

**A system and a method for producing electrically conductive
interconnecting structures and a method for producing circuits and
equipped circuits**

- 1 -

THIS SHEET HAS BEEN
REPLACED

Specification

1 The present invention relates to a system for producing electrically conduc-
tive interconnecting structures, a method for producing electrically conduc-
tive interconnecting structures, a method for producing circuits and equip-
ped circuits as well as to the circuits and equipped circuits produced accor-
5 ding to these methods.

Generally, when electronic components or equipped circuits are produced,
it is necessary to mechanically-electrically connect metallic surfaces to me-
tallic connecting elements. To this end printed circuit boards usually are
10 produced by electroplating, the printed circuit board structure being ob-
tained by additive techniques or subtractive etching technologies. These
known methods, however, imply the risk of environmental pollution and the
necessity of recycling the galvanic liquids used therefor. The thus created
printed circuit boards serve as substrates for electronic components which
15 are connected to the printed circuit board. To a small extent, also electri-
cally conductive adhesives are employed for this purpose which in contrast
to softsoldering offer the advantage of low working temperatures. However,
these conventional conductive adhesives either are physical mixtures of
electrically conductive materials such as metal powders and polymer resins
20 being the matrix, or they consist of electrically conductive plastic materi-
als. The conductivity of such systems comes about by the quasi-metallic
contact of the conductive materials in the organic matrix.

In order to achieve good adhesion on the substrates, a high amount of poly-
mer resin is desired for such electrically conductive adhesives. On the other
25 hand, to achieve good electrical conductivity, conductive materials are re-
quired in large quantities. Adhesion to substrates and electrical conductivi-
ty thus are contrary demands on such adhesives. The connecting structures
obtained thereby e.g. have the drawback that they are not solderable. These
30 and other technical shortcomings have prevented heretofore the employ-
ment of conductive adhesives on a large scale.

Also electrically conductive adhesives have become known wherein the con-
ductivity is provided by a metallurgical reaction of different metals by for-
35 ming intermetallic connections. Also here it is necessary to admix an orga-
nic polymeric matrix so that the same problems arise as with adhesives fil-

1 led with electrically conductive materials.

It is, therefore, an object of the present invention to provide a system and a method for producing electrically conductive interconnecting structures as well as methods for producing circuits and equipped circuits by using this system, wherein the shortcomings of the prior art have been overcome and in particular excellent adhesion and good electrical conductivity and solderability of the created interconnecting structures and circuits are achieved.

10

According to the invention, this object is accomplished by a system according to claim 1, a method for producing electrically conductive interconnecting structures according to claim 14, and methods for producing circuits and equipped circuits according to claims 15 and 19. Preferred or particularly useful designs of the subject-matter of the invention are defined in the subclaims.

The subject-matter of the present invention, therefore, is a system for producing electrically conductive interconnecting structures comprising A) an adhesive material; and B) an electrically conductive metal paste containing at least two metal powders having different melting points, and a small amount of organic auxiliary agents, wherein the metal powders are selected so that during heating they produce an intermetallic phase, and wherein the organic auxiliary agents are volatilisable for the most part at the temperature used for producing the intermetallic phase.

The subject-matter of the present invention further is a method for producing electrically conductive interconnecting structures with the use of the system under the present invention, comprising the steps of

30 (1) applying the adhesive material onto a substrate; (2) applying the metal paste to the thus provided adhesive material; and (3) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

35 The subject-matter of the present invention also is a method for producing a circuit using the system under the present invention, comprising the steps of

(1) applying the adhesive material in the form of a circuit pattern onto a

1 substrate); (2) applying the metal paste to the thus provided adhesive material; and (3) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

5 The subject-matter of the present invention further is a method for producing equipped circuits using the system under the present invention, comprising the steps of

(1) applying the adhesive material in the form of a circuit pattern onto a substrate; (2) applying the metal paste to the thus provided adhesive material; (3) equipping the circuit pattern provided with the adhesive material and the metal paste with electrical or electronic components; and (4) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

15 Furthermore the circuits and equipped circuits produced according to the above methods are subject-matters of the present invention.

In contrast to the techniques heretofore used it has been found in the scope of the present invention that electrically conductive metal pastes which contain only a small amount of organic auxiliary agents and in which the metal powders are selected so that during heating they produce an intermetallic phase can be employed for producing electrically conductive interconnecting structures. The generally insufficient adhesion of such metal pastes to substrates or bases is achieved by an adhesive material which

25

30

35

1 has been previously applied to the substrate or base.

The adhesive material can be an anorganic or an organic material. Anorganic and organic adhesives are known to the skilled man and can be selected
5 by him depending on the purpose of use, e.g. depending on the materials used for the substrates. Anorganic adhesives are e.g. those made predominantly on a mineral basis such as a silicate basis. Hydraulically curable anorganic materials can also be suited. Suitable adhesives on an organic basis are e.g. thermoplastic resins, in particular those having higher softening or melting points. In particular, curable organic resins proved to be
10 useful, curing being made either thermally or by radiation.

The adhesive material usually contains no metallic components and exhibits no electrical conductivity. Its purpose is to provide an adherent thermoplastic connection with the base and to permit adhesion of the second
15 component, namely of the electrically conductive metal paste. Especially one-component and two-component adhesives on an epoxy resin basis, polyurethane resins, melamine formaldehyde resins, vinylidene chloride-vinyl acetate copolymer resins or materials known as solder stop lacquers can be used as adhesive materials. Particularly preferable are two-component adhesives on an epoxy resin basis. The selection of the respective adhesives depends on the adhesion properties of the used substrates such as circuit
20 bases and the flexibility that may be required.

25 The metal paste used under the present invention suitably contains at least one metal powder of a metal of good electrical conductivity, preferably selected from the group consisting of gold, silver, copper and alloys thereof, and at least one metal powder of a metal having a lower melting point than that of the metal of good electrical conductivity, preferably selected from
30 the group consisting of tin, indium and the alloys thereof, preferably its alloys including e.g. lead and/or antimony and/or zinc, such as tin lead, tin antimony or tin antimony lead. According to the invention it is necessary that the metal powders having different melting points undergo a metallurgical reaction during heating by forming an intermetallic phase. Additive
35 metal powders from the group consisting of nickel, germanium, titanium, iron, but also other alloy components which are known as so-called grain refiners can be employed here for achieving special properties. Particularly preferable is a metal paste which contains a mixture of copper powder and

- 1 a powder of the solder alloy 62Sn36Pb2Ag in a weight ratio of from about 4:1 to about 1:1.

- 5 The metal powders of the metal paste suitably have a mean particle size of from about 1 to 100 μm , preferably of from about 10 to 50 μm , more preferably of from about 20 to 30 μm .

- 10 The content of metal powder in the metal paste should be as high as possible and under the present invention preferably is at least about 85 % by weight, more preferably at least about 90 % by weight. With a metal powder of approximately above 95 % by weight, however, the handling of the metal paste may involve difficulties.

- 15 The organic auxiliary agents contained in the metal paste under the present invention e.g. can be volatile organic compounds such as solvents, e.g. diol, glycol, glycol ether and dicarboxylic acid ester, deoxidating auxiliary agents containing metal powder activating substances such as carboxylic acid and amines, and additives controlling the viscosity such as long-chain acid amides or paraffins. Preferably, amine compositions are used which are volatile
20 at the selected metallurgical reaction temperatures. Furthermore, coactivators selected from the group consisting of the nonvolatile carboxylic acids and amines and compounds which are dehalogenating at the temperature used for producing the intermetallic phase can be contained therein. The selection of these organic auxiliary agents depends e.g. on the selected
25

30

35

1 application method of the metal paste. Further small amounts of thik-
keners, binders, natural resins such as colophonium and colophonium deri-
vates can be added to the metal pastes. A metal paste which is suitable un-
der the present invention contains e.g. about 90 % by weight metal powder
5 and about 10% by weight organic auxiliary agents.

The method for producing electrically conductive interconnecting structures
according to the present invention comprises the steps of applying the ad-
hesive material onto a substrate, applying the metal paste to the thus pro-
10 vided adhesive material and heating the metal paste at a temperature at
which the metal powder forms an intermetallic phase.

Preferably, the adhesive material applied to the substrate is subjected to
thermal treatment prior to application of the metal paste, this thermal
15 treatment, however, being dimensioned so that no or no complete curing of
the adhesive material takes place. To this end it is expedient to first flash
off the adhesive material at ambient temperature for an adequate time peri-
od for evaporating solvents, if any. Subsequently the thermal treatment is
made, e.g. at 80°C for about 20 minutes under laboratory conditions.
20 Thereby, a dry, well processable surface of the adhesive material is ob-
tained.

In a next step the previously described metal paste is applied to the dried
surface of the adhesive material. The application of the adhesive material
25 and of the metal paste can be suitably made by means of a dispenser, a
silk-screen process or any other printing method according to techniques
which are known to the skilled man.

For finally producing a conductive interconnecting structure such as a cir-
30 cuit, the metal paste is heated so that the organic auxiliary agents evapora-
te for the most part and the metal particles are interconnected by soft sol-
der, thereby producing intermetallic

1 phases. As the organic auxiliary agents are volatile at the respective working temperature, no disturbing residues remain. The adhesion to non-metallic substrates of the metal pastes is ensured by the previously applied adhesive material which has a composition suited for the respective application and the used heating temperature, respectively. In the case of thermal treatment it must be observed that the metal powders form no melt as otherwise discrete metal beads would form caused by the surface tension.

10 The thermal treatment for producing electrically conductive interconnecting structures and for producing circuits and equipped circuits can be made in apparatus known in connection with the soldering technique. For example, a so-called reflow oven is suitable, the thermal treatment preferably being made in nitrogen atmosphere. It is also possible to introduce activators for the metal powder into the gas atmosphere, preferably formic acid. On the other hand such activators may also be contained in the metal paste, as mentioned above.

20 As a result of the method under the present invention, a layer structure is obtained which is comprised of the now completely cured adhesive material and a metal layer thereon which is substantially free from organic additives. The special advantage of such a layer structure resides in the solderability of the metallic layer. In contrast thereto, interconnecting structures obtained by means of known conductive adhesives usually are not solderable due to the intimate mixture of the metal and the polymeric matrix in the form described and put on the market today.

30 By the production of intermetallic phases according to the present invention, the remelting temperature of the metals is higher so that a high remelting temperature permits subsequent soldering processes. According to the invention the production of electrically conductive interconnecting structures such as circuits on insulating carrier materials is possible, the substrates used being all kinds of bases e.g. printed circuit boards, flexible printed circuit boards, alumina ceramics or anodized aluminum printed circuit boards. The skilled man can adapt the suitable adhesive materials and adhesive systems, respectively, to the individual substrate materials. By appropriate selection of the metallurgical components, plane or three-dimensional electrically conductive structures can be produced which can be further processed by subsequent bonding steps which are standard in the

1 production of electronic components, e.g. by soldering.

5

10

15

20

25

30

35



THIS SHEET HAS BEEN
REPLACED

CLAIMS

1. A system for producing electrically conductive interconnecting structures comprising
 - A) an adhesive material; and
 - B) an electrically conductive metal paste containing at least two metal powders having different melting points, and a small amount of organic auxiliary agents, wherein said metal powders are selected so that during heating they produce an intermetallic phase, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for producing the intermetallic phase.
2. The system as set forth in claim 1, wherein said adhesive material is an anorganic material.
3. The system as set forth in claim 1, wherein said adhesive material is an organic material.
4. The system as set forth in claim 3, wherein the organic material is a thermoplastic resin.
5. The system as set forth in claim 3, wherein the organic material is an organic curable resin.
6. The system as set forth in claim 5, wherein the curable resin is a one-component or two-component adhesive on the basis of epoxy resin.
7. The system as set forth in at least one of the preceding claims, wherein the metal paste contains at least one metallic powder of a metal of good electrical conductivity and at least one metallic powder of a metal having a lower melting point than that of the metal of good electrical conductivity.
8. The system as set forth in claim 7, wherein the metal of good electrical conductivity is selected from the group



THIS SHEET HAS BEEN
REPLACED

consisting of gold, silver, copper and alloys thereof.

9. The system as set forth in claim 7 and/or claim 8, wherein the metal having the lower melting point is selected from the group consisting of tin, indium and the alloys thereof, preferably its alloys with lead and/or antimony and/or zinc.

10. The system as set forth in at least one of the preceding claims, wherein the metal paste contains a mixture of copper powder and a powder of the alloy 62Sn36Pb2Ag in a weight ratio of from about 4:1 to about 1:1.

11. The system as set forth in at least one of the preceding claims, wherein the metal powders have a mean particle size of from about 1 to 100 μm , preferably of about 10 to 50 μm , more preferably of about 20 to 30 μm .

12. The system as set forth in at least one of the preceding claims, wherein the content of the metal powders in the metal paste is at least about 85% by weight, preferably at least about 90 % by weight.

13. The system as set forth in at least one of the preceding claims, wherein the organic auxiliary agents of the metal paste are selected from volatile organic compounds, deoxidizing auxiliary agents, metal ^dpower activating substances and the additives controlling the viscosity.

14. A method for producing electrically conductive interconnecting structures by using a system of at least one of the preceding claims, comprising the steps of
(1) applying the adhesive material onto a substrate;
(2) applying the metal paste to the thus provided adhesive material; and
(3) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

15. A method for producing a circuit by using a system of at least one of claims 1 to 13, comprising the steps of:



- (1) applying the adhesive material in the form of a circuit pattern onto a substrate;
- (2) applying the metal paste to the thus provided adhesive material; and
- (3) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

16. A circuit produced by the method according to claim 15.

17. A method for producing an equipped circuit by using a system set forth in at least one of claims 1 to 13, comprising the steps of:

- (1) applying the adhesive material in the form of a circuit pattern onto a substrate;
- (2) applying the metal paste to the thus provided adhesive material;
- (3) equipping the circuit pattern provided with the adhesive material and the metal paste with electric or electronic components; and
- (4) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

18. An equipped circuit produced according to the method set forth in claim 17.

19. The method as set forth in any of claims 14, 15, and 17, wherein the applied adhesive material prior to the application of the metal paste is exposed to thermal treatment subject to the condition that the adhesive material is not or not completely cured during this process.

20. The method as set forth in at least one of claims 14, 15, 17, and 19, wherein the adhesive material and the metal paste are applied by means of a dispenser, a screening method or any other printing method.

21. The method as set forth in any of claims 14, 15, 17, 19, and 20, wherein the substrate is a plane circuit base.

SUMMARY

A system and a method for producing electrically conductive interconnecting structures and a method for producing circuits and equipped circuits

The invention describes a system for producing electrically conductive interconnecting structures comprising

A) an adhesive material; and
B) an electrically conductive metal paste containing at least two metal powders having different melting points, and a small amount of organic auxiliary agents, wherein said metal powders are selected so that during heating they produce an intermetallic phase, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for producing the intermetallic phase;

as well as a method for producing electrically conductive interconnecting structures with the use of this system, comprising the steps of:

(1) applying the adhesive material onto a substrate;
(2) applying the metal paste to the thus provided adhesive material; and
(3) heating the metal paste at a temperature at which the metal powders produce an intermetallic phase.

The invention also describes a method for producing circuits and equipped circuits by using the above-mentioned system.

According to the present invention, electrically conductive interconnecting structures such as circuits are obtained providing excellent adhesion, good electrical conductivity and solderability.

A method of producing electrically conductive structures, an electrically conductive structure obtained according to the method, and a combination for producing electrically conductive structures

- 1 -

Specification

- 1 The present invention relates to a method of producing electrically conductive structures, an electrically conductive structure obtained according to this method, and a combination for producing electrically conductive structures.
- 5 Generally, when electronic components or equipped circuits are produced, it is necessary to mechanically-electrically connect metallic surfaces to metallic connecting elements. To this end usually printed circuit boards are produced by electroplating, the land pattern structure being obtained by additive techniques or subtractive etching technologies. These known methods, however, imply the risk
- 10 of environmental pollution and the necessity of recycling the galvanic liquids used in these methods. The thus produced printed circuit boards serve as substrates for electronic components which are connected to the printed circuit board. To a small extent, also electrically conductive adhesives are employed for this purpose which, in contrast to softsoldering, offer the advantage of low working temperatures. These conventional conductive adhesives either are physical mixtures of
- 15 electrically conductive materials such as metal powders and polymer resins as the matrix, or they consist of electrically conductive plastic materials. The conductivity of such systems results from the quasi-metallic contact of the conductive materials in the organic matrix.
- 20 In order to achieve good adhesion on the substrates, a high content of polymeric resin is desired for such electrically conductive adhesives. On the other hand, to achieve good electrical conductivity, a high content of conductive materials is required. Adhesion to substrates and electrical conductivity thus are contrary demands on such adhesives. The connecting structures obtained thereby e.g. have
- 25 the drawback that they are not solderable. These and other technical shortcomings have prevented heretofore the employment of conductive adhesives on a large scale.
- 30 Also electrically conductive adhesives have become known wherein the conductivity is provided by a metallurgical reaction of different metals by forming intermetallic connections. Also in this case it is necessary to admix an organic polymeric matrix so that the same problems arise as with adhesives filled with electrically conductive materials.

35

EP 0 414 363 A2 describes a method for producing electrically conductive circuit

- 1 traces, wherein an adhesive material containing a solvent is applied onto a substrate in a selected pattern by a printing technique. Thereafter, a metal powder is added that adheres to those parts that are provided with adhesive. After removal of powder that has not adhered, conductive circuit traces corresponding to the
- 5 pattern of the application of adhesive material are formed by heating and melting the metals. Tin, lead, bismuth, indium, antimony and silver are listed as components of the metal powders that may be used. For the removal of excess powder from the printed circuit board, a vibrating apparatus or an air blower is proposed.
- 10 US 3 800 020 describes a method for producing a land pattern, wherein a metal powder is applied to a thermoplastic material. Thereafter, the thermoplastic material and the metal powder are melted together by application and heating of a die, the die having the desired circuit pattern. Thus, a circuit pattern having the desired layout is formed. Again, the remaining, not molten powder has to be removed,
- 15 e.g. by a vibration or a vacuum process.

It is the object of the present invention to provide a method and a combination of producing electrically conductive structures as well as a method of producing circuits and equipped circuits by using this combination, wherein the shortcomings

20 of the prior art do not arise, and in particular excellent adhesion to substrates, good electrical conductivity and solderability of the obtained structures and circuits are achieved.

The subject-matter of the invention, therefore, is a method of producing electrical-

25 ly conductive structures comprising the steps of (1) applying an adhesive material onto a substrate; (2) applying an electrically conductive metal paste containing at least two metal powders having different melting points in a total amount of at least 85 % by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, metal powder activating substances and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and

30 their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the inter-

35

- 1 metallic phase, onto the thus provided adhesive material; and (3) heating the thus
obtained arrangement at a temperature at which said metal powders form an in-
termetallic phase.
- 5 In a preferred embodiment of the method according to the present invention, the
adhesive material is applied in the form of a circuit pattern for producing a cir-
cuit. When in this embodiment the circuit pattern provided with the adhesive ma-
terial and the metal paste is equipped with electric or electronic components prior
to heating, it is possible to produce an equipped circuit in a simple fashion.
- 10 Subject-matters of the invention also are electrically conductive structures and
circuits, respectively, or equipped circuits obtained according to such a method.
- 15 The subject-matter of the present invention moreover is a combination for pro-
ducing electrically conductive structures, comprising A) an adhesive material; and
B) an electrically conductive metal paste containing at least two metal powders
having different melting points in a total amount of at least 85 % by weight and a
small amount of organic auxiliary agents selected from volatile organic com-
pounds, desoxidizing auxiliary agents, substances activating metal powders and
20 additives controlling the viscosity, wherein said metal paste contains at least one
metal powder of a metal of good electrical conductivity selected from the group
consisting of gold, silver, copper and their alloys and at least one metal powder of
a metal having a lower melting point than the metal of good electrical conductivity
selected from the group consisting of tin, indium and their alloys, and wherein
25 said metal powders are used in such amounts that during heating they form an
intermetallic phase at a melting temperature which is higher than that of the star-
ting metals, and wherein said organic auxiliary agents are volatilizable for the
most part at the temperature used for forming the intermetallic phase.
- 30 In contrast to the heretofore employed techniques, it has been found in the scope
of the present invention that electrically conductive metal pastes that contain only
a small amount of organic auxiliary agents and wherein the metal powders are se-
lected so that during heating they produce an intermetallic phase can be used for
producing electrically conductive connecting structures. The generally insufficient
35 adhesion of such metal pastes to substrates, and bases, respectively, is achieved
by an adhesive material which

1 application method of the metal paste. Further small amounts of thickeners, binders, natural resins such as colophonium and colophonium derivatives can be added to the metal pastes. A metal paste which is suitable under the present invention contains e.g. about 90 % by weight metal
5 powder and about 10 % by weight organic auxiliary agents.

The method for producing electrically conductive interconnecting structures according to the present invention comprises the steps of applying the adhesive material onto a substrate, applying the metal paste to the thus provided adhesive material and heating the metal paste or the thus obtained
10 arrangement at a temperature at which the metal powder forms an intermetallic phase.

Preferably, the adhesive material applied to the substrate is subjected to
15 thermal treatment prior to application of the metal paste, this thermal treatment, however, being dimensioned so that no or no complete curing of the adhesive material takes place. To this end it is expedient to first flash off the adhesive material at ambient temperature for an adequate time period for evaporating solvents, if any. Subsequently the thermal treatment is
20 made, e.g. at 80°C for about 20 minutes under laboratory conditions. Thereby, a dry, well processable surface of the adhesive material is obtained.

In a next step the previously described metal paste is applied to the dried
25 surface of the adhesive material. The application of the adhesive material and of the metal paste can be suitably made by means of a dispenser, a silk-screen process or any other printing method according to techniques which are known to the skilled man.

30 For finally producing a conductive interconnecting structure such as a circuit, the metal paste is heated so that the organic auxiliary agents evaporate for the most part and the metal particles are interconnected by soft solder, thereby producing intermetallic



New Claims

THIS SHEET HAS BEEN
REPLACED

- 1 1. A method of producing electrically conductive structures, comprising the steps of:
- (1) applying an adhesive material onto a substrate;
- (2) applying an electrically conductive metal paste containing at least two
- 5 metal powders having different melting points in a total amount of at least 85 % by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, metal powder activating substances and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of
- 10 good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the intermetallic phase, onto the thus provided adhesive material; and
- 15 (3) heating the thus obtained arrangement at a temperature at which said
- 20 metal powders form an intermetallic phase.
2. The method as set forth in claim 1, wherein said adhesive material is applied in the form of a circuit pattern for producing a circuit.
- 25 3. The method as set forth in claim 2, wherein the circuit pattern provided with the adhesive material and the metal paste is equipped with electric or electronic components prior to heating for producing an equipped circuit.
4. The method as set forth in any of claims 1 to 3, wherein the applied
- 30 adhesive material prior to application of the metal paste undergoes thermal treatment subject to the condition that the adhesive material is not or not completely cured during this process.
5. The method as set forth in at least one of claims 1 to 4, wherein the
- 35 application of the adhesive material and the metal paste is made by means of a dispenser, a silk-screen process or any other printing method.



THIS SHEET HAS BEEN
REPLACED

- 1 6. The method as set forth in at least one of claims 1 to 5, wherein the
 substrate is a plane circuit base.
7. An electrically conductive structure obtained according to the me-
5 thod set forth in at least one of claims 1 to 6.
8. A combination for producing electrically conductive structures, com-
 prising
 (A) an adhesive material; and
10 (B) an electrically conductive metal paste containing at least two metal
 powders having different melting points in a total amount of at least 85 %
 by weight and a small amount of organic auxiliary agents selected from vo-
 latile organic compounds, desoxidizing auxiliary agents, substances acti-
15 vating metal powders and additives controlling the viscosity, wherein said
 metal paste contains at least one metal powder of a metal of good electrical
 conductivity selected from the group consisting of gold, silver, copper and
 their alloys and at least one metal powder of a metal having a lower mel-
20 ting point than the metal of good electrical conductivity selected from the
 group consisting of tin, indium and their alloys, and wherein said metal
 powders are used in such amounts that during heating they form an inter-
 metallic phase at a melting temperature which is higher than that of the
 starting metals, and wherein said organic auxiliary agents are volatilizable
25 for the most part at the temperature used for forming the intermetallic
 phase.
9. The combination as set forth in claim 8, wherein the adhesive mate-
 rial is an anorganic or organic material.
10. The combination as set forth in claim 9, wherein the organic material
30 is a thermoplastic resin.
11. The combination as set forth in claim 9, wherein the organic material
 is an organic curable resin.
- 35 12. The combination as set forth in claim 11, wherein the curable resin
 is a one-component or two-component adhesive on the basis of epoxy re-
 sin.

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED

- 3 -

1 13. The combination as set forth in claim 8, wherein the metal having the lower melting point is selected from alloys of tin and/or indium with lead and/or antimony and/or zinc.

5 14. The combination as set forth in at least one of claims 8 to 13, wherein the metal paste contains a mixture of copper powder and a powder of the alloy 62Sn36Pb2Ag in a weight ratio of about 4:1 to about 1:1.

10 15. The combination as set forth in at least one of claims 8 to 14, wherein the metal powders have a mean particle size of from about 1 to 100 μm , preferably of from about 10 to 50 μm , more preferably of from about 20 to 30 μm .

15

20

25

30

35

This Sheet Has Been Replaced



THIS SHEET HAS BEEN
REPLACED

- 9 -

REPLACEMENT SHEET
14 SEP 1998

CLAIMS



- 5 1. A method of producing electrically conductive structures, comprising the steps of:
- (1) applying an adhesive material onto a substrate;
- (2) applying an electrically conductive metal paste containing at least 85% by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, metal powder activating substances and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the intermetallic phase, onto the thus provided adhesive material; and
- 10 20 (3) heating the thus obtained arrangement at a temperature at which said metal powders form an intermetallic phase having a melting temperature higher than that of the starting materials.
- 25 2. The method as set forth in claim 1, wherein said adhesive material is applied in the form of a circuit pattern for producing a circuit.
3. The method as set forth in claim 2, wherein circuit pattern provided with the adhesive material and the metal paste is equipped with electric or electronic components prior to heating for producing an equipped circuit.
- 30 4. The method as set forth in any of claims 1 to 3, wherein the applied adhesive material prior to application of the metal paste undergoes thermal treatment subject to the condition that the adhesive material is not or not completely cured during this process.
- 35

AMENDED SHEET

This Sheet Has Been Replaced





THIS SHEET HAS BEEN
REPLACED
- 10 -

REPLACEMENT SHEET

14 SEP 1998

5. The method as set forth in at least one of claims 1 to 4, wherein the application of the adhesive material and the metal paste is made by means of a dispenser, a silk-screen process or any other printing method.
6. The method as set forth in at least one of claims 1 to 5, wherein the substrate is a plane circuit base.
7. An electrically conductive structure obtained according to the method as set forth in at least one of claims 1 to 6.
8. A combination of producing electrically conductive structures, comprising:
- (A) an adhesive material which is first applied onto a substrate; and
- (B) an electrically conductive metal paste subsequently applied and containing at least two metal powders having different melting points in a total amount of at least 85% by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, substances activating metal powders and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the intermetallic phase.
9. The combination as set forth in claim 8, wherein the adhesive material is an inorganic or organic material.
10. The combination as set forth in claim 9, wherein the organic material is a thermoplastic resin.

This Sheet Has Been Replaced



AMENDED SHEET



THIS SHEET HAS BEEN
REPLACED

- 11 -

REPLACEMENT SHEET

14 SEP 1998

11. The combination as set forth in claim 9, wherein the organic material is an organic curable resin.

5

12. The combination as set forth in claim 11, wherein the curable resin is a one-component or two-component adhesive on the basis of epoxy resin.

10 13. The combination as set forth in claim 8, wherein the metal having the lower melting point is selected from alloys of tin and/or indium with lead and/or antimony and/or zinc.

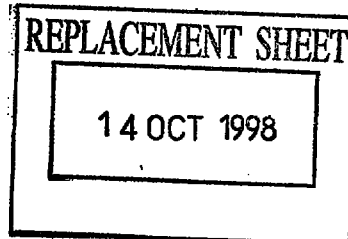
14. The combination as set forth in at least one of claims 8 to 13, wherein the metal paste contains a mixture of copper powder and a powder of the alloy
15 62Sn36Pb2Ag in a weight ratio of about 4:1 to about 1:1.

15. The combination as set forth in at least one of claims 8 to 14, wherein the metal powders have a mean particle size of about 1 to 100 μ m, more preferably of from about 20 to 30 μ m.

This Sheet Has Been Replaced



AMENDED SHEET



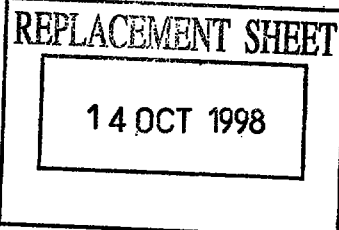
CLAIMS

- 5 1. A method of producing electrically conductive structures, comprising the steps of:
- (1) applying an adhesive material onto a substrate;
- (2) applying an electrically conductive metal paste containing at least two metal powders having different melting points in a total amount of at least 85% by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, metal powder activating substances and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the intermetallic phase, onto the thus provided adhesive material; and
- (3) heating the thus obtained arrangement at a temperature at which said metal powders form an intermetallic phase having a melting temperature higher than that of the starting materials.
- 25 2. The method as set forth in claim 1, wherein said adhesive material is applied in the form of a circuit pattern for producing a circuit.
3. The method as set forth in claim 2, wherein circuit pattern provided with the adhesive material and the metal paste is equipped with electric or electronic components prior to heating for producing an equipped circuit.
- 30 4. The method as set forth in any of claims 1 to 3, wherein the applied adhesive material prior to application of the metal paste undergoes thermal treatment subject to the condition that the adhesive material is not or not completely cured during this process.
- 35





- 10 -

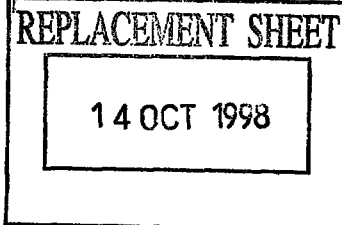


5. The method as set forth in at least one of claims 1 to 4, wherein the application of the adhesive material and the metal paste is made by means of a dispenser, a silk-screen process or any other printing method.
6. The method as set forth in at least one of claims 1 to 5, wherein the substrate is a plane circuit base.
7. An electrically conductive structure obtained according to the method as set forth in at least one of claims 1 to 6.
8. A combination of producing electrically conductive structures, comprising:
- (A) an adhesive material which is first applied onto a substrate; and
 - (B) an electrically conductive metal paste subsequently applied and containing at least two metal powders having different melting points in a total amount of at least 85% by weight and a small amount of organic auxiliary agents, selected from volatile organic compounds, desoxidizing auxiliary agents, substances activating metal powders and additives controlling the viscosity, wherein said metal paste contains at least one metal powder of a metal of good electrical conductivity selected from the group consisting of gold, silver, copper and their alloys, and at least one metal powder of a metal having a lower melting point than the metal of good electrical conductivity selected from the group consisting of tin, indium and their alloys, and wherein said metal powders are selected in such amounts that during heating they form an intermetallic phase at a melting temperature which is higher than that of the starting metals, and wherein said organic auxiliary agents are volatilizable for the most part at the temperature used for forming the intermetallic phase.
9. The combination as set forth in claim 8, wherein the adhesive material is an inorganic or organic material.
10. The combination as set forth in claim 9, wherein the organic material is a thermoplastic resin.

AMENDED SHEET



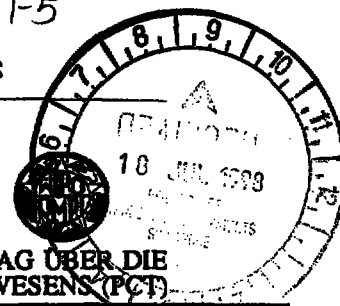
- 11 -



11. The combination as set forth in claim 9, wherein the organic material is an organic curable resin.
- 5
12. The combination as set forth in claim 11, wherein the curable resin is a one-component or two-component adhesive on the basis of epoxy resin.
13. The combination as set forth in claim 8, wherein the metal having the lower
- 10 melting point is selected from alloys of tin and/or indium with lead and/or antimony and/or zinc.
14. The combination as set forth in at least one of claims 8 to 13, wherein the metal paste contains a mixture of copper powder and a powder of the alloy
- 15 62Sn36Pb2Ag in a weight ratio of about 4:1 to about 1:1.
15. The combination as set forth in at least one of claims 8 to 14, wherein the metal powders have a mean particle size of about 1 to 100 μ m, more preferably of from about 20 to 30 μ m.

AMENDED SHEET

9705691-5

RTMP's
copy

PCT
WELTORGANISATION FÜR GEISTIGES EIGENTUM
Internationales Büro
**INTERNATIONALE ANMELDUNG VERÖFFENTLICHT NACH DEM VERTRAG ÜBER DIE
INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT)**

(51) Internationale Patentklassifikation ⁶ : H01R 4/04, H01B 1/22, H05K 3/10, 3/12	A1	(11) Internationale Veröffentlichungsnummer: WO 96/30966 (43) Internationales Veröffentlichungsdatum: 3. Oktober 1996 (03.10.96)
(21) Internationales Aktenzeichen: PCT/EP96/01373 (22) Internationales Anmeldedatum: 28. März 1996 (28.03.96) (30) Prioritätsdaten: 195 11 553.8 29. März 1995 (29.03.95) ✓ DE (71) Anmelder (für alle Bestimmungsstaaten ausser US): LIT- TON PRECISION PRODUCTS INTERNATIONAL, INC. [DE/DE]; Zweigniederlassung für Deutschland, Zweigw- erk Kester Solder, Ganghoferstrasse 45, D-82216 Gernlin- den (DE). (72) Erfinder; und (75) Erfinder/Anmelder (nur für US): LÄNTZSCH, Michael, K. [DE/DE]; Ludwig-Thoma-Strasse 4, D-82194 Gröbenzell (DE). NETZMANN, Helfried [DE/DE]; Ziegelbergstrasse 4b, D-86931 Prittriching (DE). (74) Anwalt: MERKLE, Gebhard; Ter Meer-Müller-Steinmeister & Partner, Mauerkircherstrasse 45, D-81679 München (DE). (81) Bestimmungsstaaten: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO Patent (KE, LS, MW, SD, SZ, UG), eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches Patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI Patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Veröffentlicht <i>Mit internationalem Recherchenbericht. Vor Ablauf der für Änderungen der Ansprüche zugelassenen Frist. Veröffentlichung wird wiederholt falls Änderungen eintreffen.</i>		
(54) Title: SYSTEM AND PROCESS FOR PRODUCING ELECTRICALLY CONDUCTIVE CONNECTING STRUCTURES AND A PROCESS FOR PRODUCING CIRCUITS AND PRINTED CIRCUITS (54) Bezeichnung: SYSTEM UND VERFAHREN ZUR ERZEUGUNG ELEKTRISCH LEITFÄHIGER VERBINDUNGSSTRUKTUREN SOWIE VERFAHREN ZUR HERSTELLUNG VON SCHALTUNGEN UND VON BESTÜCKTEN SCHALTUNGEN (57) Abstract The invention concerns a system for producing electrically conductive connecting structures comprising (A) an adhesive; and (B) an electrically conductive metal paste containing at least two metal powders of differing melting points and a small quantity of organic auxiliary agents. The metal powders are chosen to ensure that they form an intermetallic phase on heating and the organic auxiliary agents can be made largely to evaporate at the temperature applied in order to form the intermetallic phase. The invention also concerns a process for producing electrically conductive connecting structures using the system proposed, involving the following steps: (1) an adhesive is applied to a carrier; (2) the metal paste is applied to the adhesive; (3) the metal paste is heated to a temperature at which the metal powders form an intermetallic phase. Also disclosed are processes for producing circuits and printed circuits using this system. According to the invention, electrically conductive connecting structures such as circuits are obtained with excellent adhesion and good electrical conductivity and soldering qualities. (57) Zusammenfassung Die Erfindung beschreibt ein System zur Erzeugung elektrisch leitfähiger Verbindungsstrukturen, umfassend A) ein Klebstoffmaterial; und B) eine mindestens zwei Metallpulver mit unterschiedlichen Schmelzpunkten und eine geringe Menge organischer Hilfsstoffe enthaltende, elektrisch leitfähige Metallpaste, wobei die Metallpulver so gewählt sind, daß sie beim Erwärmen eine intermetallische Phase bilden und wobei die organischen Hilfsstoffe bei der zur Bildung der intermetallischen Phase angewandten Temperatur größtenteils verflüchtigbar sind; sowie ein Verfahren zur Erzeugung elektrisch leitfähiger Verbindungsstrukturen unter Verwendung dieses Systems, umfassend die Schritte: (1) Aufbringen des Klebstoffmaterials auf einen Träger; (2) Aufbringen der Metallpaste auf das so vorgesehene Klebstoffmaterial; und (3) Erhitzen der Metallpaste bei einer Temperatur, bei der die Metallpulver eine intermetallische Phase bilden. Die Erfindung beschreibt ebenfalls Verfahren zur Herstellung von Schaltungen und von bestückten Schaltungen unter Verwendung des obengenannten Systems. Erfindungsgemäß werden elektrisch leitfähige Verbindungsstrukturen, wie Schaltungen, mit ausgezeichneter Haftfähigkeit, guter elektrischer Leitfähigkeit sowie Lötbarkeit erhalten.		