(12) UK Patent Application (19) GB (11) 2 110 475 A

(21) Application No **8133262**
(22) Date of filing **4 Nov 1981**
(43) Application published **15 Jun 1983**
(51) INT CL[3] **H05K 1/05 1/16 3/12**
(52) Domestic classification **H1R** 10 22 AS
(56) Documents cited
GB A 2007152
GB 1419193
GB 1401815
GB 1276527
GB 1327605
GB 1196040
(58) Field of search **H1R**
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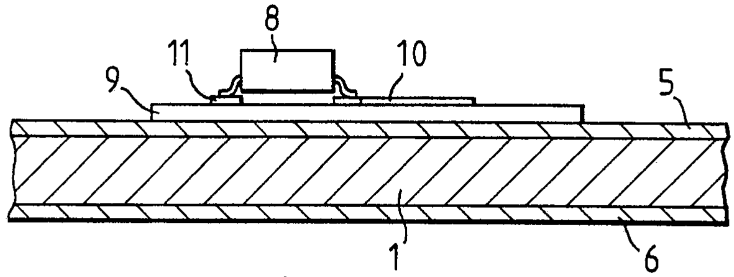
(54) Substrate for hybrid and printed circuits

(57) A hybrid or printed circuit is formed on a substrate (1) which comprises an iron-chromium-aluminium alloy which may also contain Yttrium and which forms a stable inert strongly adhering ceramic layer (5, 6) on its exposed surfaces when heated in an oxidising atmosphere.

To produce a hybrid circuit a dielectric paste is printed on the ceramic surface (5) of the alloy to form a platform (9). Conductors (10, 11) are then printed on the dielectric platform (9) and fired. One or more component(s) (8) is/are then soldered to the conductors.

Fig. 2.



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1.

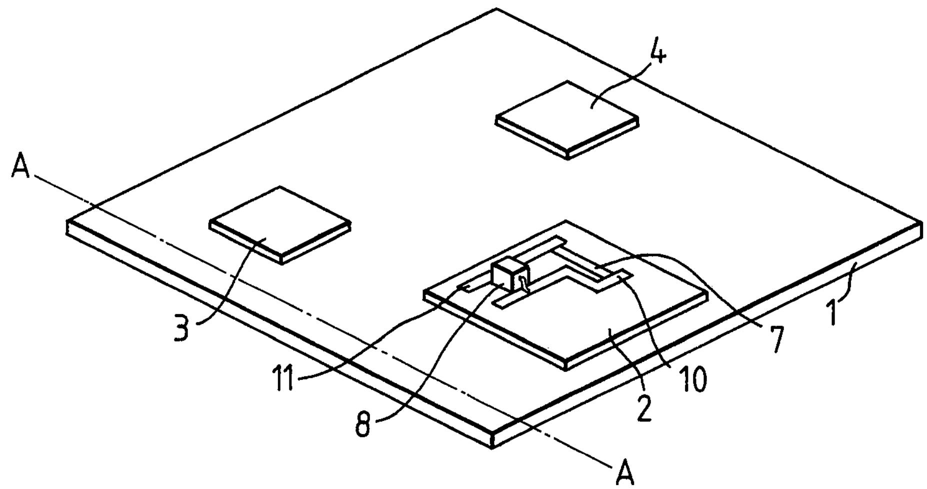
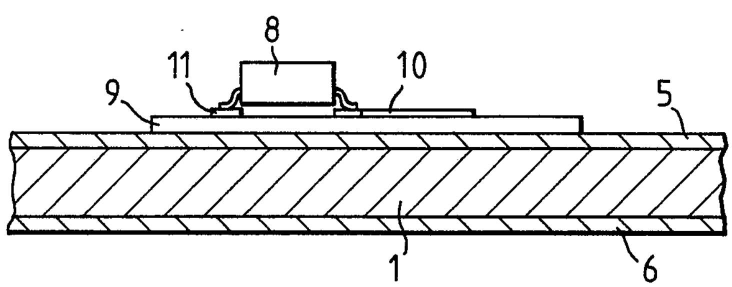


Fig. 2.



SPECIFICATION
Hybrid and printed circuits

The invention relates to hybrid circuits and printed circuit boards and their substrates and to a method of manufacturing hybrid circuits and printed circuit boards using these substrates.

Hybrid circuits typically use a substrate of alumina onto which various pastes are printed and fired to form conductors and resistors. The disadvantage of the alumina substrate is that it is brittle and becomes difficult to handle in sizes above about 4 inches square.

In printed circuit board technology there is a trend towards using "lead-less" components as these are directly soldered to the conductor tracks and do not require holes to be drilled in the boards into which component leads are inserted. The cost of drilling of printed circuit boards is a significant proportion of the total cost of the assembly. An article by P. R. Jones entitled "Leadless carriers, components increase board density by 6:1" which was published in the issue of Electronics International dated 25th August 1981 at pages 137 to 140 describes such a technique and is hereby incorporated by reference. The substrates used in the equipment described in this article were the usual epoxy-glass or polyimide-glass substrates which have significantly different temperature co-efficients of expansion from that of the components which are soldered to the printed tracks. The author of this article states that the differences in temperature co-efficients of expansion of the substrate and the ceramic leadless components did not effect the reliability of the circuits. However other articles suggest that this effect may cause broken joints between the components and the conductor tracks when the circuit is temperature cycled.

It has been proposed to use various metal alloys such as Invar or the Alloy 42 nickel-iron material as a substrate for printed circuit boards. These materials have a temperature co-efficient of expansion which is more nearly compatible with that of the leadless components. Such substrates have been described in articles in issues Electronics International dated 13th January 1981 (pages 48, 53 and 54), 10th February 1981 (pages 44 to 46) and 16th June 1981 (page 46). In all these cases the metal alloys are used as a backing material to give structural strength and are bonded to epoxy-glass layers on which the circuit is printed.

It is an object of the invention to provide a substrate for hybrid circuits which is less brittle than the currently used alumina substrates and to provide a substrate for printed circuit boards which is suitable for mounting leadless components and does not require the bonding of epoxy layers to a core.

The invention provides a substrate for printed circuit boards or for hybrid circuits comprising a ferritic alloy which when heated in an oxidising atmosphere forms a ceramic layer on its exposed surfaces.

Alternatively the substrate may comprise the ferritic alloy forming a surface coating on a substrate having a different constitution.

The ferritic alloy may be an iron-chronium-aluminium alloy which may contain Yttrium.

The invention further provides a printed circuit board and a hybrid circuit formed on such a substrate.

The invention further provides a method of producing a hybrid circuit comprising the steps of heating a ferritic alloy in an oxidising atmosphere to form a stable, inert, strongly adhering ceramic layer on its exposed surfaces, printing and firing one or more layers of dielectric paste over at least a part or parts of one of the exposed surfaces of the alloy, printing conductor tracks and/or resistors on the dielectric, and soldering components to the conductor tracks.

The method may further include the steps of printing solder onto selected locations of the circuit, mounting components on the substrate and reflow soldering the components to the substrate. The components may be attached to the substrate by vapour phase reflow soldering. A plurality of hybrid circuits may be formed on a single substrate which is then divided to form individual circuits.

The substrate may be formed into a desired shape by conventional metal working techniques after the hybrid circuit(s) has/have been formed.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing, in which:—

Figure 1 shows a perspective view of a substrate according to the invention on which a plurality of thick film circuits have been formed, and

Figure 2 is a part cross-sectional view on line A—A of Figure 1.

Figure 1 shows a substrate 1 on which thick film circuits 2, 3 and 4 are formed. The substrate 1 is formed from an alloy which has the property of forming a stable, tenacious ceramic layer on its exposed surfaces under oxidising conditions. A suitable alloy is an iron-chromium-aluminium alloy having an Yttrium addition such as the series offered by Resistalloy Limited under the trade mark Fecralloy (Fecralloy is a trade mark of the United Kingdom Atomic Energy Authority). A particular alloy of this series (Fecralloy A) has a typical composition of Carbon 0.03%, Silicon 0.3%, Chronium 15.8%, Aluminium 4.8%, Yttrium 0.3% and the balance Iron.

When the substrate 1 is formed from Fecralloy A the alloy is first heated to a temperature of 1100°C in an oxidising atmosphere. This causes a layer of alumina to be formed at the exposed surfaces of the substrate. The cross-sectional view in Figure 2 shows the layers 5 and 6 of alumina formed at the surfaces of the substrate 1. It is recommended that the substrate should be held at the temperature of 1100°C for a period of two hours when it is to be used at temperatures below 1100°C as it will be when used as a substrate for electrical circuits.

When the alumina layer 5 has been formed on the substrate 1 a dielectric paste is printed onto the layer 5 by a conventional screen printing process and then fired at a temperature of 850°C for a period of 10 minutes. This step may be repeated to build up a platform 9 of the desired thickness. Subsequently conductor tracks 10, 11 and resistor 7 are printed and fired conventionally. Solder is then screen printed onto the circuit and components 8 attached and reflow soldered to the conductors. Vapour phase soldering techniques are suitable for performing this operation. The Fecralloy substrate may then be formed into a desired shape to form a structural part of the equipment of which the circuit forms part. For example the substrate 1 could be formed to provide the base of a telephone instrument onto which a plastics cover is mounted. This enables the use of separately mounted circuit boards to be reduced or eliminated.

Fecralloy A has the important properties for the use of a substrate for electrical circuits of forming a stable, inert, strongly adherent ceramic (alumina) coating when exposed to even small quantities of oxygen at high temperatures (between 1000°C and 1200°C). The processing conditions necessary to form this coating are not critical. Once formed, this coating can withstand repeated exposure (1,000's of hours) to high temperatures (1000°C) in oxidising and reducing atmospheres, without degrading the properties of the alumina coating. Consequently, it is capable of supporting multilayered thick-film structures requiring multiple firings at temperatures up to 950°C. The final properties of these films do not differ significantly from the high qualities these same films would exhibit if deposited on ceramic substrates in the normal way i.e. conductors can be multilayered, readily soldered with conventional solders and wire bonded; resistors can be made with sheet resistivities in the range 10 ohm/sq. to 1 megohm/sq; and insulating layers can be formed between different conductor layers, providing 10^{13} ohm resistance at 400 volts.

It is possible to form this alumina coating in an even thickness all over the surface a performed, shaped sheet. This is especially important in providing a good coating onto shapes (e.g. small holes, corners, edges) that are very difficult, or impossible to achieve by other methods and materials.

A multiplicity of shaped Fecralloy substrates may be formed on a single sheet of Fecralloy so that the costs of handling individual substrates is reduced. Such individual substrates can be separated from the array using conventional metal working techniques e.g. blanking, guillotining, sawing etc.—without damage to the thick film coatings on them, but it will be desirable to seal the exposed, unoxidised Fecralloy which results from the cutting operation to prevent the formation of rust on these edges.

Fecralloy, coated with multilayered thick films may be used as a replacement for alumina (Al_2O_3) as the substrate for thick film circuits especially where irregularly shaped substrates are required or where larger sized substrates are required when alumina becomes expensive and fragile.

It may also be used as a replacement for conventional printed circuit board materials to make printed circuit boards with multilayer interconnection tracks especially for interconnecting surface mounting components. In this case an important property of Fecralloy is that its temperature coefficient of expansion (11×10^{-6} °C) is much closer to that of the surface mounted components, than is the temperature coefficient of expansion of epoxy board (50×10^{-6} °C). Thus the assembled component and boards can withstand temperature cycling over a wider temperature range, and withstand more cycles between extreme temperatures, when Fecralloy is used for the substrate material.

Claims

1. A substrate for printed circuit boards or for hybrid circuits comprising a ferritic alloy which when heated in an oxidising atmosphere forms a ceramic layer on its exposed surfaces.

2. A substrate as claimed in Claim 1, in which the ferritic alloy forms a surface coating on a substrate having a different constitution.

3. A substrate as claimed in Claims 1 or 2, in which the ceramic layer comprises alumina.

4. A substrate as claimed in any preceding claim in which the ferritic alloy is an iron-chronium-aluminium alloy.

5. A substrate as claimed in Claim 4, in which the alloy contains Yttrium.

6. A printed circuit board formed on a substrate as claimed in any preceding claim.

7. A hybrid circuit formed on a substrate as claimed in any of the claims 1 to 5.

8. A method of producing a hybrid circuit comprising the steps of heating a ferritic alloy in an oxidising atmosphere to form a stable, inert, strongly adhering, ceramic layer on its exposed surfaces, printing and firing one or more layers of dielectric paste over at least a part or parts of an exposed surface of the alloy, printing conductor tracks and/or resistors on the dielectric, and soldering components to the conductor tracks.

9. A method as claimed in Claim 8 including the steps of printing solder onto selected locations of the circuit, mounting components on the substrate and reflow soldering the components to the substrate.

10. A method as claimed in Claim 9, in which the components are attached to the substrate by vapour phase reflow soldering.

11. A method as claimed in any of Claims 8 to 10 in which a plurality of hybrid circuits are formed on a single substrate which is then divided to form individual circuits.

12. A method as claimed in any of Claims 8 to 11 in which after the hybrid circuit(s) has/have been produced the substrate is formed into a

desired shape by conventional metal working techniques.

13. A method of producing hybric circuits substantially as described herein with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained