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[54] **METALLISING PASTES**

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[51] **Int. Cl.** **B44d 1/18**

[58] **Field of Search** .... 117/227, 201, 160 R; 252/514, 518, 512, 500

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[57] **ABSTRACT**

A metallising paste, suitable for forming an adherent electrically-and thermally-conductive metal-containing deposit on a ceramic surface and having one application in providing screen-printed microcircuit conductors and a further application in providing heat abstracting pads, or "heat sinks," applied to the underside of microcircuit substrates, comprises a heat-vaporizable liquid medium containing as powder a glaze material and a component selected from aluminum or an alloy thereof, wherein the glaze dissolves the oxide of aluminum or aluminum alloy and wets ceramic surfaces at the fusion temperature of the glaze. Preferably the glaze fuses at a temperature not greater than the melting temperature of the component.

25 Claims, No Drawings

METALLISING PASTES

BACKGROUND OF THE INVENTION

This invention relates to metallising pastes which form adherent electrically-and thermally-conductive metal-containing deposits on ceramic surfaces when fired in contact therewith and to methods for forming conductive elements on ceramic surfaces with said pastes: the invention has one application in forming microcircuit conductors on ceramic substrates and a further microcircuit application in providing pads adherent to the underside of ceramic substrates for abstracting heat from the substrates by thermal conduction.

SUMMARY OF THE INVENTION

According to the present invention a metallising paste suitable for forming an adherent electrically-and thermally-conductive metal-containing deposit on a ceramic surface comprises a heat-vaporizable liquid medium containing as powder a glaze material and a component selected from aluminum or an alloy thereof, wherein the glaze dissolves the oxide of aluminum or aluminum alloy and wets ceramic surfaces at the fusion temperature of the glaze.

By dissolving the oxide of aluminum or an alloy thereof the fused glaze renders soluble at least part of the insulating oxide film known to coat the metal particles; both the electrical and thermal conductivity of the deposit are thereby substantially increased. Preferably the glaze fuses at a temperature not greater than the melting temperature of the component: it has been found that if the glaze fuses at a temperature greater than the melting temperature of the component i.e. the glaze fuses after the component is molten, the conductivity of the deposit formed is lowered.

The preferred glaze for use with aluminium or an aluminium alloy comprises an oxide of boron: the glaze may additionally comprise an oxide of lead. A suitable liquid medium for use in a metallising paste comprising aluminium or an aluminium alloy and the preferred glaze is a polymerized cyclic ketone dissolved in a solvent such as terpineol. A suitable ceramic surface for use with such an aluminium-containing metallising paste is alumina. Surfaces other than alumina which may be used include silica or alumino-silicate surfaces. Aluminium alloys which may be used in pastes according to the present invention include Al/Cu and Al/Ag alloys.

The invention also provides a method for forming an electrically-and thermally-conducting element on and adherent to a ceramic substrate comprising forming a replica of said element on said substrate using a metallising paste as afore-defined, drying the formed replica, firing the dried replica at a temperature not less than that at which the whole of the replica fuses, whereby the replica wets the substrate and is rendered conducting, and solidifying the fired replica to form a substrate-adhering electrically-and thermally-conducting element. The replica may be formed on the substrate by screen-printing.

In addition the invention provides a ceramic substrate having an electrically- and thermally-conducting element formed thereon by the method of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The nature of the present invention is further explained, by way of example, by reference to the following embodiments thereof.

A heat-vaporizable liquid medium was mixed with aluminium powder, boric oxide and lead oxide to form a paste having a consistency suitable for screen-printing microcircuitry. The liquid medium was a polymerized cyclic ketone dissolved in terpineol, a suitable medium being Engelhard 4/575 (supplied by Engelhard Industries). A suitable paste contained 35 ccs of liquid medium for each 100 gms of solids consisting of 92 gms Al, 6 gms PbO and 2 gms B_2O_3. The preferred particle size of the Al powder was 1–2 μ and of the lead and boric oxides was −400 mesh. The paste was screen-printed onto an alumina substrate to produce a replica of a microcircuit comprising a plurality of conducting elements. The substrate used was a 96% Al_2O_3 material supplied by Worcester Porcelain Co. The substrate, with replica printed thereon, was dried at between 100°–200°C (to remove the vaporizable material) and was then fired in air at 830°C at which temperature both the aluminium powder and the mixed boric oxide/lead oxide are molten. The substrate was fired for 50 mins. The molten aluminium powder formed a conductive microcircuit replica and the molten boric oxide/lead oxide wetted the substrate by interfacial reaction therewith. On subsequent cooling to ambient temperature a solidified and electrically-conductive microcircuit was formed which was bonded to the substrate by the solidified mixed oxide glaze. The electrical conductivity of microcircuitry formed from air-fired replicas as aforesaid is typically 20–30 mΩ/square (a square being 1 mm across) compared with, for example, values of 4 mΩ/square for Au, 10–15 mΩ/square for Pt/Au and 60 mΩ/square for Pd/Ag. Although the metal powder in the above embodiment is Al, powders of Al alloys may be used, in particular powders of Al/Cu and Al/Ag alloys.

Apart from providing microcircuit electrical conductors the invention provides heat-abstracting elements bonded to the underside of microcircuit substrates for the removal of heat therefrom. Such elements, usually in the form of pads and termed "heat sinks", can also be deposited as paste replicas by screen-printing and converted to thermally-conducting pads by firing and subsequent solidification. It is known in the art that the dissipation of the heat generated by high density microcircuitry presents a problem: one method of substantially reducing substrate heat is to form thermally conducting elements ("heat sinks") according to the present invention.

I claim:

1. A metallising paste suitable for forming an adherent electrical conductor on a ceramic surface consisting essentially of a heat-vaporizable liquid medium, a glaze powder and a component in powder form selected from Al or an alloy thereof, wherein the glaze dissolves the oxide of said component and wets ceramic surfaces at the fusion temperature of the glaze.

2. A metallising paste as claimed in claim **1** wherein the glaze fuses at a temperature not greater than the melting temperature of the component.

3. A metallising paste as claimed in claim 1 wherein the component is selected from the group consisting of an Al/Cu and Al/Ag alloy.

4. A metallising paste as claimed in claim 1 wherein the liquid medium is a polymerized cyclic ketone dissolved in a solvent.

5. A metallising paste as claimed in claim 1 wherein the glaze is capable of wetting a ceramic surface selected from the group consisting of alumina, silica and aluminosilicate.

6. A metallising paste as claimed in claim 1 wherein the glaze comprises an oxide of boron.

7. A metallising paste as claimed in claim 6 wherein the glaze additionally comprises an oxide of lead.

8. A metallising paste as claimed in claim 1 wherein the component is Al metal.

9. A metallising paste as claimed in claim 8 wherein the glaze comprises an oxide of boron.

10. A metallising paste as claimed in claim 9 wherein the glaze additionally comprises an oxide of lead.

11. A metallising paste as claimed in claim 9 wherein the liquid medium is a polymerized cyclic ketone dissolved in a solvent.

12. A metallising paste as claimed in claim 9 wherein the glaze is capable of wetting a ceramic surface selected from the group consisting of alumina, silica and aluminosilicate.

13. A method for forming an electrically- and thermally- conducting element on and adherent to a ceramic substrate comprising forming a replica of said element on said substrate with a metallising paste as claimed in claim 1, drying the formed replica, firing the dried replica at a temperature not less than that at which the whole of the replica fuses, whereby the replica wets the substrate and is rendered conducting, and solidifying the fired replica to form a substrate-adhering electrically-and thermally-conducting element.

14. A method as claimed in any of claim 13 whereby the replica is formed on the substrate by screen-printing.

15. A method as claimed in claim 13 wherein the glaze in the paste fuses at a temperature not greater than the melting temperature of the component.

16. A method as claimed in claim 15 wherein the component in the paste is selected from the group consisting of an Al/Cu and Al/Ag alloy.

17. A method as claimed in claim 15 wherein the glaze in the paste comprises an oxide of boron.

18. A method as claimed in claim 17 wherein the glaze additionally comprises an oxide of lead.

19. A method as claimed in claim 17 wherein the liquid medium in the paste is a polymerized cyclic ketone dissolved in a solvent.

20. A method as claimed in claim 17 wherein the glaze in the paste is capable of wetting a ceramic surface selected from the group consisting of alumina, silica and aluminosilicate.

21. A method as claimed in claim 15 wherein the component in the paste is Al metal.

22. A method as claimed in claim 21 wherein the glaze in the paste comprises an oxide of boron.

23. A method as claimed in claim 22 wherein the glaze additionally comprises an oxide of lead.

24. A method as claimed in claim 22 wherein the liquid medium in the paste is a polymerized cyclic ketone dissolved in a solvent.

25. A method as claimed in claim 22 wherein the glaze in the paste is capable of wetting a ceramic surface selected from the group consisting of alumina, silica and aluminosilicate.

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