bodies being known commercially as globar bodies. The known silicon carbide heater bodies have a maximum operating temperature of about 1400°C ., and they are made with a resistivity of 2000 to 5000 microhm centimeters because with lower resistivity it is difficult to supply such heater bodies with the much larger currents that would be required to bring them to the desired high operating temperatures.

Because of its relatively low electrical resistivity of about 22 microhm centimeters at room temperatures, no practical way was found in the past for utilizing molybdenum disilicide as electrical heater bodies. Cemented bodies of molybdenum disilicide are very brittle and fragile and proposals to increase the resistivity of molybdenum disilicide by additions of molybdenum aluminides, and/or melting oxides, such as zirconium oxide, thorium oxide which become conducting at high temperatures, and/or other high melting oxides, such as aluminum oxide, beryllium oxide, silicon oxide, likewise failed because these additions result in a further increase of the objectionable brittleness of molybdenum disilicide.

The present invention is based on the discovery that a superior electric heater body may be formed by providing a body such as a rod of graphite or similar material with a surface layer of molybdenum disilicide and heating the combined body to a high temperature at which the surface layer of molybdenum disilicide is liquefied and combined with the surface strata of the graphite body into a composite surface layer which has a melting point of about 2450°C . or higher and resists corrosion in oxidizing atmospheres at temperatures up to 1900°C . and higher.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being made to the accompanying drawings, wherein the single figure is an elevational view with parts in section showing one form of heater body exemplifying the invention.

Bodies of pure molybdenum disilicide MoSi_2 which melts at about 1880°C . can be readily molded from MoSi_2 powders by powder metallurgy and ceramic techniques. Because of their high stability and resistance to corrosion in oxidizing atmospheres at 1700 to 1800°C ., many proposals have been made in the past for using cemented MoSi_2 material in electric resistance heaters for operation at heating temperatures of about 1700°C . However, because MoSi_2 has a relatively low elec-

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trical resistivity of only 22 microhm centimeters at room temperature, heater bodies of this material would have to be made with a very thin cross-section, such as thin tubing or ribbon, and even with such thin cross-section, they would be impractical as electrical heater bodies because of the difficulties of supplying them with relatively large currents which would be required to maintain them at the desired high temperature.

In addition, such cemented MoSi_2 material is very brittle and accordingly, thin heater bodies of silicon carbide are also impractical because of their excessive critical brittleness.

Coated heater body

The present invention is based on the discovery that a novel electric heater body of desired characteristics will be formed by coating a heater body such as a heater rod of graphite or like material with a surface layer of molybdenum disilicide MoSi_2 and heating the combined coated body to a high temperature at which the surface layer of molybdenum disilicide MoSi_2 is liquefied and combined with the surface strata of the graphite body into a composite surface layer formation which has a melting point in excess of 2450°C . and thereby providing a heater body which may be operated for a long period without corrosion at temperatures in excess of 1700°C . in oxidizing atmospheres.

According to this phase of the invention, molybdenum disilicide MoSi_2 is applied in the form of a coating to a heater body or rod of a material such as graphite and the so-coated body is heated in an inert atmosphere to a high temperature above the melting temperature of molybdenum disilicide MoSi_2 which is about 1880°C . The molybdenum disilicide MoSi_2 powder may be applied to the rod by mixing it with a suspension liquid and spraying or otherwise applying the powder suspension to the surface of the rod. The so-coated body is heated in an inert atmosphere, such as argon at temperatures above the melting temperature of molybdenum disilicide MoSi_2 , such as 2250°C . When a heater rod of graphite coated with a layer of molybdenum disilicide MoSi_2 powder, is heated in an inert atmosphere to temperatures between 2200°C . the liquified molybdenum disilicide MoSi_2 decomposes and carbonizes and combines with the adjacent strata of the graphite rod and forms with it a composite surface coating having a melting temperature in excess of 2450°C . The surface formation so obtained consists essentially of Mo—Si double carbide which resists oxidation at temperatures up to about 2200°C . and higher, and it remains stable at these temperatures and has a considerably higher resistivity than molybdenum disilicide MoSi_2 . Thus the combined Mo—Si double carbide has about 300 to 500 microhm centimeter resistivity compared to 22 microhm centimeter resistivity of molybdenum disilicide MoSi_2 . This Mo—Si double carbide material has desirable characteristics in that its thermal coefficient of resistance remains substantially zero over the temperature range from about 1200°C . up to 1900°C . and higher up to below its melting temperature.

The thickness of the double carbide coating of the invention so formed may be readily controlled by controlling the thickness of the molybdenum disilicide MoSi_2 coating layer applied to the graphite rod, and such coating formation may be readily made of or built up to sufficient thickness as to cause the double carbide coating layer to form a continuous and dense tightly adhering coating formation which prevents corrosion or deterioration of the underlying strata of the graphite rod when the combined heater body is operated at temperatures of 1700°C . to 1900°C . within oxidizing atmospheres.

The graphite rods which are so provided with a double carbide coating of the invention need not have such coating at their contact ends because these contact ends are usually combined and covered with water cooled copper electrodes which maintain the contact ends at lower temperatures at which the so covered graphite is not oxidized. Accordingly, the graphite rods which have already mounted thereon the water cooled metallic contact terminal sleeves, may be coated along the exposed parts of the graphite rod with the Mo—Si double carbide coating of the invention. In other words the exposed graphite rod is coated with a layer of molybdenum disilicide MoSi_2 and the so-coated graphite rod is heated by sending heating current through the graphite rod for raising its temperature to above the melting temperature of molybdenum disilicide MoSi_2 , to wit, to about 2200 to 2300° C. while maintaining it in an atmosphere of argon or like inert gas until the double carbide formation is formed on the surface of the graphite rod in the manner explained above.

The double carbide coating may be readily formed so as to have uniform thickness since the liquefied molybdenum disilicide MoSi_2 may be readily allowed to run freely around the rod during the heating stage at which the molybdenum disilicide MoSi_2 coating remains in molten condition. The process of the invention of the type described may be repeated with successive strata of molybdenum disilicide MoSi_2 placed on the graphite rod and subjected to the treatment described above for converting the exterior of the graphite rod into a composite Mo—Si double carbide layer having great corrosion-resistance and a melting temperature of 2400° C., and a thickness which will assure protection of the underlying body of the graphite rod against corrosion at temperatures of 1700 to 2200° C.

The drawing shows a heater body exemplifying this form of the invention. A rod 21 of graphite is provided at its ends with water coated metal terminals 22. The exposed surface of the graphite rod is covered with a coating layer 23 of molybdenum disilicide MoSi_2 whereupon the graphite rod 21 is subjected to a treatment wherein the exterior is converted into an adherent corrosion resistant Mo—Si double carbide coating layer.

Good results are obtained with heater bodies of the type described above, wherein the coating layer 23 of the Mo—Si double carbide layer has a thickness of about .003 to .006 inch.

In forming composite heater bodies of the invention of the type described above, it is important that the graphite of the rod shall be substantially free of sulphur.

Heaters of the invention formed in the manner described above, are superior to conventional silicon carbide heaters because they may be operated for prolonged periods of time without corrosion at temperatures much higher than the maximum temperature of 1400° at which such silicon carbide heaters may be used, the heaters of the invention cost only a fraction of the cost of such silicon carbide heaters.

The features and principles underlying the invention described above in connection with specific exemplifications, will suggest to those skilled in the art many other modifications thereof. It is accordingly desired that the appended claims be construed broadly and that they shall not be limited to the specific details shown and described in connection with exemplifications thereof.

I claim:

1. In an electric heater device, a solid elongated heater body of substantial thickness arranged to be traversed by electric heating current and consisting of carbonaceous material, said body having metal electrodes at opposite end regions, the entire exposed surface of said heater body between said end regions having as an integral part thereof a dense continuous enclosure layer of a double carbide of molybdenum and silicon having a melting temperature of at least 1800° C.

2. In an electric heater device, as claimed in claim 1, said enclosure layer being of substantially uniform thickness of between about 0.003 to 0.006 inch.

3. In an electric heater device, a solid elongated heater body of substantial thickness arranged to be traversed by electric current and consisting of carbonaceous material, said heater body having metal electrodes at opposite end regions, the entire exposed surface of said heater body between said end regions having as an integral part thereof a dense continuous enclosure layer of a double carbide of molybdenum and silicon having a melting temperature of at least 1800° C. which enclosure layer has been formed by uniting MoSi_2 portions to said entire exposed surface of said heater body and heating said united MoSi_2 portions in an inert atmosphere at a temperature of at least 1800° C. and above the melting temperature of MoSi_2 to cause said MoSi_2 portions to liquefy, decompose and combine with underlying strata of said carbonaceous material into said double carbide of molybdenum and silicon of said enclosure layer.

4. The process of forming an electric heater device, comprising providing a solid elongated body of substantial thickness consisting of carbonaceous material having metal electrodes at opposite end regions, uniting MoSi_2 portions to the entire exposed surface of said body extending between said electrode regions, heating said united MoSi_2 portions in an inert atmosphere at a temperature of at least 1800° C. and causing said MoSi_2 portions to melt, decompose and combine with the adjacent underlying strata of said carbonaceous body into a continuous enclosure layer of a double carbide of molybdenum and silicon having a melting temperature of at least 1800° C. and enclosing the entire exposed surface of said elongated body.

5. The process of forming an electric heater device, comprising providing a solid elongated body of substantial thickness consisting of carbonaceous material having metal electrodes at opposite end regions, applying to the entire exposed surface of said body extending between said electrode regions a continuous coating of molybdenum disilicide MoSi_2 , maintaining said body in an inert atmosphere, passing electric current through said elongated body until said coating is heated to a temperature of at least 1800° C. at which the MoSi_2 of said coating layer melts and decomposes and combines with the adjacent underlying strata of said carbonaceous body into a continuous layer of a double carbide of molybdenum and silicon having a melting temperature of at least 1800° C. and enclosing the entire exposed surface of said elongated body.

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