CLAIMS

1. A paste-like adhesive composition comprising:

metal particles (A); and

a thermally polymerizable compound (B),

wherein the metal particles (A) form a particle coupling structure by causing sintering through a thermal treatment,

when dynamic viscoelasticity of the composition is measured under a condition of a measurement frequency of 1 Hz, within a temperature region of 140°C to 180°C, the composition has a temperature width of equal to or larger than 10°C in which a shear modulus of elasticity is equal to or higher than 5,000 Pa and equal to or lower than 100,000 Pa, and

an acetone insoluble fraction of a sample, which is obtained by removing the metal particles (A) and then heating the composition under conditions of 180°C and 2 hours, is equal to or lower than 5% by weight.

2. The paste-like adhesive composition according to claim 1,

wherein in a case where the composition is formed into a coating film by performing coating, and the coating film is heated to 250°C from 25°C at a heating rate of 5°C/min and then heated under conditions of 250°C and 2 hours, the obtained film has a thermal conductivity of equal to or higher than 15 W/mK in a thickness direction.

3. The paste-like adhesive composition according to claim 1 or 2,

wherein in a case where the composition is formed into a coating film by performing coating, and the coating film is heated to 250°C

from 25°C at a heating rate of 5°C/min and then heated under conditions of 250°C and 2 hours, the obtained film has a volume resistivity of equal to or lower than 25 x 10^{-6} Ω·cm in a surface direction.

4. The paste-like adhesive composition according to any one of claims 1 to 3,

wherein a content of the metal particles (A) with respect to a total amount of the paste-like adhesive composition is equal to or greater than 80% by weight and equal to or less than 95% by weight.

5. The paste-like adhesive composition according to any one of claims 1 to 4,

wherein the compound (B) contains a compound having only one radically polymerizable double bond in a molecule.

6. The paste-like adhesive composition according to any one of claims 1 to 5,

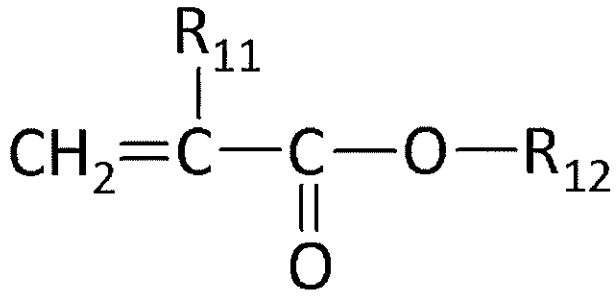
wherein the compound (B) contains a compound having a (meth)acryl group.

7. The paste-like adhesive composition according to any one of claims 1 to 6,

wherein the compound (B) contains a (meth)acrylic acid ester.

8. The paste-like adhesive composition according to claim 7,

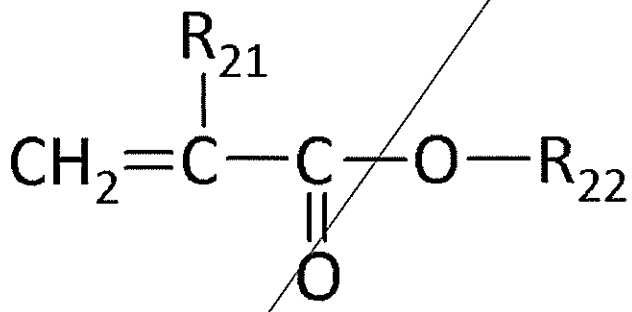
wherein the (meth)acrylic acid ester contains a compound represented by Formula (1),



(1)

(in Formula (1), R_{11} represents hydrogen or a methyl group, and R_{12} represents a monovalent organic group which contains an OH group and has 1 to 20 carbon atoms).

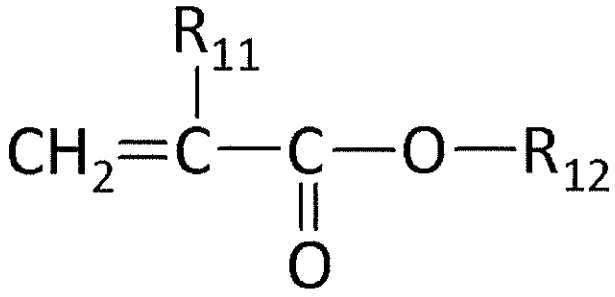
9. The paste-like adhesive composition according to claim 7 or 8, wherein the (meth)acrylic acid ester contains a compound represented by Formula (2),



(2)

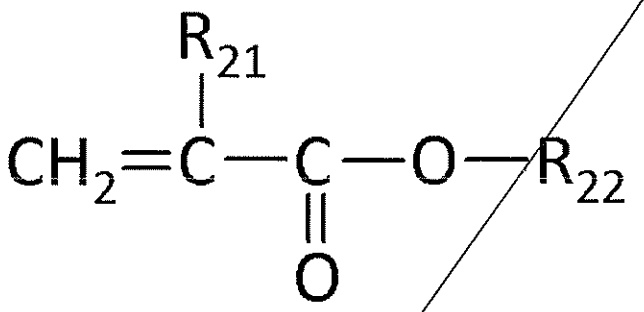
(in Formula (2), R_{21} represents hydrogen or a methyl group, and R_{22} represents a monovalent organic group which does not contain an OH group and has 1 to 20 carbon atoms).

10. The paste-like adhesive composition according to claim 7, wherein the (meth)acrylic acid ester contains the compound represented by Formula (1) and the compound represented by Formula (2),



(1)

(in Formula (1), R_{11} represents hydrogen or a methyl group, and R_{12} represents a monovalent organic group which contains an OH group and has 1 to 20 carbon atoms),



(2)

(in Formula (2), R_{21} represents hydrogen or a methyl group, and R_{22} represents a monovalent organic group which does not contain an OH group and has 1 to 20 carbon atoms).

11. The paste-like adhesive composition according to any one of claims 1 to 10,

wherein the compound (B) contains a compound having only one epoxy group in a molecule.

12. The paste-like adhesive composition according to any one of claims 1 to 11, further comprising:

a compound having a tertiary amino group.

13. The paste-like adhesive composition according to any one of claims 1 to 12,

wherein a temperature at 5% weight loss of the composition is equal to or higher than 100°C and equal to or lower than 180°C.

14. The paste-like adhesive composition according to any one of claims 1 to 13,

wherein the metal particles (A) contain one kind of metal or two or more kinds of metals selected from the group consisting of Ag, Au, and Cu.

15. The paste-like adhesive composition according to any one of claims 1 to 14,

wherein the metal particles (A) contain spherical particles.

16. The paste-like adhesive composition according to any one of claims 1 to 15,

wherein a mean particle size D_{50} of the metal particles (A) is equal to or greater than 0.1 μm.

17. A semiconductor device comprising:

a substrate; and

a semiconductor element mounted on the substrate through an adhesive layer obtained by performing a thermal treatment on the paste-like adhesive composition according to any one of claims 1 to 16.

18. The semiconductor device according to claim 17,

wherein a planar shape of the semiconductor element is a rectangle having a side equal to or longer than 5 mm.

19. A method for manufacturing a semiconductor device, comprising:

a step of mounting a semiconductor element on a substrate through the paste-like adhesive composition according to any one of claims 1 to 16; and

a step of heating the paste-like adhesive composition.

20. The method for manufacturing a semiconductor device according to claim 19,

wherein the step of heating the paste-like adhesive composition includes a step of heating the paste-like adhesive composition under a temperature condition of lower than 200°C and a step of heating the paste-like adhesive composition under a temperature condition of equal to or higher than 200°C.

21. The method for manufacturing a semiconductor device according to claim 19 or 20,

wherein the step of heating the paste-like adhesive composition is performed in a state of applying a pressure to the paste-like adhesive composition.

22. A method for bonding a heatsink, comprising:

a step of bonding a heatsink to a semiconductor device through

the paste-like adhesive composition according to any one of claims 1 to 16; and

a step of heating the paste-like adhesive composition.

23. The method for bonding a heatsink according to claim 22,

wherein the step of heating the paste-like adhesive composition includes a step of heating the paste-like adhesive composition under a temperature condition of lower than 200°C and a step of heating the paste-like adhesive composition under a temperature condition of equal to or higher than 200°C.

24. The method for bonding a heatsink according to claim 22 or 23,

wherein the step of heating the paste-like adhesive composition is performed in a state of applying a pressure to the paste-like adhesive composition.

CLAIMS

1. A paste-like adhesive composition used for forming an adhesive layer in which metal particles (A) are sintered by heat treatment to form a particle coupling structure, comprising:

the metal particles (A); and

a thermally polymerizable compound (B),

wherein the compound (B) is one or more selected from a compound having only one radical polymerizable double bond in the molecule and having no epoxy group, or a compound having only one epoxy group in the molecule and having no radical polymerizable double bond,

wherein the composition does not include a solvent,

wherein when dynamic viscoelasticity of the composition is measured under a condition of a measurement frequency of 1 Hz, within a temperature region of 140°C to 180°C, the composition has a temperature width of equal to or larger than 10°C in which a shear modulus of elasticity is equal to or higher than 5,000 Pa and equal to or lower than 100,000 Pa, and

an acetone insoluble fraction of a sample, which is obtained by removing the metal particles (A) and then heating the composition under conditions of 180°C and 2 hours, is equal to or lower than 5% by weight,

wherein in a case where the composition is formed into a coating film by performing coating, and the coating film is heated to 250°C from 25°C at a heating rate of 5°C/min and then heated under conditions of 250°C and 2 hours, the obtained film has a thermal conductivity of equal to or higher than 15 W/mK in a thickness direction.

2. The paste-like adhesive composition according to claim 1,

wherein in a case where the composition is formed into a coating film by performing coating, and the coating film is heated to 250°C from 25°C at a heating rate of 5°C/min and then heated under conditions of 250°C and 2 hours, the obtained film has a volume resistivity of equal to or lower than 25 x 10^{-6}

Ω·cm in a surface direction.

3. The paste-like adhesive composition according to claims 1 or 2,

wherein a content of the metal particles (A) with respect to a total amount of the paste-like adhesive composition is equal to or greater than 80% by weight and equal to or less than 95% by weight.

4. The paste-like adhesive composition according to any one of claims 1 to 3,

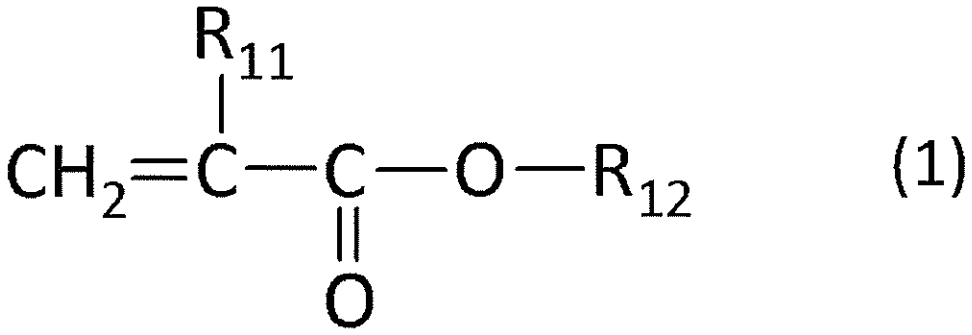
wherein the compound (B) contains a compound having a (meth)acryl group.

5. The paste-like adhesive composition according to any one of claims 1 to 4,

wherein the compound (B) contains a (meth)acrylic acid ester.

6. The paste-like adhesive composition according to claim 5,

wherein the (meth)acrylic acid ester contains a compound represented by Formula (1),



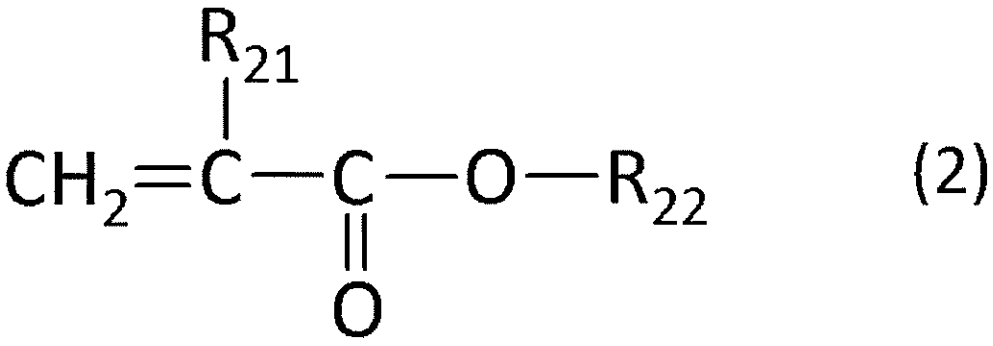
(1)

(in Formula (1), R_{11} represents hydrogen or a methyl group, and R_{12} represents a monovalent organic group which contains an OH group and has 1 to 20 carbon atoms).

7. The paste-like adhesive composition according to claim 5

or 6,

wherein the (meth)acrylic acid ester contains a compound represented by Formula (2),

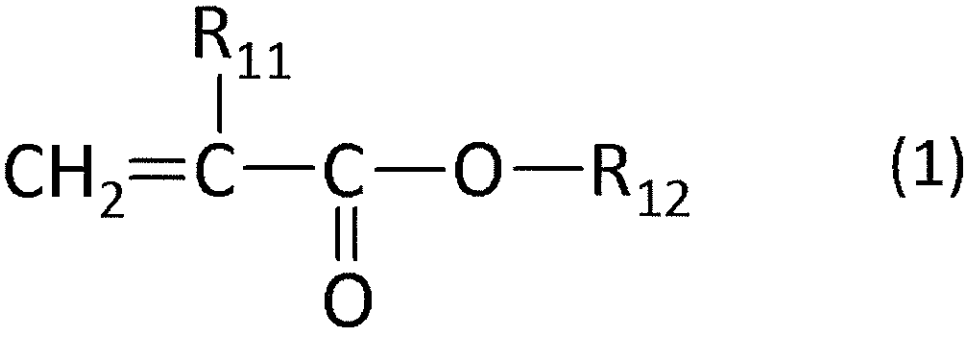


(2)

(in Formula (2), R_{21} represents hydrogen or a methyl group, and R_{22} represents a monovalent organic group which does not contain an OH group and has 1 to 20 carbon atoms).

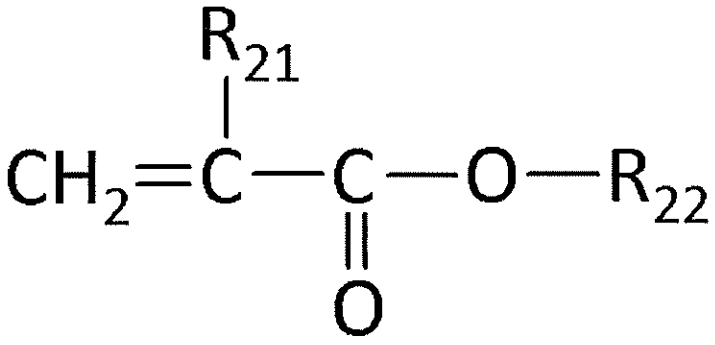
8. The paste-like adhesive composition according to claim 5,

wherein the (meth)acrylic acid ester contains the compound represented by Formula (1) and the compound represented by Formula (2),



(1)

(in Formula (1), R_{11} represents hydrogen or a methyl group, and R_{12} represents a monovalent organic group which contains an OH group and has 1 to 20 carbon atoms),



(2)

(in Formula (2), R_{21} represents hydrogen or a methyl group, and R_{22} represents a monovalent organic group which does not contain an OH group and has 1 to 20 carbon atoms).

9. The paste-like adhesive composition according to any one of claims 1 to 8, further comprising:

a compound having a tertiary amino group.

10. The paste-like adhesive composition according to any one of claims 1 to 9,

wherein a temperature at 5% weight loss of the composition is equal to or higher than 100°C and equal to or lower than 180°C.

11. The paste-like adhesive composition according to any one of claims 1 to 10,

wherein the metal particles (A) contain one kind of metal or two or more kinds of metals selected from the group consisting of Ag, Au, and Cu.

12. The paste-like adhesive composition according to any one of claims 1 to 11,

wherein the metal particles (A) contain spherical particles.

13. The paste-like adhesive composition according to any one of claims 1 to 12,

wherein a mean particle size D_{50} of the metal particles

(A) is equal to or greater than 0.1 μm.

14. A semiconductor device comprising:

a substrate; and

a semiconductor element mounted on the substrate through an adhesive layer obtained by performing a thermal treatment on the paste-like adhesive composition according to any one of claims 1 to 13.

15. The semiconductor device according to claim 14,

wherein a planar shape of the semiconductor element is a rectangle having a side equal to or longer than 5 mm.

16. A method for manufacturing a semiconductor device, comprising:

a step of mounting a semiconductor element on a substrate through the paste-like adhesive composition according to any one of claims 1 to 13; and

a step of heating the paste-like adhesive composition.

17. The method for manufacturing a semiconductor device according to claim 16,

wherein the step of heating the paste-like adhesive composition includes a step of heating the paste-like adhesive composition under a temperature condition of lower than 200°C and a step of heating the paste-like adhesive composition under a temperature condition of equal to or higher than 200°C.

18. The method for manufacturing a semiconductor device according to claim 16 or 17,

wherein the step of heating the paste-like adhesive composition is performed in a state of applying a pressure to the paste-like adhesive composition.

19. A method for bonding a heatsink, comprising:

a step of bonding a heatsink to a semiconductor device

through the paste-like adhesive composition according to any one of claims 1 to 13; and

a step of heating the paste-like adhesive composition.

20. The method for bonding a heatsink according to claim 19,

wherein the step of heating the paste-like adhesive composition includes a step of heating the paste-like adhesive composition under a temperature condition of lower than 200°C and a step of heating the paste-like adhesive composition under a temperature condition of equal to or higher than 200°C.

21. The method for bonding a heatsink according to claim 19 or 20,

wherein the step of heating the paste-like adhesive composition is performed in a state of applying a pressure to the paste-like adhesive composition.