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METAL PASTE AND THE USE THEREOF FOR JOINING STRUCTURAL ELEMENTS

DESCRIPTION

The present invention relates to a metal paste and a method for bonding structural elements in which this metal paste is used.

The bonding of components, such as LEDs or very thin silicon chips, which have a high pressure and temperature sensitivity, in the field of power and consumer electronics represents a particular challenge.

For this reason, such pressure and temperature sensitive components are often joined by adhesive bonding. However, the adhesive bonding technique has the disadvantage that the contact portions created between the components have insufficient thermal conductivity or electrical conductivity.

In order to solve this problem, the components to be bonded are frequently sintered. The sintering technique is a very simple method for the stable bonding of components.

One difficulty of the conventional sintering method is that the stable bonding of devices often does not succeed with reasonable reliability in the case of base metal contact surfaces, such as copper or aluminum. Presumably, oxide components on the base metal contact surfaces interfere with the formation of a reliable sintered connection.

The use of metal pastes in a sintering process for bonding structural elements in the field of power electronics are known. For example, WO2011/026623 A1 discloses a metal paste containing 75 to 90 wt.-% of at least one metal in the form of particles having a coating that contains at least one organic compound, 0 to 12 wt.-% of at least a metal precursor, 6 to 20 wt.-% of at least one solvent, and 0.1 to 15 wt.-% of at least one sintering aid, as well as the use of the metallic paste for the bonding of components by means of a sintering process.

The object of the invention is to provide a sintering method for the stable bonding of components. The contact points between the components to be bonded according to the method should be designed to have a low porosity and high electrical and thermal conductivity. In particular, the sintering process should be suitable for a stable bonding of construction elements with non-noble metal surfaces, for example, of copper or aluminum. Another object of the present invention is to provide a metal paste suitable for carrying out such a sintering method.

The invention relates to a method for bonding components, wherein (a) a sandwich structure is provided comprising at least (a1) a component 1, (a2) a component 2, and (a3) a metal paste located between component 1 and component 2, and (b) sintering the sandwich structure, wherein the metal paste (A) comprises 75 to 90 wt.-% of at least one metal in the form of particles having a coating containing at least one organic compound, and (B) comprises 6 to 20 wt.-% of organic solvent, characterized in that the metal paste further comprises (C) 2 to 10 wt.-% of at least one ammoniumtetrafluoroborate represented by the formula $(NHR1R2R3)^+(BF4)^-$, wherein the radicals R1, R2 and R3 are identical or different radicals selected from H (hydrogen) and hydrocarbon radicals, each having ≤12 carbon atoms.

The invention further relates to a metal paste comprising (A) 75 to 90 wt.-% of at least one metal in the form of particles having a coating containing at least one organic compound, and (B) 6 to 20 wt.-% of organic solvent, characterized in that the metal paste further comprises (C) 2 to 10 wt% of at least one ammoniumtetrafluoroborate represented by the formula $(NHR1R2R3)^+(BF4)^-$, wherein the radicals R1, R2 and R3 are identical or different radicals selected from H and hydrocarbon radicals, each having ≤12 carbon atoms.

The metal paste according to the invention contains 75 to 90 wt.-%, preferably 77-89 wt.-%, more preferably 78-87 wt.-% and still more preferably 78 to 86 wt.% of at least one metal present in the form of particles having a coating containing at least an organic compound. The weight information herein includes the weight of the coating compounds on the particles with one.

The term "metal" covers both pure metals and metal alloys.

In the context of the invention, the term "metal" refers to elements in the periodic table of elements in the same period as boron but left of boron, in the same period as silicon but left of silicon, in the same period as germanium but left of germanium, and in the same period as antimony but left of antimony, as well as all the elements having a higher atomic number than 55.

In the context of the invention, the term "pure metals" refers to metals having a purity of at least 95 wt.-%, preferably at least 98 wt.-%, more preferably at least 99 wt.-%, and even more preferably at least 99.9 wt.-%.

According to a preferred embodiment, the metal is copper, silver, gold, nickel, palladium, platinum or aluminum, in particular silver.

Suitable metal alloys are metallic mixtures comprising at least two components, of which at least one is a metal.

According to a preferred embodiment, an alloy containing copper, aluminum, nickel and/or noble metals is used as a metal alloy. The metal alloy preferably comprises at least one metal selected from the group consisting of copper, silver, gold, nickel, palladium, platinum, and aluminum. Particularly preferred metal alloys contain at least two metals selected from the group consisting of copper, silver, gold, nickel, palladium, platinum, and aluminum. It may further be preferred that the proportion of the metals which are selected from the group consisting of copper, silver, gold, nickel, palladium, platinum and aluminum, is present in the metal alloy by an amount of at least 90 wt.-%, preferably at least 95 wt.-%, more preferably at least 99 wt.-%, and still more preferably 100 wt.-%. The alloy may, for example, be an alloy containing copper and silver, copper, silver and gold, copper and gold, silver and gold, silver and palladium, platinum and palladium or nickel and palladium.

The metal paste according to the invention may comprise as the metal, a pure metal, a plurality of types of pure metals, one type of metal alloy, a plurality of types of metal alloys, or mixtures thereof.

The metal is present in the metal paste in the form of particles.

The metal particles may be of different shape. For example, the metal particles may have the form of flakes or spherical (spheroidal) shape. According to a particularly preferred embodiment, the metal particles are in the form of flakes. However, this does not exclude that a minor portion may have a different shape among the metal particles used. However, it is preferred that at least 70 wt.-%, more preferably at least 80 wt.-%, still more preferably at least 90 wt.-% or 100 wt.-% of the particles are present in the form of flakes.

The metal particles are coated.

The term "coating of particles" is understood to mean an adherent layer on the surface of particles.

The coating of the metal particles contains at least one type of coating compound.

These coating compounds are organic compounds.

The organic compounds serving as coating compounds are carbonaceous compounds, which prevent agglomeration of the metal particles.

According to a preferred embodiment, the coating compounds comprise at least one functional group. Suitable functional groups include, in particular, carboxylic acid groups, carboxylate groups, ester groups, keto groups, aldehyde groups, amino groups, amide groups, azo groups, imide groups or nitrile groups. Preferred functional groups are carboxylic acid groups and carboxylic acid ester groups. The carboxylic acid group may be deprotonated.

The coating compounds having at least one functional group are preferably saturated, monounsaturated or polyunsaturated organic compounds.

Those coating compounds having at least one functional group may also be branched or unbranched.

The coating compounds containing at least one functional group preferably have 1 to 50, more preferably 2 to 24, even more preferably 6 to 24, and still more preferably 8 to 20 carbon atoms.

The coating compounds may be ionic or nonionic.

Preferably, free fatty acids, fatty acid salts or fatty acid esters are used as coating compounds.

The free fatty acids, fatty acid salts and fatty acid esters are preferably unbranched.

Furthermore, the free fatty acids, fatty acid salts or fatty acid esters are preferably saturated.

Preferred fatty acid salts are the salts of ammonium, monoalkylammonium, dialkylammonium, trialkylammonium, aluminum, copper, lithium, sodium and potassium.

Preferred esters are alkyl esters, especially methyl esters, ethyl esters, propyl esters and butyl esters.

According to a preferred embodiment, the free fatty acids, fatty acid salts or fatty acid esters are compounds having 8 to 24, more preferably 8 to 18 carbon atoms.

Preferred coating compounds are caprylic (octanoic), capric acid (decanoic), lauric acid (dodecanoic), myristic (myristic), palmitic (hexadecanoic), margarinic (heptadecanoic), stearic acid (octadecanoic), arachidic (eicosanoic/icosansäure), behenic (docosanoic), lignoceric (tetracosanoic), as well as the corresponding esters and salts.

Particularly preferred coating compounds are dodecanoic, octadecanoic, aluminum, copper stearate, sodium stearate, potassium stearate, sodium palmitate and potassium palmitate.

The coating compounds may be applied to the surface of the metal particles by means of conventional and known prior art methods.

For example, it is possible for the coating compounds, in particular the above-mentioned stearates or palmitates, to be suspended in solvents, and for the coating compounds in suspension to be ground with the metal particles in ball mills. After grinding, the metal particles coated with the coating compounds are dried and then dusted.

Preferably, the proportion of organic compounds, in particular the proportion of compounds selected from the group consisting of free fatty acids, fatty acid salts and fatty acid esters, represent at least 60 wt.-%, more preferably at least 70 wt.-% , even more preferably at least 80 wt.-%, still more preferably at least 90 wt.-%, in particular at least 95 wt.-%, at least 99 wt.-% or 100 wt.-%, with respect to the entire coating.

Usually, the proportion of coating compounds, preferably the coating compounds which are selected from the group consisting of free fatty acids, fatty acid salts and fatty acid esters represent 0.01 to 2 wt.-%, preferably 0.3 to 1.5 wt.-% , based on the weight of the coated metal particles.

The degree of coating, which is defined as the ratio of the mass of coating compounds to the surface of the metal particles, is preferably from 0.00005 to 0.03 g, more preferably 0.0001 to 0.02 g of coating compounds per square meter (m^2) of the surface of the metal particles.

The metal paste according to the invention contains 6 to 20 wt.-%, preferably 7 to 18 wt.-%, more preferably 8 to 17 wt.-%, and still more preferably 10 to 15 wt.-% of organic solvents (B), i.e. an organic solvent or a mixture of at least two organic solvents.

The organic solvent(s) is/are organic solvent(s) commonly used for metal pastes. Examples include terpineols, N-methyl-2-pyrrolidone, ethylene glycol, dimethylacetamide, 1-tridecanol, 2-tridecanol, 3-tridecanol, 4-tridecanol, 5-tridecanol, 6-tridecanol, isotridecanol, with the exception of a methyl subsitution for the penultimate C atom unsubstituted 1-hydroxy-C16-C20-alkane, such as 16-methyl heptadecan-1-oil, dibasic esters (preferably dimethyl esters of glutaric, adipic or succinic acid or mixtures thereof), glycerol, diethylene glycol, triethylene glycol, and aliphatic, in particular saturated aliphatic hydrocarbons having 5 to 32 carbon atoms, more preferably 10 to 25 carbon atoms, and even more preferably 16 to 20 carbon atoms. Such aliphatic hydrocarbons are sold for example by Exxon Mobil under the tradename Exxsol™ 0140 or the brand Isopar M™.

It is essential according to the invention that the metal paste comprises 2 to 10 wt.-%, preferably 3 to 8 wt.-%, of at least one ammoniumtetrafluoroborate (C) of the formula $(NHR1R2R3)^{+}(BF4)^{-}$, where the radicals R1, R2 and R3 are identical or different radicals selected from H and hydrocarbon radicals each having ≤12, preferably 1 to 8, especially 1 to 4 carbon atoms. The hydrocarbon radicals are, in particular, aliphatic hydrocarbon radicals, especially alkyl radicals.

Therefore mono-, di- or tri-alkyl ammonium tetrafluoroborate are preferred. Pure inorganic ammonium tetrafluoroborate NH_4BF_4 is particularly preferred.

NH_4BF_4 is particularly preferably used as the only ammonium tetrafluoroborate, in particular in a proportion of 2 to 8 wt.-%, especially 3 to 7 wt.-%, based on an application-ready metal paste according to the invention.

The metal paste according to the invention may contain 0 to 12 wt.-%, preferably 0.1 to 12 wt.-%, more preferably 1 to 10 wt.-% and still more preferably 2 to 8 wt.-%, of at least one metal precursor (D).

In the context of the invention, the term "metal precursor" is understood to mean a compound containing at least one metal. Preferably, this is a compound which decomposes at temperatures below 200 °C in order to release a metal. Preferably, therefore, a metal is formed in situ using a metal precursor in the sintering process. It may be determined in a simple manner whether the metal precursor is a compound. For example, a paste that contains a compound to be tested is deposited on a substrate having a silver surface, heated to 200 °C, and kept at this temperature for 20 minutes. Thereafter, it is checked whether or not, under these conditions, the compound to be tested has decomposed to a metal. For example, the content of the metal-containing paste components may be weighed before the test, and the theoretical mass of metal calculated from this.

After the test, the mass of material deposited on the substrate is determined gravimetrically. If the mass of material deposited on the substrate corresponds to the theoretical mass of the metal, with the usual measurement errors being taken into account, the tested compound is a metal precursor.

According to a preferred embodiment, the metal precursor is an endothermic decomposable metal precursor. The term "endothermic decomposable metal precursor" is understood to mean a metal precursor whose thermal decomposition represents an endothermic process, preferably under an inert gas atmosphere.

This thermal decomposition should lead to the release of metal from the metal precursor.

According to a further preferred embodiment, the metal precursor comprises a metal that is also included in the particulate metal (A).

Preferably, the metal precursor comprises as the metal, at least one element selected from the group consisting of copper, silver, gold, nickel, palladium and platinum.

It may be preferred to use as the metal precursor, endothermically decomposable carbonates, lactates, formates, citrates, oxides, or salts of fatty acids, preferably fatty acid salts having 6 to 24 carbon atoms, of the metals mentioned.

In particular embodiments, silver carbonate, silver(I)lactate, silver(II)formate, silver citrate, silver (for example, AgO or Ag_2O), copper(II)lactate, copper stearate, copper oxides (for example, CU_2O or CuO) or gold oxides (for example, AU_2O or AuO) is used as the metal precursor

According to a particularly preferred embodiment, silver carbonate, silver(I)oxide or silver(II)oxide is used as the metal precursor. If present, the metal precursor is preferably in the form of particles in the metal paste.

The metal precursor particles may take the form of flakes or spherical (spheroidal) shape. Preferably, the particles of the metal precursor are in the form of flakes.

Furthermore, the metal paste according to the invention may contain 0 to 10 wt.-%, preferably 0 to 8 wt.-%, of at least one sintering aid (E). Examples of sintering aids are organic peroxides, inorganic peroxides and inorganic acids, for example as described in WO2011/026623 A1.

The metal paste according to the invention may, in addition to the above-described components (A) to (E), contain 0 to 15 wt.-%, preferably 0 to 12 wt.-%, more preferably 0.1 to 10 wt.-% of one or more other components (F). These other components may preferably be components commonly used in metal pastes. For example, further components that may be contained in the metal paste are dispersants, surfactants, defoamers, binders, polymers such as cellulose derivatives, for example methylcellulose, ethylcellulose, ethylmethylcellulose, carboxy cellulose, hydroxypropyl cellulose, hydroxyethylcellulose, hydroxymethylcellulose, and/or viscosity controlling agents.

The sum of the wt.-% of the components (A) to (F) is, for example, 100 wt.%, based on the metal paste according to the invention, i.e. prior to their application. Accordingly, the preparation of the metal paste according to the invention may be carried out by mixing the ingredients (A) to (F). Accordingly, conventional devices known to the person skilled in the art may be used, for example, mixers and three roll mills.

The metal paste according to the invention may be used as sintering paste, i.e. used in a sintering process. The term "sintering" is understood to mean the bonding of two or more components by heating, while avoiding the metal particles (A) reaching the liquid phase.

By using the method with the metal paste according to the invention, the sintering process may be carried out under pressure or without pressure. Carrying out the sintering process without pressure means that a sufficiently firm bonding between the components is achieved despite the lack of the application of pressure. The possibility of carrying out the sintering process without pressure allows us to use pressure-sensitive components in the sintering process, such as fragile components or components that are mechanically sensitive in their structure. Mechanically sensitive electronic components suffer electrical malfunctions in their bonding in the event of inappropriate pressure.

The term "bonding of at least two components" is understood to mean the fastening of a first component on a second component. In this context, "on" only means that a surface of the first component is bonded to a surface of the second component, wherein it does not depend on the relative position of the two components or the arrangement that comprises the at least two components.

In the context of the invention, the term "component" preferably refers to items. These items are preferably not further decomposable.

According to particular embodiments, "components" refer to parts that are used in electronics.

Accordingly, in the components may be, for example, diodes, LEDs (light emitting diodes), DCB (Direct Copper Bonded) substrates, leadframes, dice, IGBT (insulated-gate bipolar transistors), IC (integrated circuits), sensors, heat sink (preferably aluminum heat sink or copper heat sink) or other passive components (such as resistors, capacitors or coils).

The components to be bonded may be the same or different components.

Embodiments of the invention relate to the combination of LED with lead frame, of LED with a ceramic substrate, of dice, diodes, IGBT or IC with leadframes, ceramic substrates or DCB substrates, of sensor with lead frame or ceramic substrate. In addition, the bonding of noble metal contact surfaces according to the present invention enables, in particular, the production of reliable bonding at room temperature and at higher temperatures between a base and a noble metal, or even between two base contact surfaces. The bonding may, for example, be between aluminum, copper or silver contact surfaces of the electronic components and aluminum, copper or silver contact surfaces of the substrates, i.e. there may be bonding, for example, of aluminum-copper, aluminum-silver, aluminum-aluminum, copper-silver, copper-copper or silver-silver.

The components, comprising for example at least one of the components 1 and 2, insofar as not without one metal, may comprise a metal contact surface, in the form of a metallization layer, in particular a metal contact surface of a base metal such as copper or aluminum, wherein the previously mentioned sandwich arrangement results in the context of the method according to the invention.

This metallization layer is preferably part of the component. The metallization layer is preferably located on at least one surface of the component.

Preferably, the bonding of the components is carried out by means of the inventive metal paste on the said metallization layer(s).

The metallization layer may comprise a pure metal. Thus, it may be preferred if the metallization layer contains at least 50 wt.-%, more preferably at least 70 wt.-%, still more preferably at least 90 wt.-%, or 100 wt.-%, of pure metal. The pure metal is selected, for example, from the group consisting of aluminum, copper, silver, gold, palladium and platinum.

A particular advantage of the present invention is that the pure metal may be a non-noble metal such as aluminum or copper.

On the other hand, the metallization layer may also comprise an alloy. The alloy of the metallization layer preferably contains at least one metal selected from the group consisting of aluminum, silver, copper, gold, nickel, palladium and platinum.

The metallization layer may also have a multilayer structure. Thus, for example, it may be preferred if at least one surface of the components to be bonded comprises a metallization layer consisting of several layers, which have the above-mentioned pure metals and/or alloys.

In the method according to the invention, at least two components are bonded to one another by sintering.

To do this, the two or more components are brought into contact with each other. The contacting takes place via the metal paste according to the invention. To this end, an arrangement is provided, wherein the metal paste according to the invention is respectively located between two of the at least two components.

If, therefore, two components, component 1 and component 2, are to be bonded to one another, then the metal paste according to the invention is located between component 1 and component 2 before sintering. On the other hand, it is conceivable that more than two components are to be bonded to one another. For example, three components, component 1, component 2 and component 3, are bonded together in such a manner that component 2 is located between component 1 and component 3. In this case, the metal paste according to the invention is both between component 1 and component 2, as well as between component 2 and component 3.

The individual components are present in a sandwich arrangement and are interconnected. By the term "sandwich" is to be understood an arrangement wherein two components are superimposed and the components are arranged substantially parallel to one another.

The arrangement of at least two components and the metal paste according to the invention, wherein the metal paste is located between two components of this arrangement, may be produced by a method known from the prior art.

Preferably, a surface of a component 1 is at least first provided with the metal paste according to the invention. Subsequently, one of the surfaces of another component 2 is placed on the metal paste that has been applied to the surface of component 1.

The application of the metal paste according to the invention onto the surface of a component may be carried out by conventional methods, for example by means of printing processes such as screen printing or stencil printing. On the other hand, the application of the metal paste according to the invention may also be effected by means of a dispensing technique, pin transfer or by dipping.

Following the application of the metal paste according to the invention, the surface of this component provided with the metal paste is preferably brought into contact with a surface of the component to be bonded therewith via the metal paste. Thus, a layer of metal paste according to the invention is located between the components to be bonded.

The wet film thickness between the components to be bonded is preferably in the range of 20 to 100 µm. By the term "wet layer thickness" is to be understood the distance between the facing surfaces of the components to be connected before a possible drying and sintering. The preferred wet film thickness depends on the method selected to apply the metal paste.

If the metal paste is applied, for example, by means of screen printing then a wet layer thickness of 20 to 50 µm may be preferred. If the application of the metal paste is effected by means of stencil printing, then the preferred wet film thickness may be in the range of 20 to 100 µm. When using the dispensing technique, the preferred wet film thickness may range from 20 to 100 µm.

Optionally, a drying step may be carried out prior to sintering, i.e. the removal of organic solvent from the applied metal paste. According to a preferred embodiment, the proportion of organic solvent in the metal paste after drying is, for example, 0 to 5 wt.-%, based on the initial content of organic solvent in the metal paste according to the invention, i.e. the application-ready metal paste. In other words, according to this preferred embodiment, for example, 95 to 100 wt.-% of the organic solvent originally contained in the metal paste according to the invention is extracted during the drying process.

If a drying is implemented, then the drying in the case of sintering without pressure may take place after the production of the arrangement, i.e. after the contacting of the components to be bonded. In the case of sintering under pressure, the drying may be carried out on the at least one surface of the component and prior to contacting with the component to be bonded, even after the application of the metal paste.

The drying temperature is preferably in the range of 100 to 150 °C.

It is understood that the drying time is a function of the composition of the metal paste according to the invention and the size of the bonding surface of the assembly to be sintered. The usual drying times are in the range of 5 to 45 minutes.

The arrangement of the at least two components and the metal paste located between the components is finally subjected to a sintering process.

The actual sintering is carried out at a temperature of, for example, 200 to 280 °C, either as a process without pressure or as sintering under pressure.

In the case of sintering under pressure, the process pressure is preferably below 30 MPa and more preferably below 5 MPa. For example, the process pressure lies in the range of 1 to 30 Mpa, and more preferably in the range of 1 to 5 MPa.

The sintering time lies, for example in the range of 2 to 60 minutes, while in the case of sintering under pressure, it lies, for example, in the range of 2 to 5 minutes, and in the case of sintering without pressure, it lies, for example in the range of 30 to 60 minutes.

The sintering process may be carried out in an atmosphere which is not particularly subject to restrictions. Thus, on the one hand, the sintering may be carried out in an atmosphere containing oxygen. On the other hand, it is also possible to perform the sintering in an oxygen-free atmosphere. By the term "oxygen-free atmosphere" in the context of the invention, is to be understood an atmosphere, whose oxygen content is not more than 10 ppm, preferably not more than 1 ppm, and even more preferably not more than 0.1 ppm.

Sintering is carried out in a conventional apparatus that is suitable for sintering in which the process parameters described above may be set.

The invention is illustrated hereinafter by means of examples, which, however, should not be construed as limiting.

Examples:

1. Production of metal pastes:

First metal pastes 1 to 4 according to the invention and the comparison pastes 5 to 7 were made by mixing the individual components in accordance with the following table. All amounts are wt.-%.

	Paste 1	Paste 2	Paste 3	Paste 4	Paste 5	Paste 6	Paste 7
Silver particles[1]	85	80.3	80.3	80.3	85	84.3	84.5
Silver carbonate		5		5		5	5
Ag_2O			4				
NH_4BF_4	6	4	3	3			
Exxsol™ D140		6				6	
Terpineol	4.5	4.4	4	3.5	7.5	4.4	3
Adipic dimethyl ester			8.5	8			7.3
Tridecanol	4.5				7.5		
Ethylcellulose		0.3	0.2	0.2		0.3	0.2
Total	100	100	100	100	100	100	100

[1] silver flakes having an average particle diameter (d50) of 4.50 µm and a coating of 0.7 wt.-% octane acid/stearic acid (weight ratio 1:1)

2. Application and sintering of metal pastes without pressure:

The respective metal paste was applied by means of dispensing on the aluminum surface of a DBA (direct bonded aluminum) substrate in a wet layer thickness of 50 µm. Then, the applied metal paste was brought into contact without prior drying with a silicon chip with a silver contact face (4.8 mm²). The subsequent sintering without pressure was performed according to the following warm-up profile: the contact part was continuously heated to 200 °C within 60 minutes, and held at 200 °C for 30 minutes. Subsequently, the temperature was increased continuously to 280 °C within 15 minutes, and held there for 60 minutes. Then it was cooled continuously to 30 °C within 60 minutes.

After sintering, the adhesiveness was determined via the shear strength. The components were sheared with a shearing chisel at a speed of 0.3 mm/s at 260 °C. The force was recorded by means of a load cell (DAGE 2000 apparatus from DAGE, Germany). Table 2 shows the results obtained with the metal pastes 1-7.

Table 2:

Paste	1	2	3	4	5	6	7
Shear strength at 260 °C (N/mm²)	5.6	6.8	6.4	6.9	0	1.2	2.1

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FÉMPASZTA, ÉS ALKALMAZÁSA ALKOTÓRÉSZEK EGYESÍTÉSÉHEZ

SZABADALMI IGÉNYPONTOK

1. Fémpaszta, amely tartalmaz: (A) legalább egy fémet 75-90 tömeg %-ban, amely részecskék (particle) formájában van jelen, ahol ezek tartalmaznak egy olyan bevonatot (coating), amely tartalmaz legalább egy szerves vegyületet; és (B) 6-20 tömeg % szerves oldószert, **azzal jellemezve, hogy** a fémpaszta tartalmaz továbbá (C) 2-10 tömeg % legalább egy ammónium-tetrafluor-borátot, amelyet az $(NHR1R2R3)^+(BF_4)^-$ általános képlet jellemez, ahol az R1, R2 és R3 gyökök jelentése azonos vagy különböző, és a következők közül választható ki: H, és szénhidrogén gyökök, amelyek ≤ 12 szénatommal bírnak.

2. Az 1. igénypont szerinti fémpaszta, ahol a legalább egy fém a következők közül választható ki: réz, ezüst, arany, nikkel, palládium, platina és alumínium.

3. Az 1. vagy 2. igénypont szerinti fémpaszta, ahol a fémrészecskék pehely-alakú (flake-shaped) fémrészecskék.

4. Az 1-3. igénypontok bármelyike szerinti fémpaszta, ahol a legalább egy szerves vegyület a következők közül választható ki: szabad zsírsavak, zsírsav-sók és zsírsav-észterek.

5. Az 1-4. igénypontok bármelyike szerinti fémpaszta, ahol a szénhidrogén gyök vagy gyökök alkil-gyökök.

6. Az 1-5. igénypontok bármelyike szerinti fémpaszta, ahol a (C) pont szerinti legalább egy ammónium-tetrafluor-borát tartalmaz NH_4BF_4-et.

7. A 6. igénypont szerinti fémpaszta, amely tartalmaz NH_4BF_4-et, mint egyedüli (C) pont szerinti ammónium-tetrafluor-borátot.

8. Az 1-7. igénypontok bármelyike szerinti fémpaszta, amely tartalmaz, az (A) és (C) alkotórészek mellett, 0-12 tömeg % legalább egy fém prekurzort (D), 0-10 tömeg % legalább egy zsugorodást segítő anyagot (sintering aid) (E), és 0-15 tömeg % egyéb alkotórészt (F), amely a következők közül választható ki: diszpergáló szerek, felületaktív anyagok (surfactant), habmentesítő (de-foaming) szerek, kötő (binding) szerek, polimerek, és/vagy viszkozitást szabályozó (reológiai) szerek [viscosity-controlling (rheological) agent].

9. Eljárás alkotórészek (component) összekötésére (connect), amely a következő lépéseket tartalmazza: (a) szolgáltatunk egy szendvics elrendezést, amely tartalmaz legalább egy (a1) 1. alkotórészt, (a2) 2. alkotórészt és (a3) fémpasztát, amely az 1-8. igénypontok bármelyike szerinti fémpaszta, ahol ez utóbbi az 1. alkotórész és a 2. alkotórész között helyezkedik el, és (b) zsugorítjuk (sinter) a szendvics elrendezést.

10. A 9. igénypont szerinti eljárás, ahol a legalább egy 1. alkotórész és 2. alkotórész tartalmaz egy alumínium érintkező felületet (contact surface) vagy réz érintkező felületet, amelynek segítségével hajtjuk végre a szendvics elrendezést.

11. A 9. vagy 10. igénypont szerinti eljárás, ahol a zsugorítási folyamat úgy megy végbe, hogy vagy alkalmazunk nyomást, vagy nem alkalmazunk nyomást.

12. A 9-11. igénypontok bármelyike szerinti eljárás, ahol az alkotórészek olyan részek, amelyek az elektronikában használatosak.

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