US 20060202335A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2006/0202335 A1**

Mu (43) **Pub. Date: Sep. 14, 2006**

(54) **TAPE BALL GRID ARRAY PACKAGE WITH ELECTROMAGNETIC INTERFERENCE PROTECTION AND METHOD FOR FABRICATING THE PACKAGE**

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(21) Appl. No.: **11/436,961**

(22) Filed: **May 16, 2006**

Related U.S. Application Data

(62) Division of application No. 10/938,836, filed on Sep. 10, 2004, now Pat. No. 7,071,556.

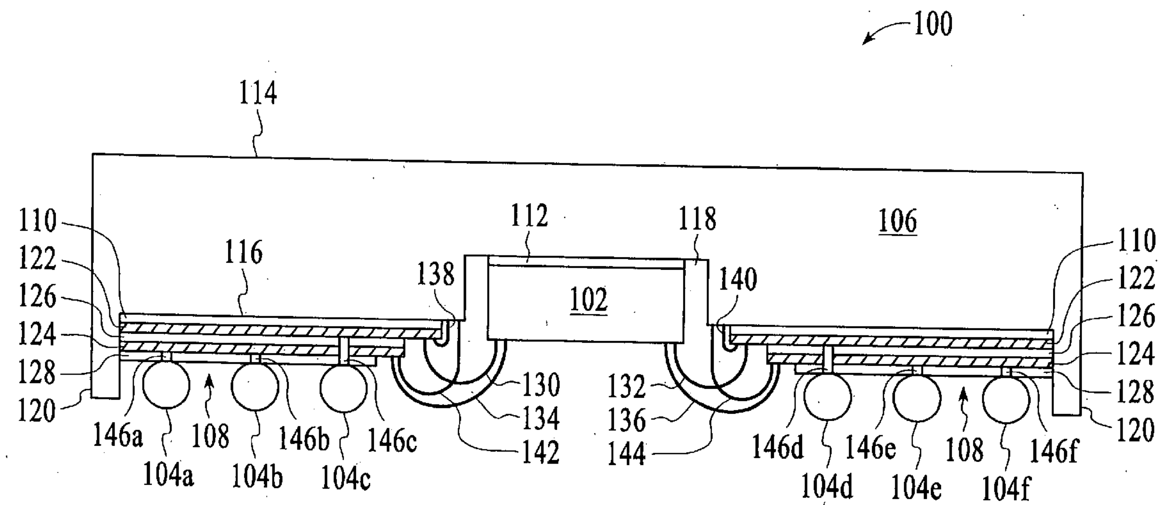
Publication Classification

(51) **Int. Cl.**
H01L 23/48 (2006.01)

(52) **U.S. Cl.** **257/738**

(57) **ABSTRACT**

A tape ball grid array (TBGA) package and method for fabricating the package utilizes at least one electrical connection between a conductive stiffener and a patterned metal layer of a tape substrate, which is connected to a solder ball that is designated to be connected to AC ground, so that the conductive stiffener can be AC grounded. The electrical connection between the conductive stiffener and the AC ground-designated solder ball may be achieved by wirebonding the conductive stiffener to the patterned metal layer of the tape substrate. Since the conductive stiffener can be AC grounded, the conductive stiffener can be used as an electromagnetic interference (EMI) shield.



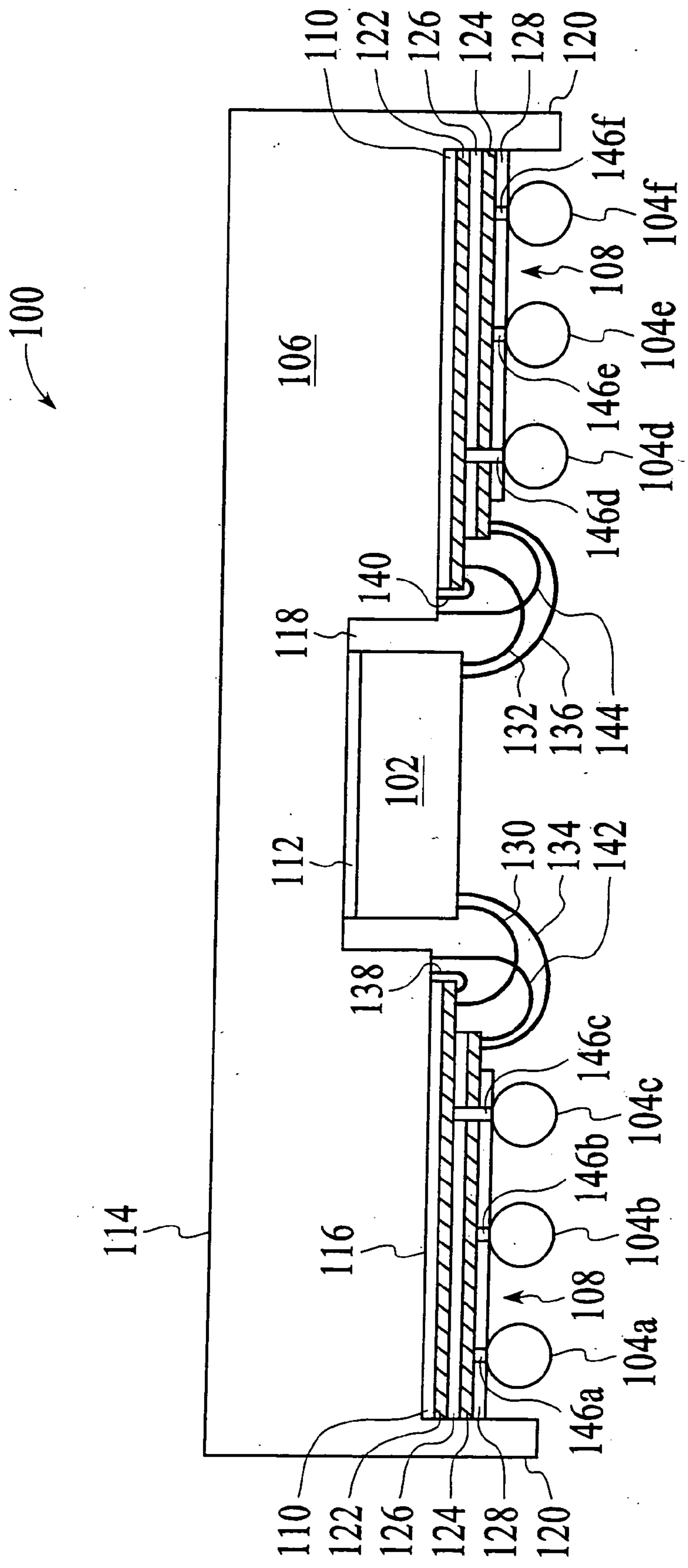
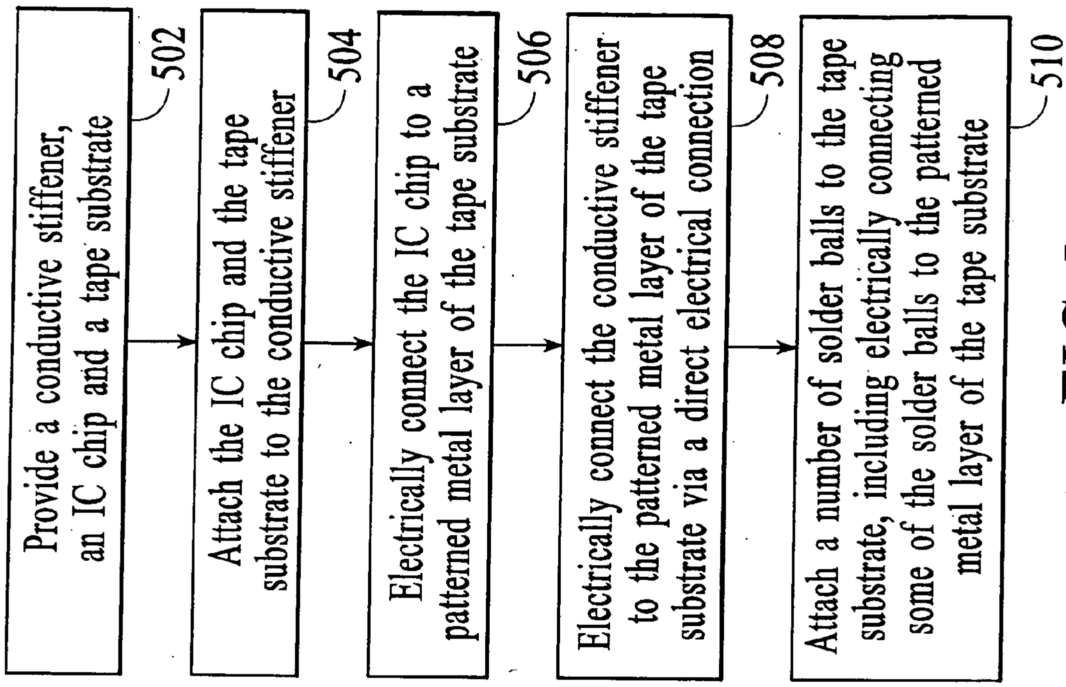
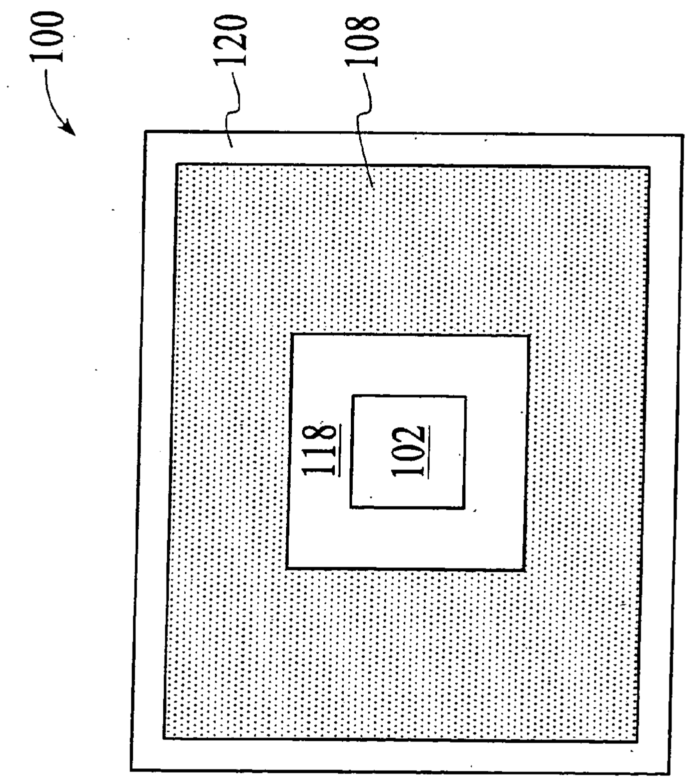

100
106
102
110
122
126
124
128
120
146f
104f
108
104e
146e
104d
146d
140
118
132
136
144
112
130
134
142
138
146c
104c
146b
104b
114
116
108
104a
146a
110
122
126
124
128
120

FIG.1



Provide a conductive stiffener, an IC chip and a tape substrate
502
Attach the IC chip and the tape substrate to the conductive stiffener
504
Electrically connect the IC chip to a patterned metal layer of the tape substrate
506
Electrically connect the conductive stiffener to the patterned metal layer of the tape substrate via a direct electrical connection
508
Attach a number of solder balls to the tape substrate, including electrically connecting some of the solder balls to the patterned metal layer of the tape substrate
510

FIG.5



100
120
108
118
102

FIG.2

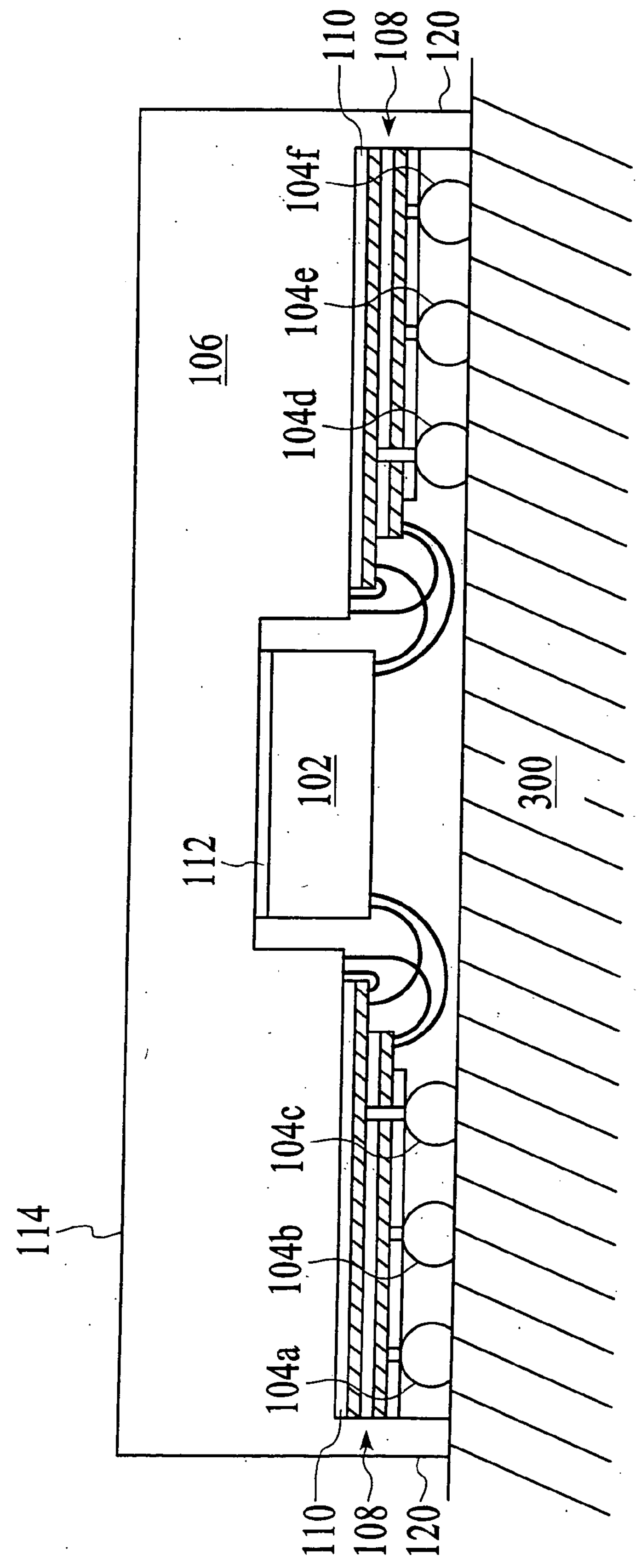

100
106
102
112
114
300
104a
104b
104c
104d
104e
104f
110
108
120
110
108
120

FIG.3

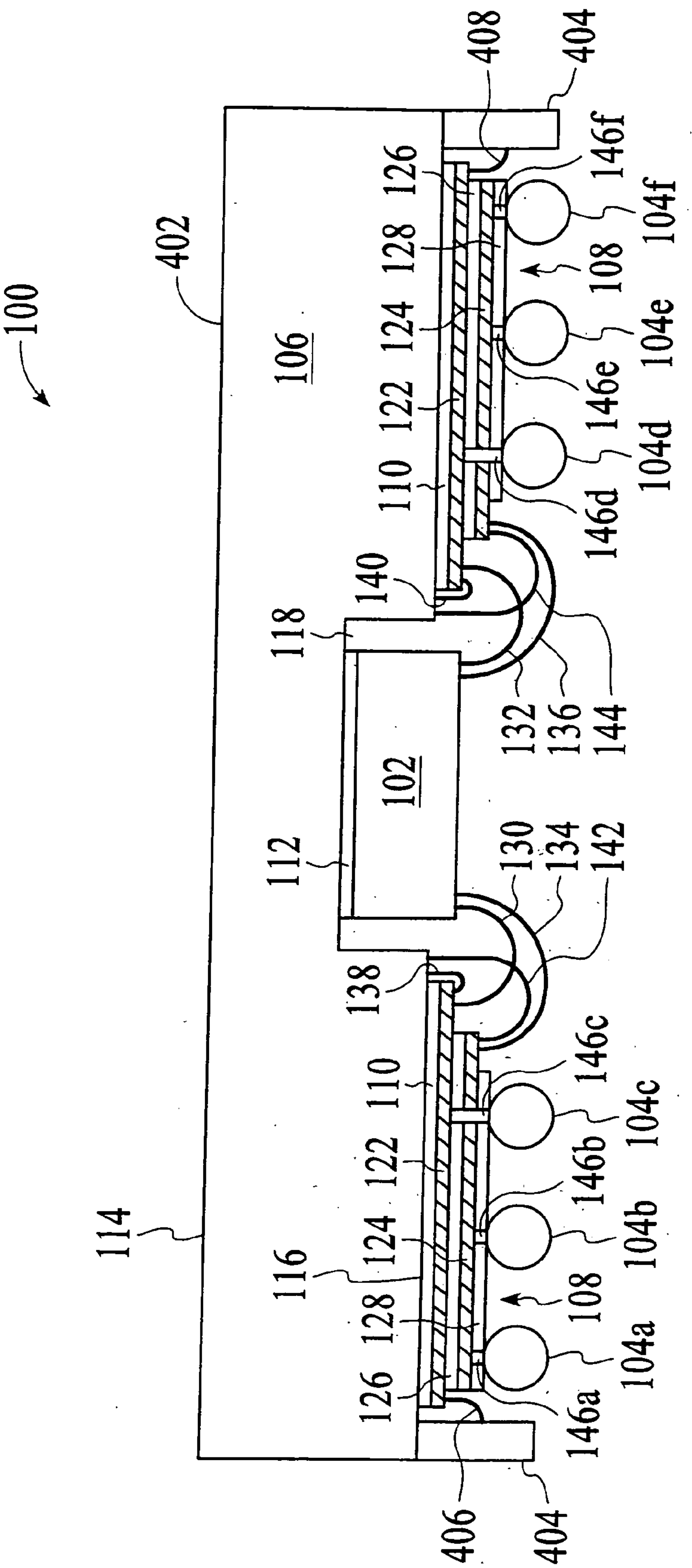

100
402
106
114
116
112
118
102
110
122
124
128
126
140
138
130
134
142
132
136
144
408
404
146f
104f
108
146e
104e
146d
104d
146c
104c
146b
104b
146a
104a
406
404

FIG.4

TAPE BALL GRID ARRAY PACKAGE WITH ELECTROMAGNETIC INTERFERENCE PROTECTION AND METHOD FOR FABRICATING THE PACKAGE

BACKGROUND OF THE INVENTION

[0001] Integrated circuit (IC) chips are becoming more complex with increased circuit density and higher input/output (I/O) counts. In order to accommodate these IC chips, different types of IC packages have been developed, such as tape ball grid array (TBGA) packages, chip scale packages and flip chip packages. Of these different types of IC packages, TBGA packages have become popular due to their low cost and ease of manufacture.

[0002] A conventional TBGA package of interest comprises a tape substrate, an IC chip, and a conductive stiffener. The tape substrate includes at least one dielectric layer and one or more patterned metal layers. The patterned metal layers are typically used for signal transmission and AC signal ground connection. The patterned metal layers are electrically connected to the IC chip via wirebonds. In order to physically and electrically connect the TBGA package to a printed circuit board (PCB), the TBGA package utilizes a number of solder balls that are selectively connected to the patterned layers of the tape substrate. These solder balls are used to attach the TBGA package directly to a PCB or indirectly to the PCB via a socket, and to electrically connect the patterned metal layers of the tape substrate (and thus, the IC chip) to the circuitry on the PCB. The IC chip and the tape substrate are attached to the conductive stiffener, which provides structural support and electrical connection. The conductive stiffener is typically AC signal grounded or floated.

[0003] When the conductive stiffener of the TBGA package is AC signal grounded, the conductive stiffener generates electromagnetic signal into the surrounding environment, and thus, creates electromagnetic interference (EMI) to other electrical components near the TBGA package. In addition, the TBGA package is itself susceptible to EMI caused by electromagnetic field from the surrounding environment.

[0004] One technique to protect the TBGA package from EMI is to connect the conductive stiffener to AC ground, rather than to AC signal ground, so that the conductive stiffener can be used as an EMI shield. The two current methods to connect the conductive stiffener of a TBGA package to AC ground are (1) electrically connecting the conductive stiffener to the IC chip using first wirebonds and electrically connecting the IC chip to a patterned metal layer of the tape substrate using second wirebonds such that the conductive stiffener is electrically connected to the solder balls designated to be connected to AC ground via the first wirebonds, the IC chip, the second wirebonds and the patterned metal layer, and (2) electrically connecting the AC ground-designated solder balls directly to the conductive stiffener using apertures through the tape substrate.

[0005] A concern with the first method to connect the conductive stiffener to AC ground is that the method requires a significant amount of pad space on the IC chip and numerous wirebonds between the IC chip and the tape substrate. Another concern with the first method is that long electrical paths are created between the conductive stiffener to the AC ground-designated solder balls since each signal path includes one of the first wirebonds and one of the second wirebonds.

[0006] A concern with the second method to connect the conductive stiffener to AC ground is that this method requires a special packaging process to attach the AC ground-designated solder balls to the conductive stiffener using the apertures through the tape substrate.

[0007] Consequently, there is a need for a TBGA package with EMI protection and method for fabricating the TBGA package that alleviates some or all of the above-described concerns.

SUMMARY OF THE INVENTION

[0008] A tape ball grid array (TBGA) package and method for fabricating the package utilizes at least one electrical connection between a conductive stiffener and a patterned metal layer of a tape substrate, which is connected to a solder ball that is designated to be connected to AC ground, so that the conductive stiffener can be AC grounded. The electrical connection between the conductive stiffener and the AC ground-designated solder ball may include a wirebond. Since the conductive stiffener can be AC grounded, the conductive stiffener can be used as an electromagnetic interference (EMI) shield.

[0009] A TBGA package in accordance with an embodiment of the invention comprises a conductive supporting structure, an integrated circuit chip attached to the conductive supporting structure, a substrate attached to the conductive supporting structure, the substrate including a patterned metal layer and a dielectric layer, the patterned metal layer being electrically connected to the integrated circuit chip, and a direct electrical connection between the conductive supporting structure and the patterned metal layer.

[0010] A TBGA package in accordance with another embodiment of the invention comprise a metal stiffener with a recessed region, an integrated circuit chip attached to the metal stiffener at the recessed region, a tape substrate attached to the metal stiffener, the tape substrate including a patterned metal layer and a dielectric layer, the pattern metal layer being electrically connected to the integrated circuit chip via a first wirebond, the patterned metal layer further being electrically connected to the metal stiffener via a second wirebond, and a plurality of solder balls attached to the tape substrate, some of the solder balls being electrically connected to the patterned metal layer of the tape substrate such that the metal stiffener is electrically connected to at least one of the solder balls through the second wirebond and the patterned metal layer

[0011] A method for fabricating a TBGA package in accordance with an embodiment of the invention comprises providing a conductive supporting structure, an integrated circuit chip and a substrate, attaching the integrated circuit chip and the substrate to the conductive supporting structure, electrically connecting the integrated circuit chip to a patterned metal layer of the substrate, electrically connecting the conductive supporting structure to the patterned metal layer of the substrate via a direct electrical connection, and attaching a plurality of solder balls to the substrate, including electrically connecting some of the solder balls to the patterned metal layer of the substrate.

[0012] Other aspects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrated by way of example of the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a cross-sectional view of a tape ball grid array (TBGA) package in accordance with an embodiment of the invention.

[0014] **FIG. 2** is a bottom view of the TBGA package of **FIG. 1**.

[0015] **FIG. 3** shows the TBGA package of **FIG. 1** mounted onto a printed circuit board (PCB).

[0016] **FIG. 4** is a cross-sectional view of a TBGA package in accordance with an alternative embodiment of the invention.

[0017] **FIG. 5** is a flow diagram of a method for fabricating a TBGA package in accordance with an embodiment of the invention.

DETAILED DESCRIPTION

[0018] With reference to **FIG. 1**, a tape ball grid array (TBGA) package **100** in accordance with an embodiment of the invention is described. The TBGA package **100** allows an integrated circuit (IC) chip **102** to be electrically and physically attached to a printed circuit board (PCB) in an efficient manner via a number of solder balls **104**. As described in more detail below, the TBGA package **100** includes a conductive stiffener **106** that can be connected to AC ground, which is separate from AC signal ground. The TBGA package **100** does not require a special packaging process, as is the case in some conventional TBGA packages with a conductive stiffener that can also be connected AC ground. Furthermore, when compared to comparable conventional TBGA packages, the TBGA package **100** has shorter electrical paths between the conductive stiffener **106** and the solder balls **104** designated to be connected to AC ground, and requires a fewer number of electrical connections and a fewer number of pads on the IC chip **102** to connect the conductive stiffener to the AC ground-designated solder balls. In an exemplary embodiment, the conductive stiffener **106** is designed to provide an effective electromagnetic interference (EMI) shield when the TBGA package **100** is mounted onto a PCB.

[0019] As shown in **FIG. 1**, which is a cross-sectional view, the TBGA package **100** includes the conductive stiffener **106**, a tape substrate **108**, the IC chip **102**, and the solder balls **104**. The solder balls **104** are attached to the tape substrate **108**, which is attached to the conductive stiffener **106** by a layer of adhesive material **110**, such as a layer of epoxy. Thus, the tape substrate **108** is situated between the solder balls **104** and the conductive stiffener **106**. The IC chip **102** is directly attached to the conductive stiffener **106** by an adhesive material **112**, preferably a thermally conductive material, such as epoxy. The TBGA package **100** is designed to be mounted onto a PCB by attaching the solder balls **104** to electrical contacts on a PCB or on a socket of the PCB.

[0020] The conductive stiffener **106** of the TBGA package **100** provides structural support for the IC chip **102**, the tape substrate **108** and the solder balls **104** that are attached to the tape substrate **108**. Thus, the conductive stiffener **106** can be viewed as a supporting structure for the entire TBGA package **100**. The conductive stiffener **106** also provides heat dissipation, especially the heat from the IC chip **102**. Therefore, the conductive stiffener **106** functions as a heatsink. The conductive stiffener **106** also provides AC ground electrical connection when the conductive stiffener is AC grounded. Thus, the conductive stiffener **106** is preferably made of a sturdy material that is both electrically conductive and thermally conductive, such as copper or other comparable metallic material.

[0021] The conductive stiffener **106** has an exposed surface **114** and an inner surface **116**. The exposed surface **114** of the conductive stiffener **106** will be the top surface of the TBGA package **100** when the package is mounted onto a PCB. The inner surface **116** of the conductive stiffener **106** is the surface on which the tape substrate **108** and the IC chip **102** are attached to the conductive stiffener. As illustrated in **FIG. 1**, the conductive stiffener **106** includes a recessed region **118** on the inner surface **116**. The recessed region **118** is designed to accommodate the IC chip **102**. The IC chip **102** is attached to the conductive stiffener **106** at the recessed region **118** by the adhesive material **112**.

[0022] In the exemplary embodiment, the conductive stiffener **106** includes a protruding member **120** located on the inner surface **116**. Thus, the protruding member **120** is on the same side of the conductive stiffener **106** on which the IC chip **102** and the tape substrate **108** are attached. The protruding member **120** surrounds an area in which the IC chip **102** and the tape substrate **108** are located. Thus, the protruding member **120** forms a wall around the IC chip **102** and the tape substrate **108**, as illustrated in **FIG. 2**, which is a bottom view of the TBGA package **100**. **FIG. 2** only shows the protruding member **120** of the conductive stiffener **106**, the tape substrate **108** and the IC chip **102**. The solder balls **104** and other components or features of the TBGA package **100** are not illustrated in **FIG. 2**. The protruding member **120** of the conductive stiffener **106** is shown in **FIGS. 1 and 2** to be located on the edges of the inner surface **116**. However, the protruding member **120** of the conductive stiffener **106** may be located at some distance from the edges of the inner surfaces **116**.

[0023] As illustrated in **FIG. 3**, the protruding member **120** allows the conductive stiffener **106** to substantially enclose the IC chip **102** and the tape substrate **108** over a PCB **300** when the TBGA package **100** is mounted onto the PCB. In **FIG. 3**, some of the reference numerals for the components of the TBGA package **100** are not shown to provide a more clear illustration. When the solder balls **104** are reflowed to attach the TBGA package **100** onto the PCB **300**, the protruding member **120** of the conductive stiffener **106** can contact or almost contact the surface of the PCB such that the IC chip **102** and the tape substrate **108** are substantially covered by the conductive stiffener. Thus, the height of the protruding member **120** should be at least the thickness of the tape substrate **108**. Since the conductive stiffener **106** substantially covers the IC chip **102** and the tape substrate **108**, when the conductive stiffener **106** is connected to AC ground, the conductive stiffener serves as an effective shield that protects the IC chip **102** and the tape substrate **108** from EMI.

[0024] Turning back to **FIG. 1**, the tape substrate **108** of the TBGA package **100** includes patterned metal layers **122** and **124**, a dielectric layer **126** and a cover layer **128**. The patterned metal layers **122** and **124** are used for AC signal ground connection and for signal transmission. As an example, the patterned metal layer **122** can be used for AC signal ground connection and the patterned metal layer **124** can be used for signal transmission. The patterned metal layers **122** and **124** provide electrical connections between the conductive stiffener **106**, the IC chip **102** and the solder balls **104**, as described in more detail below. The patterned metal layers **122** and **124** are made of electrically conductive material, such as copper. The dielectric layer **126** is positioned between the metal layers **122** and **124**, and thus, provides electrical insulation between the metal layers. As an example, the dielectric layer **126** may be made of a polyimide material. The cover layer **128** is positioned between the metal layer **124** and the solder balls **104**. The cover layer **128** is made of a dielectric material to provide electrical insulation for the patterned metal layer **124**.

[0025] The patterned metal layers **122** and **124** of the tape substrate **108** are electrically connected to the IC chip **102**, the conductive stiffener **106** and the solder balls **104**. As illustrated in **FIG. 1**, the patterned metal layer **122** is electrically connected to the IC chip **102** by wirebonds **130** and **132**, while the patterned metal layer **124** is electrically connected to the IC chip by wirebonds **134** and **136**. Similarly, the patterned metal layer **122** is electrically connected to the conductive stiffener **106** by wirebonds **138** and **140**, while the patterned metal layer **124** is electrically connected to the conductive stiffener by wirebonds **142** and **144**.

[0026] The solder balls **104** are electrically connected to either the patterned metal layer **122** or the patterned metal layer **124** through apertures **146** in the tape substrate **108**. These apertures **146** either extend through just the cover layer **128** of the tape substrate **108** or through the cover layer, the patterned metal layer **124** and the dielectric layer **126** of the tape substrate. In the illustrated embodiment, the solder balls **104***a*, **104***b*, **104***e* and **104***f* are electrically connected to the patterned metal layer **124** through the apertures **146***a*, **146***b*, **146***e* and **146***f*, respectively, and the solder balls **104***c* and **104***d* are electrically connected to the patterned metal layer **122** through the apertures **146***c* and **146***d*, respectively.

[0027] Although only four wirebonds **130**, **132**, **134** and **136** that provide electrical connections between the IC chip **102** and the patterned metal layers **122** and **124** are illustrated in **FIG. 1**, there are in fact many more wirebonds connected between the IC chip and the patterned metal layers, and consequently there are many more solder balls that the illustrated solder balls **104***a*-**104***f*. The exact number of wirebonds connected between the IC chip **102** and the patterned metal layers **122** and **124** and the exact number of solder balls attached to the tape substrate **108** depend on the IC chip type and the application for which the TBGA package **100** is designed to be used. Similarly, although four wirebonds **138**, **140**, **142** and **144** that provide electrical connections between the conductive stiffener **106** and the patterned metal layers **122** and **124** are illustrated in **FIG. 1**, there may be fewer or more wirebonds connected between the conductive stiffener and the patterned metal layers.

[0028] The patterned metal layers **122** and **124** essentially function as electrical signal lines. Thus, the patterned metal layers **122** and **124** can selectively connect the wirebonds **130-144** to the solder balls **104**. In the illustrated embodiment, the patterned metal layer **122** electrically connects the wirebonds **138** and **140** to the solder balls **104***c* and **104***d*, respectively. The patterned metal layer **124** electrically connects the wirebonds **142** and **144** to the solder balls **104***b* and **104***e*, respectively. The patterned metal layer **124** also electrically connects the wirebonds **134** and **136** to the solder balls **104***a* and **104***f*, respectively, for signal transmission between the solder balls **104***a* and **104***f* and the IC chip **102**. Since the wirebonds **138**, **140**, **142** and **144** are connected to the conductive stiffener **106**, the solder balls **104***b*, **104***c*, **104***d* and **104***e* are electrically connected to the conductive stiffener. The solder balls **104***b*, **104***c*, **104***d* and **104***e* are designated to be connected to AC ground. Therefore, the conductive stiffener **106** can be AC grounded by connecting the solder balls **104***b*, **104***c*, **104***d* and **104***e* to AC ground, which can be a board chassis.

[0029] As illustrate in **FIGS. 1 and 3**, the protruding member **120** of the conductive stiffener **106** is an integrated part of the conductive stiffener. That is, the conductive stiffener **106** with the protruding member **120** is a single structural unit. However, in an alternative embodiment, the conductive stiffener **106** may be composed of separate structural components, as illustrated in **FIG. 4**. In this embodiment, the conductive stiffener **106** includes a main body **402** and a protruding member **404**, which are separate structural components of the conductive stiffener. Since the protruding member **404** of the conductive stiffener **106** may not be electrically connected to the main body **402**, the protruding member may be electrically connected to the patterned layer **122** and/or the patterned layer **124** of the tape substrate **108** via wirebonds so that the protruding member can also be AC grounded to provide EMI protection for the IC chip **102** and the tape substrate **108** when the TBGA package **100** is mounted onto a PCB. As an example, in **FIG. 4**, the protruding member **404** of the conductive stiffener **106** is electrically connected to the patterned metal layer **122** of the tape substrate **108** via wirebonds **406** and **408** such that the protruding member is electrically connected to the AC ground-designated solder balls **104***c* and **104***d*.

[0030] In conventional TBGA packages, the conductive stiffener is typically connected to AC ground-designated solder balls in one of two methods. The first method involves making apertures in the tape substrate that extend completely through the tape substrate and then forming the AC ground-designated solder balls on the apertures so that the solder balls electrically contact the conductive stiffener. The second method involves electrically connecting the conductive stiffener to the IC chip using first wirebonds and then electrically connecting the IC chip to a patterned metal layer of the tape substrate using second wirebonds, which is electrically connected to the AC ground-designated solder balls, such that the conductive stiffener is electrically connected to the AC ground-designated solder balls through the first wirebonds, the IC chip, the second wirebonds and the patterned metal layer of the tape substrate.

[0031] A concern with the first conventional method is that the method involves a special packaging process, which increases the complexity and cost for fabricating the TBGA packages. This concern is not applicable to the TBGA package **100** because the TBGA package **100** does not use such apertures in the tape substrate **106** to electrically connect the conductive stiffener **106** to the AC ground-designated solder balls **104***b*, **104***c*, **104***d* and **104***e*.

[**0032**] A concern with the second conventional method is that signal paths from the conductive stiffener to the AC ground-designated solder balls include the length of the first wirebonds and the length of the second wirebonds. Thus, the electrical bond length and impedance between the conductive stiffener and one of the patterned layers of the tape substrate in the conventional TBGA packages are significantly greater than the TBGA package **100**, which uses only a single wirebond, rather than two wirebonds, to connect the conductive stiffener **106** to one of the patterned metal layers **122** and **124** of the tape substrate **108**.

[**0033**] Another concern with the second conventional method is that, since the first and second wirebonds are connected to the IC chip, a single electrical connection between the conductive stiffener and an AC ground-designated solder ball requires two pads on the IC chip so that two wirebonds can be connected to the IC chip for each electrical connection between the conductive stiffener to one of the AC ground-designated solder balls. In contrast, the TBGA package **100** does not require these pads on the IC chip **102** to make electrical connections between the conductive stiffener **106** and the AC ground-designated solder balls **104***b*, **104***c*, **104***d* and **104***e*.

[**0034**] A method for fabricating a TBGA package in accordance with an embodiment of the invention is described with reference to the process flow diagram of **FIG. 5**. At block **502**, a conductive stiffener, an IC chip and a tape substrate are provided. Next, at block **504**, the IC chip and the tape substrate are attached to the conductive stiffener. Next, at block **506**, the IC chip is electrically connected to a patterned metal layer of the tape substrate. In an exemplary embodiment, the IC chip is wirebonded to the patterned metal layer of the tape substrate using a number of wirebonds. Next, at block **508**, the conductive stiffener is electrically connected to the patterned metal layer of the tape substrate via a direct electrical connection. In the exemplary embodiment, the metal stiffener is wirebonded to the patterned metal layer of the tape substrate using one or more wirebonds. Next, at block **510**, a number of solder balls are attached to the tape substrate. The attaching of the solder balls to the tape substrate includes electrically connecting some of the solder balls to the patterned metal layer of the substrate. Since the conductive stiffener is electrically connected to some of the solder balls via the patterned metal layer of the tape substrate, the conductive stiffener can be AC grounded, for example, to a board chassis.

[**0035**] Although specific embodiments of the invention have been described and illustrated, the invention is not to be limited to the specific forms or arrangements of parts so described and illustrated. The scope of the invention is to be defined by the claims appended hereto and their equivalents.

1-15. (canceled)

16. A method for fabricating a tape ball grid array package, the method comprising:

providing a conductive supporting structure, an integrated circuit chip and a substrate;

attaching the integrated circuit chip and the substrate to the conductive supporting structure;

electrically connecting the integrated circuit chip to a patterned metal layer of the substrate;

electrically connecting the conductive supporting structure to the patterned metal layer of the substrate via a direct electrical connection; and

attaching a plurality of solder balls to the substrate, including electrically connecting some of the solder balls to the patterned metal layer of the substrate.

17. The method of claim 16 further comprising electrically connecting the conductive supporting structure to a second patterned metal layer of the substrate.

18. The method of claim 16 wherein the electrically connecting of the conductive supporting structure to the patterned metal layer of the substrate includes wirebonding the conductive supporting structure to the patterned metal layer of the substrate.

19. The method of claim 16 wherein the conductive supporting structure includes a protruding member on the same side of the conductive supporting structure on which the integrated circuit chip is attached, the protruding member being configured to substantially surround the integrated circuit chip attached to the conductive supporting structure.

20. The method of claim 19 further comprising electrically connecting the protruding member to the patterned metal layer of the substrate.

* * * * *