BOW CONTROL IN AN ELECTRONIC PACKAGE

Field of the Invention

The invention relates to electronic circuit packaging and, more particularly, to bow control in an electronic package.

Background of the Invention

Figure 1 is an illustration of a prior art electronic package 100. The electronic package 100 includes a die 102, a die substrate 104, a package substrate 106, solder elements 108 and a molding compound 110. The die 102 is mounted on the die substrate 104. The die substrate 104 is mounted on the package substrate 106. The purpose of the solder elements 108 is to electrically couple the die substrate 104 to the package substrate 106. The molding compound 110 encapsulates the electronic connections. As can be seen in Figure 1, the die substrate 104 is encapsulated by the molding compound 110 on only one side of the die substrate 104. During the curing of the molding compound 110, the molding compound 110 shrinks and subjects the die substrate 104 to stress that causes the die substrate 104 to bow. A bowed die substrate 104 causes open connections at the solder elements 108 which increases the electrical failure rate of the electronic package.

For these and other reasons there is a need for an electronic package that resists bowing.

Summary of the Invention

The above mentioned problems associated with bowing and other problems are addressed by the present invention and will be understood by reading and studying the following specification.

In one embodiment, a package is provided that includes a package substrate, a die-substrate assembly and a molding compound. The die-substrate assembly includes a substrate that includes a plurality of layers. The plurality of layers includes a layer comprising a mesh to stiffen the substrate. The substrate is adapted to mount one or more dice, and the molding compound attaches the substrate to the package substrate.

In an alternative embodiment, the package includes a mesh formed from copper that includes a plurality of substantially circular openings.

These and other embodiments, aspects, advantages, and features of the present invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art by reference to the following description of the invention and referenced drawings or by practice of the invention. The aspects, advantages, and features of the invention are realized and attained by means of the instrumentalities, procedures, and combinations particularly pointed out in the appended claims.

Brief Description of the Drawings

Figure 1 is an illustration of a side view of a prior art electronic package;

Figure 2A is an illustration of a side view of one embodiment of a package comprising a package substrate, a die-substrate assembly, a molding compound and solder elements according to the teachings of the present invention;

Figure 2B is an illustration of a top view of one embodiment of the die-substrate assembly shown in Figure 2A according to the teachings of the present invention;

Figures 2C-2E are illustrations of some alternative embodiments of a layer included in the die-substrate assembly shown in Figure 2B according to the teachings of the present invention;

Figures 2F-2J are illustrations of some embodiments of a mesh having mesh opening shapes suitable for use in connection with the die-substrate assembly shown in Figure 2A according to the teachings of teachings of the present invention;

Figure 2K is an illustration of a side view of an alternative embodiment of the die-substrate assembly according to the teachings of the present invention; and

Figure 2L is an illustration of system including a processor and a package according to the teachings of the present invention.

Description

In the following detailed description of the invention, reference is made to the accompanying drawings which form a part hereof, and in which are shown, by way of illustration, specific embodiments of the invention which may be practiced. In the drawings, like numerals describe substantially similar

components throughout the several views. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the present invention. The following detailed description is not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

Figure 2A is an illustration of a side view of one embodiment of a package 200 comprising a package substrate 202, a die-substrate assembly 204, a molding compound 206 and solder elements 208 according to the teachings of the present invention.

The package substrate 202 provides a base for mounting the die-substrate assembly 204. As such, the package substrate 202 is not limited to being fabricated from a particular material. In some embodiments, the package substrate 202 is fabricated from an insulator or a combination of insulators. Exemplary insulators suitable for use in the fabrication of the package substrate 202 include ceramics, epoxies, fiber glasses or combinations of such insulators. However, the package substrate 202 can also include conductive materials which are formed into conductive paths (not shown) or planes (not shown) to couple electronic signals to-and-from the die-substrate assembly 204.

The die-substrate assembly 204 is mounted on the package substrate 202 and includes a substrate 210. The substrate 210 includes a plurality of layers, such as layers 212 and 214, with the layer 214 including a mesh to stiffen the substrate 210. The substrate 210 is adapted to mount one or more dice, such as die 216. The substrate 210 is electrically coupled to the package substrate 202 by the solder elements 208.

The layer 212 provides a substrate on which to mount the die 216. The layer 212 is not limited to being fabricated from a particular material. In some embodiments, the layer 212 is fabricated from an insulator or combination of insulators. Exemplary insulators suitable for use in the fabrication of the layer 212 include ceramics, epoxies, fiber glasses or combinations of such insulators. However, the layer 212 can also include conductive materials which are formed

into conductive paths (not shown) or planes (not shown) to couple electronic signals to-and-from the die-substrate assembly 204.

Figure 2B is an illustration of a top view of one embodiment of the die-substrate assembly 204 shown in Figure 2A according to the teachings of the present invention. As can be seen in Figure 2B, the layer 214 is formed on a surface 218 of the layer 212 which is an outer or exposed surface of the substrate 210. The layer 214 has an annular shape including a substantially rectangular opening 220. However, the layer 214 is not limited to having a substantially rectangular opening. Figures 2C-2E are illustrations of some alternative embodiments of the layer 214 included in the die-substrate assembly shown in Figure 2B according to the teachings of the present invention. As shown in Figure 2C, the layer 214 has a substantially square opening 222. As shown in Figure 2D, the layer 214 has a substantially elliptical opening 224. As shown in Figure 2E, the layer 214 has a substantially circular opening 226. The layer 214 is not limited to being formed with an opening. In an alternative embodiment, the layer 214 can be formed without an opening.

The layer 214 comprises a mesh including a plurality of openings. Each of the plurality of openings has a shape, but the openings are not limited to a particular shape. Figures 2F-2J are illustrations of some embodiments of a mesh having mesh opening shapes suitable for use in connection with the die-substrate assembly shown in Figure 2A according to the teachings of teachings of the present invention. As shown in Figure 2F, the mesh includes a plurality of substantially rectangular openings. As shown in Figure 2G, the mesh includes a plurality of substantially square openings. As shown in Figure 2H, the mesh includes a plurality of substantially triangular openings. As shown in Figure 2I, the mesh includes a plurality of substantially elliptical openings. As shown in Figure 2J, the mesh includes a plurality of substantially circular openings.

The layer 214 is not limited to being fabricated from a particular material. In some embodiments, the layer 214 is fabricated from a metal. Exemplary metals suitable for use in the fabrication of the mesh include but are not limited to copper, gold, silver, nickel and aluminum. The layer 214 is not limited to being fabricated using a particular method. One method of fabricating the layer 214 includes depositing a metal layer on the layer 214 and etching the

desired annular opening and mesh openings in the metal layer. The layer 214 is deposited to a thickness that provides the necessary resistance to bowing for the selected mesh opening.

Figure 2K is an illustration of a side view of an alternative embodiment of the die-substrate assembly 204 according to the teachings of the present invention. As shown in Figure 2K, the layer 214 is an inner layer of the die-substrate assembly 204. An inner layer is a layer located between two other layers. Locating the layer 214 internal to the die-substrate assembly 204 permits the layer 214 to substitute for a ground or power plane in the die-substrate assembly 204. This substitution reduces the cost of the die-substrate assembly 204 while increasing the die-substrate assembly resistance to bowing or warping.

Referring again to Figure 2A, the die 216 is mounted on the substrate 216 and includes an electronic circuit that performs an electronic function. In one embodiment, the die 216 includes an electronic circuit, such as a dynamic random access memory circuit or a static random access memory circuit, that performs a memory function. In an alternative embodiment, the die 216 includes an electronic circuit, such as an analog radio frequency amplifier, that performs an analog signal processing function. In another alternative embodiment, the die 216 includes an electronic circuit, such as a processor, that performs a logic function. In still another alternative embodiment, the die 216, includes an electronic circuit, such as a mixed-signal application specific integrated circuit for monitoring and controlling the performance of an automobile engine, that performs a combination of analog and digital circuit functions.

The die 216 is not limited to being fabricated from a particular material. In some embodiments, the die 216 is fabricated from a single type of semiconductor. For example, in one embodiment the die 216 is fabricated from silicon. In an alternative embodiment, the die 216 is fabricated from gallium arsenide. In still another alternative embodiment, the die 216 is fabricated from germanium. In other embodiments, the die 216 is fabricated from a combination of semiconductors. For example, in one embodiment the die 216 is fabricated from silicon and germanium. In an alternative embodiment, the die 216 is fabricated from silicon and gallium arsenide. In another alternative embodiment, the die 216 is fabricated from germanium and gallium arsenide.

As can be seen in Figure 2A, the layer 214 stiffens the die-substrate assembly 204 and reduces warping in the die-substrate assembly 204. The layer 214 stiffens the die-substrate assembly 204 by providing a super-structure formed by the layer 214 to resist the stresses at the molding compound/substrate interface induced by shrinkage of the molding compound during curing.

Figure 2L is an illustration of system 230 including a processor 232 and a package 200 according to the teachings of the present invention. The system 230 is not limited to use in connection with a particular type of processor. Exemplary processors suitable for use in connection with the system 230 include complex instruction set processors, reduced instruction set processors, very long instruction word processors and digital signal processors. The processor 232 is communicatively coupled to the die 210 of the die-substrate assembly 204 mounted on the package substrate 202. The processor 222 can be communicatively coupled to the die 210 by physically connecting the processor 222 to the die 210 through a conductive element or communicatively coupled to the die 210 through a wireless communication link such as radio frequency communication link.

Although specific embodiments have been described and illustrated herein, it will be appreciated by those skilled in the art, having the benefit of the present disclosure, that any arrangement which is intended to achieve the same purpose may be substituted for a specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.

CLAIMS

1. A substrate comprising:

a plurality of layers including a layer comprising an annular mesh to stiffen the substrate adapted to mount one or more dice.

2. The substrate of claim 1, wherein at least one of the plurality of layers comprises a ceramic material.

3. The substrate of claim 2, wherein the annular mesh comprises a plurality of substantially elliptical openings.

4. A substrate comprising:

a plurality of layers including a layer comprising an annular mesh formed from a metal to stiffen the substrate adapted to mount one or more dice.

5. The substrate of claim 4, wherein the annular mesh comprises a plurality of substantially circular openings.

6. The substrate of claim 5, wherein the metal comprises copper.

7. The substrate of claim 6, wherein at least one of the plurality of layers comprises a ceramic material.

8. A substrate comprising:

a plurality of layers including a layer comprising an annular mesh formed as an outer surface of the substrate to stiffen the substrate adapted to mount one or more dice.

9. The substrate of claim 8, wherein the annular mesh comprises a plurality of substantially rectangular openings.

10. The substrate of claim 9, wherein the annular mesh comprises gold.

11. A substrate comprising:

a plurality of layers including a layer comprising an annular mesh formed as an inner layer of the substrate adapted to mount one or more dice.

12. The substrate of claim 11, wherein the annular mesh comprises a plurality of substantially square openings.

13. The substrate of claim 12, wherein at least one of the plurality of layers comprises a ceramic material.

14. A substrate comprising:

a plurality of layers including a layer having an annular shape, the layer comprising a mesh to stiffen the substrate adapted to mount one or more dice.

15. The substrate of claim 14, wherein the mesh comprises a plurality of substantially triangular openings.

16. The substrate of claim 15, wherein the annular shape has a substantially rectangular opening.

17. A substrate comprising:

a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an outer surface of the substrate to stiffen the substrate adapted to mount one or more dice.

18. The substrate of claim 17, wherein the mesh comprises a plurality of substantially elliptical openings.

19. The substrate of claim 18, wherein the annular shape has a substantially circular opening.

20. A substrate comprising:

a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an inner surface of the substrate to stiffen the substrate adapted to mount one or more dice.

21. The substrate of claim 20, wherein the mesh comprises a plurality of substantially square openings.

22. The substrate of claim 21, wherein the annular shape has a substantially elliptical opening.

23. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer comprising an annular mesh to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

24. The die-substrate assembly of claim 23, wherein at least one of the one or more dice comprises silicon.

25. The die-assembly substrate of claim 23, wherein at least one of the one or more dice comprises a memory die.

26. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer comprising an annular mesh formed from a metal to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

27. The die-substrate assembly of claim 26, wherein at least one of the one or more dice comprises germanium.

28. The die-substrate assembly of claim 26, wherein at least one of the one or more dice comprises a digital logic die.

29. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer comprising an annular mesh formed as an outer surface of the substrate to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

30. The die-substrate assembly of claim 29, wherein at least one of the one or more dice comprises gallium arsenide.

31. The die-substrate assembly of claim 30, wherein at least one of the one or more dice comprises an analog die.

32. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer comprising an annular mesh formed as an inner layer of the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

33. The die-substrate assembly of claim 32, wherein at least one of the one or more dice comprises a semiconductor.

34. The die-substrate assembly of claim 33, wherein the one or more dice comprises a memory die.

35. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

36. The die-substrate assembly of claim 35, wherein at least one of the one or more dice comprises silicon.

37. The die-substrate assembly of claim 35, wherein at least one of the one or more dice comprises a processor die.

38. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an outer surface of the substrate to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

39. The die-substrate assembly of claim 38, wherein at least one of the one or more dice comprises germanium.

40. The die-substrate assembly of claim 38, wherein at least one of the one or more dice comprises a mixed signal die.

41. A die-substrate assembly comprising:

a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an inner surface of the substrate to stiffen the substrate adapted to mount one or more dice; and

one or more dice mounted on the substrate.

42. The die-substrate assembly of claim 41, wherein at least one of the one or more dice comprises gallium arsenide.

43. The die-substrate assembly of claim 42, wherein at least one of the one or more dice comprises a radio frequency analog die.

44. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer comprising an annular mesh to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

45. The package of claim 44, wherein at least one of the one or more dice comprises a memory die.

46. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer comprising an annular mesh formed from a metal to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

47. The package of claim 46, wherein at least one of the one or more dice comprises a digital logic die.

48. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer comprising an annular mesh formed as an outer surface of the substrate

to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

49. The package of claim 48, wherein at least one of the one or more dice comprises an analog die.

50. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer comprising an annular mesh formed as an inner layer of the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

51. The package of claim 50, wherein at least one of the one or more dice comprises a processor die.

52. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

53. The package of claim 52, wherein at least one of the one or more dice comprises a memory die.

54. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an outer surface of the substrate to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate.

55. The package of claim 54, wherein at least one of the one or more dice comprises a mixed signal die.

56. A package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer having an annular shape, the layer comprising a mesh formed from a metal and the layer formed as an inner surface of the substrate to stiffen the substrate adapted to mount one or more dice, and one or more dice mounted on the substrate; and a molding compound to attach the substrate to the package substrate.

57. The package of claim 56, wherein at least one of the one or more dice comprises a radio frequency gallium arsenide die.

58. A system comprising:

a package comprising:

a package substrate;

a die-substrate assembly comprising a substrate comprising a plurality of layers including a layer comprising an annular mesh to stiffen the substrate adapted to mount one or more dice, and one or more memory dice mounted on the substrate; and

a molding compound to attach the substrate to the package substrate; and

a processor coupled to at least one of the one or more memory dice.

59. A method comprising:

forming an annular mesh layer in a die-substrate assembly;

mounting the die-substrate assembly on a package substrate; and

applying a molding compound between the package substrate and the substrate.