

CLAIMS

WHAT IS CLAIMED:

1. A method, comprising:
providing an integrated circuit die having a plurality of solder balls, each of which have a layer of oxide on an outer surface of the ball;
performing a heating process to heat at least the solder balls; and
applying a force that causes each of a plurality of piercing bond structures on a substrate to pierce one of the solder balls and its associated oxide layer to thereby establish a conductive connection between the solder ball and the piercing bond structure.
2. The method of claim 1, wherein the steps recited in claim 1 are performed in an ambient, oxygen-containing environment.
3. The method of claim 1, wherein performing the heating process comprises heating at least the solder balls to a temperature that is above a melting point of a material of the solder balls.
4. The method of claim 1, wherein applying the force comprises applying a force ranging from 5-12 kp for a duration ranging from 0.5-2 seconds.
5. The method of claim 2, wherein the steps recited in claim 1 are performed without applying a flux to the plurality of solder balls.
6. The method of claim 3, wherein the substrate comprises a printed circuit board.
7. The method of claim 4, wherein each of the plurality of piercing bond structures has a substantially triangular cross-sectional configuration.

8. The method of claim 1, further comprising forming a standoff structure between the integrated circuit die and the substrate.

9. The method of claim 1, further comprising forming an anti-oxidation layer on at least one of the plurality of piercing bond structures.

10. The method of claim 9, wherein the anti-oxidation layer includes a first layer with a first thickness of about 2.5 μm and a second layer with a second thickness of about 0.3 μm .

11. The method of claim 9, wherein the anti-oxidation layer includes a first layer of gold and a second layer of nickel.

12. The method of claim 1, further comprising determining a distance between the integrated circuit and the substrate at least by controlling the heating process.

13. The method of claim 1, further comprising controlling a distance between the integrated circuit and the substrate at least by adjusting the force.

14. A method, comprising:
forming a plurality of solder balls on a microelectronic component, wherein the individual solder ball includes an oxide layer;
forming a plurality of piercing bond structures on a substrate, wherein the individual piercing bond structure includes an anti-oxidation layer;
heating at least the solder balls; and
moving the piercing bond structures and/or the microelectronic component to pierce the solder balls and the associated oxide layers;
establishing a conductive connection between the microelectronic component and the piercing bond structures.

15. The method of claim 14, further comprising forming a standoff structure between the microelectronic component and the substrate.

16. The method of claim 14, wherein the anti-oxidation layer includes a first layer of gold and a second layer of nickel, and wherein the first layer has a first thickness of about 2.5 μm and the second layer has a second thickness of about 0.3 μm .

17. The method of claim 14, wherein heating at least the "solder balls" comprises heating the solder balls to a temperature that is above a melting point of a material of the solder balls.

18. A device, comprising:

- a microelectronic component having a plurality of solder balls conductively coupled to bond pads on the microelectronic component, each of the solder balls having an oxide layer on its outer surface;
- a substrate having a plurality of piercing bond structures, each of the piercing bond structures penetrating the corresponding oxide layer and extending partially into the corresponding solder ball to establish a conductive connection; and
- a standoff structure positioned between the microelectronic component and the substrate, wherein the standoff structure spaces the microelectronic device apart from the substrate by a desired distance.

19. A device, comprising:

- an integrated circuit die having a plurality of solder balls that are conductively coupled to bond pads on the die, each of the solder balls having a layer of oxide on an outer surface thereof; and
- a substrate comprising a plurality of piercing bond structures, each of the piercing bond structures penetrating and extending at least partially into a corresponding solder ball to thereby establish a conductive connection between the solder ball and the piercing bond structure, the piercing bond structure penetrating the layer of oxide, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

20. The device of claim 19, wherein the piercing bond structures have a non-flat end.

21. The device of claim 19, wherein each of the piercing bond structures comprises at least one anti-oxidation layer formed on an outer surface of the piercing bond structure.

22. The device of claim 19, wherein the plurality of piercing bond structures has a substantially triangular cross-sectional configuration.

23. An integrated circuit device, comprising:

a first component configured to be conductively coupled to a first solder ball and a second solder ball, the first solder ball having a first layer of oxide, the second solder ball having a second layer of oxide, wherein the first solder ball is larger than the second solder ball; and

a second component configured to have a first piercing bond structure and a second piercing bond structure,

wherein the first piercing bond structure penetrates the first layer of oxide and extends at least partially into the first solder ball to establish a first conductive connection, and

wherein the second piercing bond structure penetrates the second layer of oxide and extends at least partially into the second solder ball to establish a second conductive connection.

24. The device of claim 23, wherein the first piercing bond structure includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of the first piercing bond structure.

25. The device of claim 23, wherein the second piercing bond structure includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of the second piercing bond structure.

26. The device of claim 24, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the first piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

27. The device of claim 25, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the second piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

28. The device of claim 23, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially triangular cross-sectional configuration.

29. The device of claim 23, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially pointed end.

30. The device of claim 23, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially rounded end.

31. The device of claim 23, wherein the first piercing bond structure and the second piercing bond structure respectively have an end with multiple peaks.

32. An electronic device including a semiconductor structure, the semiconductor structure comprising:

an integrated circuit component having a plurality of solder balls that are conductively coupled to the integrated circuit, each of the solder balls having a layer of oxide on an outer surface thereof;

a substrate carrying a plurality of piercing bond structures positioned on a substrate and conductively coupled to a plurality of bond pads, each of the piercing bond structures penetrating and extending at least partially into a corresponding solder ball to establish a conductive connection between the integrated circuit and the plurality of bond pads; and

a standoff structure positioned between the integrated circuit component and the substrate, wherein the standoff structure spaces the integrated circuit component apart from the substrate by a desired distance.

33. The device of claim 32, wherein each of the plurality of piercing bond structures includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of the second piercing bond structure.

34. The device of claim 33, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

35. The device of claim 33, wherein the plurality of piercing bond structures respectively have a substantially triangular cross-sectional configuration.

CLAIMS

1. A method, comprising:
providing an integrated circuit die having a plurality of solder balls, each of which have a layer of oxide on an outer surface of the ball;
performing a heating process to heat at least the solder balls; and
applying a force that causes each of a plurality of piercing bond structures on a substrate to pierce one of the solder balls and its associated oxide layer to thereby establish a conductive connection between the solder ball and the piercing bond structure.
2. The method of claim 1, wherein the steps recited in claim 1 are performed in an ambient, oxygen-containing environment.
3. The method of claim 1, wherein performing the heating process comprises heating at least the solder balls to a temperature that is above a melting point of a material of the solder balls.
4. The method of claim 1, wherein applying the force comprises applying a force ranging from 5-12 kp for a duration ranging from 0.5-2 seconds.
5. The method of claim 2, wherein the steps recited in claim 1 are performed without applying a flux to the plurality of solder balls.
6. The method of claim 3, wherein the substrate comprises a printed circuit board.
7. The method of claim 4, wherein each of the plurality of piercing bond structures has a substantially triangular cross-sectional configuration.

8. The method of claim 1, further comprising forming a standoff structure between the integrated circuit die and the substrate.

9. The method of claim 1, further comprising forming an anti-oxidation layer on at least one of the plurality of piercing bond structures.

10. The method of claim 9, wherein the anti-oxidation layer includes a first layer with a first thickness of about 2.5 μm and a second layer with a second thickness of about 0.3 μm .

11. The method of claim 9, wherein the anti-oxidation layer includes a first layer of gold and a second layer of nickel.

12. The method of claim 1, further comprising determining a distance between the integrated circuit and the substrate at least by controlling the heating process.

13. The method of claim 1, further comprising controlling a distance between the integrated circuit and the substrate at least by adjusting the force.

14. A method, comprising:

forming a plurality of solder balls on a microelectronic component, wherein the individual solder ball includes an oxide layer;

forming a plurality of piercing bond structures on a substrate, wherein the individual piercing bond structure includes an anti-oxidation layer;

heating at least the solder balls; and

moving the piercing bond structures and/or the microelectronic component to pierce the solder balls and the associated oxide layers;

establishing a conductive connection between the microelectronic component and the piercing bond structures.

15. The method of claim 14, further comprising forming a standoff structure between the microelectronic component and the substrate.

16. The method of claim 14, wherein the anti-oxidation layer includes a first layer of gold and a second layer of nickel, and wherein the first layer has a first thickness of about 2.5 μm and the second layer has a second thickness of about 0.3 μm .

17. The method of claim 14, wherein heating at least the solder balls comprises heating the solder balls to a temperature that is above a melting point of a material of the solder balls.

18. A device, comprising:

- a microelectronic component having a plurality of solder balls conductively coupled to bond pads on the microelectronic component, each of the solder balls having an oxide layer on its outer surface;
- a substrate having a plurality of piercing bond structures, each of the piercing bond structures penetrating the corresponding oxide layer and extending partially into the corresponding solder ball to establish a conductive connection; and
- a standoff structure positioned between the microelectronic component and the substrate, wherein the standoff structure spaces the microelectronic component apart from the substrate by a desired distance.

19. A device, comprising:

- an integrated circuit die having a plurality of solder balls that are conductively coupled to bond pads on the die, each of the solder balls having a layer of oxide on an outer surface thereof; and
- a substrate comprising a plurality of piercing bond structures, wherein each of the piercing bond structures comprises at least one anti-oxidation layer formed on an outer surface of the piercing bond structure, each of the piercing bond structures

penetrating and extending at least partially into a corresponding solder ball to thereby establish a conductive connection between the solder ball and the piercing bond structure, the piercing bond structure penetrating the layer of oxide, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

20. The device of claim 19, wherein the piercing bond structures have a non-flat end.

21. The device of claim 19, wherein the plurality of piercing bond structures has a substantially triangular cross-sectional configuration.

22. An integrated circuit device, comprising:

a first component configured to be conductively coupled to a first solder ball and a second solder ball, the first solder ball having a first layer of oxide, the second solder ball having a second layer of oxide, wherein the first solder ball is larger than the second solder ball; and

a second component configured to have a first piercing bond structure and a second piercing bond structure,

wherein the first piercing bond structure penetrates the first layer of oxide and extends at least partially into the first solder ball to establish a first conductive connection, and

wherein the second piercing bond structure penetrates the second layer of oxide and extends at least partially into the second solder ball to establish a second conductive connection.

23. The device of claim 22, wherein the first piercing bond structure includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of the first piercing bond structure.

24. The device of claim 22, wherein the second piercing bond structure includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of the second piercing bond structure.

25. The device of claim 23, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the first piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

26. The device of claim 24, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the second piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

27. The device of claim 22, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially triangular cross-sectional configuration.

28. The device of claim 22, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially pointed end.

29. The device of claim 22, wherein the first piercing bond structure and the second piercing bond structure respectively have a substantially rounded end.

30. The device of claim 22, wherein the first piercing bond structure and the second piercing bond structure respectively have an end with multiple peaks.

31. An electronic device including a semiconductor structure, the semiconductor structure comprising:

- an integrated circuit component having a plurality of solder balls that are conductively coupled to the integrated circuit, each of the solder balls having a layer of oxide on an outer surface thereof;
- a substrate carrying a plurality of piercing bond structures positioned on a substrate and conductively coupled to a plurality of bond pads, each of the piercing bond structures penetrating and extending at least partially into a corresponding solder ball to establish a conductive connection between the integrated circuit and the plurality of bond pads; and
- a standoff structure positioned between the integrated circuit component and the substrate, wherein the standoff structure spaces the integrated circuit component apart from the substrate by a desired distance.

32. The device of claim 31, wherein each of the plurality of piercing bond structures includes a non-flat end, and wherein at least one anti-oxidation layer is formed on an outer surface of at least one piercing bond structure.

33. The device of claim 32, wherein the at least one anti-oxidation layer comprises a plurality of layers of material, and wherein the plurality of layers comprises a layer comprising gold formed on an exposed surface of the piercing bond structure and a layer comprising nickel formed on the layer comprising gold.

34. The device of claim 32, wherein the plurality of piercing bond structures respectively have a substantially triangular cross-sectional configuration.