EMI SHIELDING FOR ELECTRONIC PACKAGES

Field of the Invention

The present invention relates to electronic packages incorporating EMI shielding.

Background of the Invention

In carrying out the production of electronic packages, particularly semiconductor devices which incorporate chip carriers or substrates of either laminates or organic materials or ceramics and the like, and which support one or more semiconductor chips which are covered by a heat-dissipating lid or cap structure, the reliable functioning thereof is potentially adversely affected due to encountered electromagnetic interference (EMI). This requires that an EMI shield be provided to counteract and eliminate the adverse effects. Moreover, the EMI shielding is intended to also function as an emission shield; in effect, to inhibit or stop outgoing EMI energy. Quite frequently, such semiconductor devices may comprise a substrate providing for electrical connections to one or more semiconductor chips positioned on the substrate. Also, a heat-dissipating structure such as a heat spreader in the form of a cap or lid is, in turn, arranged above the chip or chips in thermally-conductive mechanical adhesive connection.

Various electrical components and interconnects are normally provided on both sides of the substrates in electrical communication with the chip or chips, as is well known in the semiconductor or electronic packaging technology. In order to effectively screen out any encountered EMI during operation of the semiconductor devices, it has been proposed to provide structure extending about the chip and interposed between the heat-dissipating lid structure or cap and also the substrate, in that suitable connections or wiring is to be provided, thereby creating an EMI shield for the semiconductor device or electronic package. In this connection, numerous types of EMI shields or similar types of EMI protective structures for the electronic packages or semiconductor devices have been proposed in the technology, possessing varying degrees of efficacy in protecting or shielding the devices from electromagnetic interference (EMI).

U.S. Patent No. 5,866,943 discloses a system and method for forming a grid array device package employing electromagnetic shielding, in which a stiffener is disposed intermediate a substrate and a lid or cap structure having a semiconductor chip interposed therebetween. The stiffener which encompasses the semiconductor chip includes various electrical interconnections between the semiconductor chip, substrate and the heat spreader or cover so as to, in effect, provide for the necessary EMI shield to protect against the effects of EMI during operation of the electronic package.

U.S. Patent No. 5,650,659 discloses a semiconductor component package assembly, which includes an EMI shield interposed between a substrate and a heat dissipating structure, and encompassing an integrated circuit chip to provide for electrical connections forming an integral radio frequencies/electromechanical interference (RF/EMI) shield. In one particular embodiment, an adhesive of an electrically conductive nature may be interposed between the substrate and the structure forming the EMI shield as necessary to provide for the electrical grounding of the component.

U.S Patent No. 5,761,053 also discloses a Faraday cage in which a cover positioned on a substrate and encompassing integrated circuit components enables the energy of EMI/RFI to be dissipated so as to render the effects thereof harmless to the operation of the device.

Similarly, U.S. Patent No. 5,317,107 discloses a semiconductor device including a substrate and a cover portion having an integrated circuit chip interposed therebetween, and including shielding to block EMI energy which would have an adverse effect on the functioning of the device.

U.S. Patent No. 6,261,251 discloses a wirebond package for low cost (radio frequency) applications utilizing a complex metal-lead frame structure to provide for isolation from disruptive frequencies.

U.S. Patent No. 5,939,784 discloses a package for a wirebond die employed in a acoustical wave device, and which possess an EMI shielded surface.

U.S Patent No. 5,939,772 discloses a wirebond package incorporating metal plates in a surrounding configuration which are adapted to impart magnetic shielding to the package.

U.S. Patent No. 5,838,093 discloses a piezoelectric element package incorporating a device with a surrounding metal cup which provides shielding from EMI energy during functioning of the package.

U.S. Patent No. 5,536,907 discloses a wirebond package for a semiconductor device including a metal lid incorporated therein and structure providing for EMI shielding.

U.S. Patent No. 5,254,871 provides for a tape automatic bonding (TAB) carrier including an incorporated or integrated heatsink and metal plate construction which enables functioning thereof as an EMI shielding.

U.S. Patent No. 5,227,583 discloses a wirebond package having a ceramic lid which is metallized as a signal shielding component protective from the energy generated by EMI.

Furthermore, Schelhorn U.S. Patent No. 4,967,315; Kling U.S. Patent No. 4,323,155; Hayashi U.S. Patent No. 5,898,344; Strobel et al. U.S Patent No. 5,635,754; Marrs U.S. Patent No. 5,485,037; Bethurum U.S. Patent No. 5,477,421; Moulton, et al. U.S. Patent No. 5,371,408; Knecht, et al. U.S. Patent No. 5,313,371; and Mahulikar et al. U.S. Patent No. 5,043,534 each, to some extent, describe various types of structures in the shape of either electronic packages or semiconductor devices which incorporate EMI shielding arrangements so as to inhibit the effects of EMI on the performance of the various devices or electronic packages.

SUMMARY OF THE INVENTION

Advantageously, the present invention provides configurations of grounded-lid or electronic packages that are particularly suitably adapted for extremely high-speed electronic switching applications, such as for Hyper BGAs', and which require a highly efficient type of EMI shielding.

According to one aspect, the present invention provides an electronic package incorporating shielding against the emissions of electromagnetic interference (EMI); comprising: a circuitized substrate having opposite first and second surfaces, said first surface having a first portion and second portion; an electrically-conductive ground band being embedded in said substrate and extending between said second portion of said first surface and said second surface; a semiconductor chip being

arranged on said first portion of said first surface; a plurality of electrically conductive circuit members being positioned on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and a lid member comprising an electrically conductive material being arranged on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package.

Preferably, an electrically conductive stiffener is positioned on said second portion on the first surface of said substrate, said stiffener being electrically connected to at least one of said electrically conductive circuit members on said first portion on said first surface of said substrate, and to at least one electrically conductive member on the second surface of said substrate through said electrically conductive ground band. The stiffener is in electrical connection with said lid member and is located proximate the perimeter of the substrate so as to radially extend about the semiconductor chip. Aptly, the stiffener is constituted of a metallic composition selected from a group of materials comprising: copper, aluminum, tin, chromium, silicon carbide, carbon, diamond, titanium, stainless steel, nickel, ceramic having an electrically-conductive coating, alloys of the materials, and composites of the materials.

In a preferred embodiment, the substrate is comprised of a dielectric organic material and the ground band is embedded in the substrate proximate the perimeter of the substrate. An electrically conductive adhesive is arranged between the stiffener and the ground band and between the stiffener and the lid member so as to form electrical connections between these elements.

The lid member (or thermally-conductive cap) is preferably selected from a group of materials comprising: copper, aluminum, tin, chromium, silicon carbide, carbon, diamond, titanium, stainless steel, nickel, ceramic having an electrically-conductive coating, alloys of the materials, and composites of the materials. Preferably, a compliant, thermally conductive adhesive is arranged between the semiconductor chip and the lid member.

Preferably, the electrically conductive circuit members on the first portion on the first surface of the substrate are solder balls and the electrical conductive members on the second surface of the substrate is a ball grid array (BGA).

In an alternative embodiment, the substrate comprises a rigid dielectric ceramic material. The ground band is in electrical connection with the lid member through the interposition of an electrically conductive gasket positioned between the second portion on the first surface of the substrate and the lid member. Preferably, the lid member has an annular flange extending into proximity to the ground band at the first surface of said substrate, said ground band being in electrical connection with said lid member through the interposition of an electrically conductive adhesive material positioned between the second arereal portion on the first surface of said substrate and a facing end surface on said annular depending flange of said lid member.

According to a second aspect, the present invention provides an electronic package incorporating shielding against the effects of outgoing and incident electromagnetic interference (EMI); comprising: a circuitized substrate having opposite first and second surfaces, said first surface having a first portion and second portion; an electrically-conductive ground band being embedded in said substrate proximate the perimeter thereof and extending between said second portion of said first surface and said second surface; a semiconductor chip being arranged on said first portion of said first surface; a plurality of electrically conductive circuit members being positioned on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and a lid member comprising an electrically conductive material being arranged on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package; said electrically conductive stiffener being positioned on said second portion on the first surface of said substrate proximate the perimeter of said substrate, said stiffener being electrically connected to said lid member and to at least one of said electrically conductive circuit member on said first portion on the first surface of said substrate, and to at least one electrically

conductive member on the second surface of said substrate through said electrically conductive ground band.

According to a third aspect, the present invention provides an electronic package incorporating shielding against the effects of outgoing and incident electromagnetic interference (EMI); comprising: a circuitized ceramic substrate having opposite first and second surfaces, said first surface having a first portion and second portion; an electrically-conductive ground band being embedded in said substrate proximate the perimeter thereof and extending between said second portion of said first surface and said second surface; a semiconductor chip being arranged on said first portion of said first surface; a plurality of electrically conductive circuit members being positioned on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and a lid member comprising an electrically conductive material being arranged on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package; said electrically conductive stiffener being positioned on said second portion on the first surface of said substrate proximate the perimeter of said substrate, said stiffener being electrically connected to said lid member and to at least one of said electrically conductive circuit member on said first portion on the first surface of said substrate, and to at least one electrically conductive member on the second surface of said substrate through said electrically conductive ground band.

According to a fourth aspect, the present invention provides a method of providing an electronic package incorporating shielding against the emissions and incidence of electromagnetic interference (EMI); comprising: providing a circuitized substrate having opposite first and second surfaces, said first surface having a first portion and second portion; an electrically-conductive ground band being embedded in said substrate and extending between said second portion of said first surface and said second surface; arranging a semiconductor chip being arranged on said first portion of said first surface; positioning a plurality of electrically conductive circuit members on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and arranging a lid member comprising an electrically

conductive material on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package.

In one embodiment, there is provided a semiconductor device comprising an organic substrate or chip carrier, wherein a lid of a electrically and thermally-conductive structure is attached to a stiffener which is interposed between the perimetrical regions of the substrate and the lid, and wherein an integrated circuit or semiconductor chip is positioned between the lid and the organic substrate, while encompassing the stiffener, and includes an adhesive between the chip and substrate which is of a compliant, thermally conductive nature so as to promote a good thermo-mechanical connection of good reliability between the components. Arranged embedded in the organic carrier is an electrically conductive ground band so as to extend around the perimeter portion of the carrier and between the top and bottom surfaces of the substrate. The stiffener may be attached to the substrate by means of an electrically non-conductive adhesive material so as to cover the active circuitized area on the chip carrier or substrate extending about the integrated circuit chip, and with an electrically-conductive adhesive material extending over the ground band which is embedded in the substrate.

In another embodiment, the chip carrier or substrate may comprise a rigid ceramic element mounting a ball grid array (BGA), which element interconnected to a chip through the intermediary of solder balls which may be embedded in an underfill. An electrically and thermally-conductive lid, such as a heat-dissipating cap structure is superimposed on the chip and is connected by means of a suitable dielectric adhesive. A conductive ground band is formed proximate the perimeter in the ceramic substrate so as to be embedded therein, and with an EMI gasket of electrically conductive nature interconnecting the ground with the heat-dissipating lid or cap structure. The ground band component forms a grounded connection with the ball grid array to produce an EMI shield for the entire arrangement.

In yet another embodiment, the lid or cap structure may have a depending annular flange portion which electrically communicates with the embedded wiring forming the ground band in the perimeter area of the

ceramic substrate by means of an EMI adhesive, whereas in the preceding embodiment, rather than an adhesive there is employed an EMI gasket.

The rigid or inherently stiff nature of the substrates utilized in two of the above embodiments, such as a ceramic chip carrier, eliminates the need for the provision of a stiffener structure as is required in connection with the less rigid organic substrate or laminated chip carrier of the first embodiment.

Accordingly, it is an advantage of the present invention to provide a novel electronic package arrangement incorporating EMI shielding comprising a stiffener positioned intermediate a substrate of an organic nature and an electrically conductive lid or heat dissipating cap between which there is arranged an integrated circuit chip encompassed by the stiffener, and wherein the substrate is provided with ground connections for producing an EMI shield, with a ground band being embedded in the perimetrical region of the organic substrate.

A further advantage of the present invention resides in the provision of an electronic package of the type described comprising an EMI barrier to incident or incoming EMI energy. A still further advantage of the present invention resides in the provision of an electronic package of the type described herein comprising an EMI shield for outgoing or emitted EMI energy.

In one embodiment, there is provided an arrangement which imparts EMI shielding to a semiconductor package the type of described wherein an EMI gasket is interposed between a ceramic substrate having band-shaped grounding wires imbedded proximate the perimeter thereof, and providing for electrical interconnections with a metallic lid or heat-dissipating cap structure and with a ball grid array on the substrate.

In another embodiment, there is provided an electronic package or semiconductor structure which includes an EMI adhesive interposed between an annular depending flange on a heat-dissipating lid or cap, and electrically conductive wiring embedded in a ceramic substrate and connected to a ball grid array so as to form a grounding connection with the metallic lid, so as to produce an EMI shield for the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to preferred embodiments thereof, as illustrated in the following drawings, in which:

Figure 1 illustrates generally diagrammatically, a first embodiment in a partial cross-sectional representation of a semiconductor package, including an organic substrate and a stiffener structure employed in forming a grounded EMI shield;

Figure 2 illustrates a second embodiment of a package with a ceramic substrate including an embedded ground band electrically communicating with a lid through an EMI gasket to form an EMI shield in a semiconductor package; and

Figure 3 illustrates a third embodiment of a semiconductor package similar to the second embodiment but utilizing an EMI adhesive rather than a gasket interposed between electrical ground wires extending perimetrically within a ceramic substrate and a conductive cap or lid.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a there is diagrammatically represented a semiconductor package 10 comprising an organic substrate 12 (which may be constituted of a laminate) and an integrated circuit chip 14. Interposed between the chip 14 substrate 12 are suitable solder balls 16, as is well known in the technology, and which may be encapsulated in an underfill material 17.

Arranged above the chip 14, opposite the side facing the substrate 12, and extending radially outwardly of the chip 14 is a lid or heat-dissipating cap structure 18 of an electrically-conductive material, for instance, such as but not limited to copper, aluminum, tin, chromium, silicon, carbide, carbon, diamond, ceramic with electrically-conductive coatings, alloys and compositions thereof, and the like, as are well known in the technology, which is attached to the chip by means of a thermally-conductive compliant adhesive 20 in order to promote good thermo-mechanical reliability in their interconnection, the adhesive being essentially of an electrically non-conductive or low-conductive nature in composition, such as being a silver-filled adhesive which is both thermally and electrically-conductive.

Positioned to extend along the peripheral region 22 intermediate the lower surface of the lid or cap structure 18 and the upper surface of the organic substrate 12 is a stiffener member 24 which, in its plane, may be essentially of a box-shaped configuration with a central opening 26 extending in spaced relationship about the peripheral extent of the chip 14. The stiffener member 24 may be of a suitable electrically-conductive material, similar to the lid or heat-dissipating cap 18, by being constituted of the materials as set forth hereinabove, of both metallic and non-metallic compositions. The lid or cap structure 18 is fastened to the stiffener 24 through the interposition of an electrically-conductive adhesive 28, whereas in contrast, the adhesive between the chip and lid is normally a compliant thermally conductive and electrically non-conductive adhesive. Alternatively, the adhesive 28 may be electrically non-conductive but provided with internal conductive elements to form an electrical path between the stiffener 24, lid 18 and the substrate 12.

The opposite side of the organic substrate 12 may include electrical connections to the solder balls 16, such as for example, such as a circuit path to array a BGA 30, only schematically indicated, and which form electrical interconnections with the chip 14, as is well known in the technology.

Embedded in the area along the perimeter of the organic substrate 12 is a ring-shaped electrical ground band 32 extending between the top surface of the organic substrate and the connections 30 at the opposite surface. The attachment of the stiffener 24 to the lid or cap 18, as described previously, is an electrically conductive adhesive material, and on the opposite side of the stiffener facing the substrate, an electrically-nonconductive adhesive 34, such as pyrolux, which covers the active circuitized area on the substrate, and a further electrically conductive adhesive material 36 extending over the ground band 32 on the upper surface of the organic substrate 12 so as to form an electrical connection with the stiffener 24, whereas the ground band at the lower surface of the substrate electrically contacts the ball grid array 30. The internal electrical circuitization on the substrate upper surface has a connection 38 formed with the ground band 32 and one or more solder balls 16 on the perimeter of the module, thereby resultingly creating an electromagnetic interference (EMI) shield for the entire semiconductor package 10, shield against outgoing EMI energy and also forming a barrier to incoming or incident EMI energy.

Although, in essence the basic concept of providing EMI shields for various types of devices is known in the technology, it is the specific and advantageous arrangement of the ground band 32 embedded within the organic substrate 12 in communication with the stiffener 24, which in this embodiment creates a superior and unique EMI shield. This is particularly effective for the very high speed switching applications of semiconductor devices which are currently being contemplated in the technology.

Referring now to the embodiment of Figure 2 of the drawings, in this instance, the stiffener utilized in the embodiment of Figure 1 has been eliminated, in that the substrate 40 comprises a rigid ceramic material and consequently does not necessitate the use of a stiffener member; the stiffness being inherently provided by the properties of ceramic material.

As in the previous embodiment, an integrated circuit chip 42 is arranged on an upper surface of the ceramic substrate 40, with the interposition of solder balls 44 which are embedded in an underfill material 46. A lid or heat-dissipating cap structure 48 which extends radially outwardly of the peripheral confines of the integrated circuit chip 42, and which is constituted of an electrically-conductive material, such as has been described in connection with lid or cap structure is, in electrical communication with a ground band 50 consisting of wires embedded within the peripheral region of the substrate 40 and extending between the opposite surfaces thereof. An EMI gasket 52 presenting an electrically-conductive path is interposed between the lid 48 and the upper wire ends of the ground band 50, the latter of which is embedded within the substrate and is located along the perimeter of the latter, whereby the gasket 52 may be adhered to either the lid or the ground band. The lower end of the ground band 50 is in electrically grounding connection with a ball grid array 56 on the surface of the substrate distal to the chip, and further electrical connections can be provided with the chip through one or more of the solder balls and the adhesive extending between the lid and the ground band wire ends at the upper surface of the substrate 40.

With regard to the embodiment of Figure 3 of the drawings, which is substantially similar to that of Figure 2, in this instance, the electrically-conductive cap or lid structure 48 is equipped with a depending peripheral flange 60 having a lower end surface 62 in close proximity with the upper surface of the ceramic substrate 40. Hereby, in lieu of the gasket 52 of adhesive material of Figure 2 extending between

the lower surface of the lid and the upper wire ends of the peripherally embedded ground band 50, there is utilized an electrically conductive EMI adhesive 64 which also communicates with at least one of the solder balls 44 and integrated circuit on the chip so as to form an EMI shield structure similar to that in the embodiments of Figures 1 and 2.

Advantageously, ground bands which are embedded in the perimetrical region of the substrates 12,40 of the various embodiments, provide a highly effective EMI shield or barrier surrounding the entire package or semiconductor structure, thereby reducing or even completely eliminating any outgoing EMI emissions and incoming EMI energy encountered during the operation of the modules.

CLAIMS

1. An electronic package incorporating shielding against the emissions of electromagnetic interference (EMI); comprising:

a circuitized substrate having opposite first and second surfaces, said first surface having a first portion and second portion;

an electrically-conductive ground band being embedded in said substrate and extending between said second portion of said first surface and said second surface;

a semiconductor chip being arranged on said first portion of said first surface;

a plurality of electrically conductive circuit members being positioned on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and

a lid member comprising an electrically conductive material being arranged on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package.

2. An electronic package as claimed in Claim 1, wherein an electrically conductive stiffener is positioned on said second portion on the first surface of said substrate, said stiffener being electrically connected to at least one of said electrically conductive circuit members on said first portion on said first surface of said substrate, and to at least one electrically conductive member on the second surface of said substrate through said electrically conductive ground band.

3. An electronic package as claimed in Claim 2, wherein said stiffener is in electrical connection with said lid member.

4. An electronic package as claimed in Claim 2 or Claim 3, wherein said substrate is comprised of a dielectric organic material.

5. An electronic package as claimed in any preceding claim, wherein said ground band is embedded in said substrate proximate the perimeter of said substrate.

6. An electronic package as claimed in any of claims 2 to 5, wherein an electrically conductive adhesive is arranged between said stiffener and said ground band and between said stiffener and said lid member.

7. An electronic package as claimed in any of claims 2 to 6, wherein said stiffener is located proximate the perimeter of said substrate so as to radially extend about said semiconductor chip.

8. An electronic package as claimed in any preceding claim, wherein a compliant, thermally conductive adhesive is arranged between said semiconductor chip and said lid member.

9. An electronic package as claimed in Claim 1, wherein said substrate comprises a rigid dielectric ceramic material, said ground band being in electrical connection with said lid member through the interposition of an electrically conductive gasket positioned between the second portion on the first surface of said substrate and said lid member.

10. An electronic package as claimed in Claim 1, wherein said substrate comprises a rigid dielectric ceramic material, said lid member having an annular flange extending into proximity to the ground band at the first surface of said substrate, said ground band being in electrical connection with said lid member through the interposition of an electrically conductive adhesive material positioned between the second aereal portion on the first surface of said substrate and a facing end surface on said annular depending flange of said lid member.

11. A method of providing an electronic package incorporating shielding against the emissions and incidence of electromagnetic interference (EMI); comprising:

providing a circuitized substrate having opposite first and second surfaces, said first surface having a first portion and second portion; an electrically-conductive ground band being embedded in said substrate and extending between said second portion of said first surface and said second surface;

arranging a semiconductor chip being arranged on said first portion of said first surface;

positioning a plurality of electrically conductive circuit members on said first portion of said first surface of said substrate each being electrically coupled to said semiconductor chip; and

arranging a lid member comprising an electrically conductive material on a surface of said semiconductor chip distal from the surface facing said substrate whereby said ground band is electrically connected with at least one electrically conductive member arranged on the second surface of said substrate, said lid member and at least one said electrically conductive circuit member on said first portion of the first surface of said substrate so as to impart an electromagnetic shield to said electronic package.