Claims

1. An electroconductive paste comprising:

50–90 wt. % of a copper ~~particle~~component comprising at least two types of copper particles each having different median particle diameters d_{50};

0.5–10 wt. % of a glass frit;

0.1–5% wt. % of adhesion promoter, which is at least one selected member from the group consisting of cuprous oxide, titanium oxide, zirconium oxide, boron resinate, zirconium resinate, amorphous boron, lithium phosphate, bismuth oxide, aluminum oxide, and zinc oxide; and

5–20 wt. % of an organic vehicle.

2. An electroconductive paste comprising:

50–90 wt. % of a copper particle;

0.5–1.5 wt. % of a glass frit;

0.1–5% wt. % of adhesion promoter, which is at least one selected member from the group consisting of cuprous oxide, titanium oxide, zirconium oxide, boron resinate, zirconium resinate, amorphous boron, lithium phosphate, bismuth oxide, aluminum oxide, and zinc oxide; and

5–20 wt. % of an organic vehicle.

~~2.~~3. The electroconductive paste according to claim 1 or 2, wherein the copper particle comprises at least one of:

a first copper particle having a median particle diameter (d_{50}) of about 2.0–2.9 μm, preferably about 2.5 μm;

a second copper particle having a median particle diameter (d_{50}) of about 3.0–3.9 μm, preferably about 3.5 μm; and

a third copper particle having a median particle diameter (d_{50}) of about 4.0–4.9 μm, preferably about 4.5 μm.

~~3.~~4. The electroconductive paste according to any one of the preceding claims ~~1 or 2~~, wherein the first copper particle has a specific surface area of about 0.25–0.5 m^2/g.

~~4.~~5. The electroconductive paste according to any of the preceding claims, wherein the second copper particle has a specific surface area of about 0.25–0.75 m^2/g.

~~5.~~6. The electroconductive paste according to any of the preceding claims, wherein the third copper particle has a specific surface area of about 0.25–0.50 m^2/g.

~~6.~~7. The electroconductive paste according to any of the preceding claims, wherein the first copper particle is about 45 to about 65 wt. % of the electroconductive paste.

~~7.~~8. The electroconductive paste according to any of the preceding claims, wherein the second copper particle is about 15 to about 30 wt. % of the electroconductive paste.

~~8.~~9. The electroconductive paste according to any of the preceding claims, wherein the third copper particle is about 5 to about 15 wt. % of the electroconductive paste.

~~9.~~10. The electroconductive paste according to any of the preceding claims, wherein the glass frit comprises about 45–65% Bi_2O_3, 25–45% SiO_2, and 1–15% B_2O_3, preferably 50–60% Bi_2O_3, 30–40% SiO_2, and 1–10% B_2O_3, most preferably 55–60% Bi_2O_3, 35–40% SiO_2, and 5–10% B_2O_3.

~~10.~~11. The electroconductive paste ~~of~~ according to any of ~~the preceding~~ claims 1 or 3-10, wherein the glass frit is about 0.5 to about 5 wt. % of the electroconductive paste, more preferably about 0.5 to about 1.5 wt. % of the electroconductive paste.

~~11.~~12. The electroconductive paste according to any of the preceding claims, wherein the adhesion promoter is bismuth oxide.

~~12.~~13. The electroconductive paste according to any of the preceding claims, further comprising about 0.5 to about 3 wt. % copper oxide.

~~13.~~14. An article comprising:

(a) an aluminum nitride substrate; and

(b) an electroconductive electrode comprising an electroconductive paste according to any of the preceding claims.

~~14.~~15. A method of forming an electroconductive circuit comprising:

(i) depositing a first layer of base layer electroconductive paste according to any of claims 1-~~12~~13 on an aluminum nitride substrate;

(ii) drying the aluminum nitride substrate with the deposited base layer electroconductive paste at a temperature at about 100°C to about 125°C for about 5 to about 10 minutes;

(iii) subjecting the deposited base layer electroconductive paste and the aluminum nitride substrate to a temperature of about 900°C to about 1000°C in a nitrogen atmosphere comprising from about 1 to about 20 ppm oxygen;

(iv) depositing a second layer of a top layer electroconductive paste according to any of claims 1-~~12~~13 on the substrate;

(v) drying the aluminum nitride substrate with the deposited top layer electroconductive paste at a temperature at about 100°C to about 125°C for about 5 to about 10 minutes; and

(vi) subjecting the deposited layers and the aluminum nitride substrate to a temperature of about 900°C to about 1000°C in a nitrogen atmosphere comprising from about 1 to about 20 ppm oxygen.

~~15.~~16. The method according to claim ~~14~~15, wherein steps (iv) – (vi) are repeated 1–10 times.

~~16.~~17. The method according to claims ~~14~~15 or ~~15~~16, wherein the base layer electroconductive paste comprises from about 1 to about 5 wt. % of adhesion promoter, preferably from about 2 to about 4 wt. %, more preferably about 3 wt. % of adhesion promoter.

~~17.~~18. The method according to any of claims ~~14~~15-~~16~~17, wherein the top layer electroconductive paste comprises from about 0.25 to about 1.25 wt. % of adhesion promoter, preferably from about 0.75 to about 1.25 wt. %, more preferably about 1 wt. % of adhesion promoter.

~~18.~~19. The method according to any of claims ~~14~~15-~~17~~18, wherein the adhesion promoter is bismuth oxide.

~~19.~~20. The method according to any of claims ~~14~~15-~~18~~19, wherein the nitrogen atmosphere comprises from about 1 to about 10 ppm oxygen, preferably from about 1 to about 3 ppm oxygen.

~~20.~~21. The method according to any of claims ~~14~~15-~~19~~20, wherein the step of subjecting the deposited base layer electroconductive paste to a temperature, and the step of subjecting the deposited layers to a temperature, includes heating from room temperature to about 950˚C for about 5 to about 10 minutes and then cooling to room temperature.