Abstract: A no-exposed-pad quad flat no-lead (QFN) packaging structure is disclosed. The no-exposed-pad QFN packaging structure includes a metal substrate, a first die coupled to a top surface of the metal substrate, and a plurality of I/O pads formed based on the metal substrate and extends to proximity of the die. The no-exposed-pad QFN packaging structure also includes a first metal layer, which contains a plurality of inner leads corresponding to the plurality of I/O pads and extending to proximity of the die and is formed on the metal substrate by a multi-layer electrical plating process such that a lead pitch of the plurality of inner leads is significantly reduced. Further, the no-exposed-pad QFN packaging structure includes metal wires connecting the die and the plurality of inner leads, and a second metal layer formed on a back surface of the plurality of I/O pads. The die, the plurality of inner leads, and metal wires are sealed with a molding compound.
NO-EXPOSED-PAD QUAD FLAT NO-LEAD (QFN) PACKAGING STRUCTURES
AND METHOD FOR MANUFACTURING THE SAME

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims the priority of Chinese patent application no. 201110383889.2, filed on semiconductor packaging technology, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention generally relates to the field of semiconductor assembly or packaging and, more particularly, to quad flat no-lead (QFN) packaging technologies.

BACKGROUND

[0003] There are mainly two types of conventional lead frame structures used in semiconductor packaging processes. For the first type, as shown in Figure 48, after performing chemical etching and electrical plating (or simply plating) on the metal substrate, a layer of high-temperature resistant film is affixed on the back surface of the metal substrate to form the lead frame carrier to be used in the packaging process.

[0004] For the second type, as shown in Figure 50, chemical half etching is first performed on the back surface of the metal substrate, and the chemically half etched areas are sealed with encapsulation material. Further, chemical half
etching for inner leads is performed on the top surface of the metal substrate and followed by plating on the surface of inner leads of the lead frame so as to complete the lead frame.

[0005] However, both of these two types of lead frames may have certain disadvantages in the packaging process. For example, for the first type, the issues may include:

1) Because an expensive high-temperature film must be affixed on the back surface of the metal substrate, the manufacturing cost is directly increased;

2) In the die attaching process of the packaging process, also because a high-temperature resistant film must be affixed on the back surface of the metal substrate, only epoxy may be used in the die attaching process, and certain techniques such as the eutectic process or soft solder technique cannot be used, which greatly limits choices of available products;

3) In the wire bonding process of the packaging process, also because a high-temperature resistant film must be affixed on the back surface of the metal substrate and the high-temperature resistant film is a kind of soft material, the wire bonding parameters may become unstable, which seriously impacts on the quality of wire bonding and the reliability and stability of the product; and

4) In the molding process, also because a high-temperature resistant film must be affixed on the back surface of the metal substrate, the molding pressure during the molding process may cause certain mold bleeding between the lead frame and the high-temperature resistant film, which may change a conductive metal lead into an insulated lead, as shown in Figure 49 (certain metal leads on the left side of the drawing are insulated by bleeding material).
For the second type conventional lead frame structure, the issues may include:

1) Because the etching process was carried out twice, manufacturing cost may be increased;

2) Because the composition of the lead frame is metal material and compound, when operated in a high and low temperature environment, the lead frame may be warping due to the different expansion and shrinkage stress of the different materials;

3) The warpage of the lead frame may impact the accuracy of die attaching process and may also affect the production yield due to the impact on the smooth transferring of the warping lead frames in the die attaching process;

4) The warpage of the lead frame may also impact the alignment accuracy of the wire bonding and may also affect the production yield due to the impact on the smooth transferring of the warping lead frames in the wire bonding process; and

5) Because the inner leads on the top surface of the lead frame are formed using etching technique, the width of the inner leads might have to be greater than 100im and the distance between two adjacent inner leads also must have to be greater than 100im. Thus, it may be difficult to achieve high density for the inner leads.

The disclosed methods and systems are directed to solve one or more problems set forth above and other problems.
One aspect of the present disclosure includes a no-exposed-pad quad flat no-lead (QFN) packaging structure. The no-exposed-pad QFN packaging structure includes a metal substrate, a first die coupled to a top surface of the metal substrate, and a plurality of I/O pads formed based on the metal substrate. The no-exposed-pad QFN packaging structure also includes a first metal layer, which contains a plurality of inner leads corresponding to the plurality of I/O pads and extending to proximity of the die and is formed on the metal substrate by a multi-layer electrical plating process such that a lead pitch of the plurality of inner leads is significantly reduced. Further, the no-exposed-pad QFN packaging structure includes metal wires connecting the die and the plurality of inner leads, and a second metal layer formed on a back surface of the plurality of I/O pads. The die, the plurality of inner leads, and metal wires are sealed with a molding compound.

Another aspect of the present disclosure includes a method for manufacturing a no-exposed-pad quad flat no-lead (QFN) packaging structure. The method includes providing a metal substrate, forming a first photoresist film on a top surface of the metal substrate, and forming a plating pattern in the first photoresist film using photolithography. The method also includes forming a first metal layer containing a plurality of inner leads by a multi-layer electrical plating process using the plating pattern in the first photoresist film as a mask, such that a lead pitch of the plurality of inner leads is significantly reduced. Further, the method includes attaching at least one die in a predetermined region on the top
surface of the metal substrate, and connecting the die and the plurality of inner leads using metal wires by a wire bonding process. The method also includes sealing the die, the plurality of inner leads, and metal wires with a molding compound, and etching the metal substrate from a back surface of the metal substrate to form a plurality of I/O pads corresponding to the plurality of inner leads. In addition, the method includes attaching a second metal layer on a back surface of the plurality of I/O pads.

[0010] Other aspects of the present disclosure can be understood by those skilled in the art in light of the description, the claims, and the drawings of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figures 1-15 illustrate an exemplary process for manufacturing an exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

[0012] Figures 16(A)-16(B) illustrate an exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

[0013] Figures 17(A)-17(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

[0014] Figures 18(A)-18(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;
Figures 19(A)-19(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 20(A)-20(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 21(A)-21(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 22(A)-22(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 23(A)-23(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 24(A)-24(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 25(A)-25(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 26(A)-26(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 27(A)-27(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 28(A)-28(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;
Figures 29(A)-29(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 30(A)-30(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 31(A)-31(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 32(A)-32(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 33(A)-33(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 34(A)-34(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 35(A)-35(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 36(A)-36(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 37(A)-37(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 38(A)-38(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;
Figures 39(A)-39(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 40(A)-40(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 41(A)-41(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 42(A)-42(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 43(A)-43(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 44(A)-44(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 45(A)-45(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 46(A)-46(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figures 47(A)-47(B) illustrate another exemplary no-exposed-pad QFN packaging structure consistent with the disclosed embodiments;

Figure 48 shows a high-temperature resistant film affixed on a lead frame;
[0045] Figure 49 shows mold bleeding between the lead frame and the high-temperature resistant film; and

[0046] Figure 50 shows a two-side etched lead frame.

DETAILED DESCRIPTION

[0047] Reference will now be made in detail to exemplary embodiments of the invention, which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[0048] Figure 16(A) and Figure 16(B) illustrate an exemplary no-exposed-pad quad flat no-lead (QFN) packaging structure consistent with the disclosed embodiments. Figure 16(A) is a cross-section view of Figure 16(B). A no-exposed-pad QFN packaging structure, as used herein, may refer to a QFN packaging structure that does not have an outer die pad on the back surface of the QFN packaging structure.

[0049] As shown in Figure 16(A) and Figure 16(B), the no-exposed-pad QFN packaging structure includes a plurality of input/output (I/O) pads 1, a plurality of inner leads 3, die 4, metal wire(s) 5, and encapsulation material 6, such as EMC compound. Certain components may be omitted and other components may be added.

[0050] Die 4 may include any pre-made semiconductor chip to be assembled or packaged. The I/O pads 1 may include a plurality of metal pads or traces to provide external connections to the die 4 or any other components inside
the no-exposed-pad QFN packaging structure through inner leads 3. The I/O pads 1 may be in any appropriate shape, such as a rectangle. The plurality of pads of the I/O pads 1 may be arranged in an array configuration or any other appropriate configuration. For example, in certain embodiments, as shown in Figure 16(B), the I/O pads 1 are arranged in a single ring configuration.

[0051] The die 4 may be mounted on the top surface of a substrate or other planar supporting structure through a conductive or non-conductive adhesive material 7, such as epoxy, soft solder, or other conductive or non-conductive material. Further, from the top surface of the I/O pads 1, an electrical plating (or simply plating) process such as multi-plating may be used to form the inner leads 3. More specifically, multiple layers may be formed by plating such that the distance between adjacent inner leads (i.e., inner lead pitch) may be substantially reduced. The top surface of the inner leads 3 and the top surface of die 4 may be connected by the metal wires 5. Further, the inner leads 3 may be formed significantly close to the die 4 via lead traces, such that the length of metal wires 5 connecting the die 4 to the inner leads 3 may also be substantially reduced.

[0052] All inner leads 3 may be referred as a first metal layer. That is, the first metal layer includes all leads of inner leads 3 or the inner leads 3 are formed as part of the first metal layer. The inner leads 3, the die 4, and the metal wires 5 are covered with encapsulation material 6, such as EMC compound. Further, at the backside of the substrate, sealant 9 is filled in the peripheral areas of the I/O pads 1 and the area between adjacent I/O pads 1. The back surface of the I/O pads 1 are exposed from the sealant 9 and a second metal layer 8 is formed on the
back surface of the I/O pads 1. Sealant 9 may include any appropriate type of sealant, such as a no-filler compound or a small-filler compound.

[0053] The process for manufacturing the above described packaging structure may be explained below in detail with corresponding drawings 1-15. The process may be used to make a plurality of components (packaged ICs). Because each component or packaged IC may be made in the same way, only a single packaged IC or QFN packaging structure may be described for illustrative purposes.

[0054] As shown in Figure 1, at the beginning, a metal substrate 10 is provided for the lead frame manufacturing and packaging process. Metal substrate 10 may have a desired thickness and be made from various metal materials depending on particular types of die 4. For example, metal substrate 10 may be made from one of copper, aluminum, iron, copper alloy, stainless steel, or nickel-iron alloy. Other materials may also be used.

[0055] Further, as shown in Figure 2, a layer of photoresist film 11 and a layer of photoresist film 12 may be formed (pasted or coated) on the top surface and the back surface of the metal substrate 10, respectively. The photoresist film 11 and/or photoresist film 12 may be formed using various ways. For example, photoresist film 11 and/or photoresist film 12 may be coated on the surface or may be pasted on the surface. The photoresist films 11 and 12 may be used to protect the metal substrate 10 in subsequent plating processes, and the photoresist films 11 or 12 may include a dry photoresist film or a wet photoresist film. Other types of photoresist films may also be used.
Further, as shown in Figure 3, portions of the photoresist film 11 on the top surface of the metal substrate 10 may be removed to form a pattern by photolithography. As shown in Figure 3, photolithography equipment may be used to perform exposure, development, and etching on the photoresist film 11 using a corresponding mask to form a plating pattern in the photoresist film 11. The plating pattern may expose the predetermined areas of the metal substrate 10 for subsequent plating process to form the first metal layer 13, i.e., a first metal layer pattern.

After forming the plating pattern or the first metal layer pattern, as shown in Figure 4, a multi-layer plating process may be performed to form the first metal layer 13 in the areas of the metal substrate 10 exposed by the plating pattern in the photoresist film 11. In other words, the multi-layer plating process is performed on the top surface of the metal substrate 10 using the pattern in the photoresist film 11 as a mask to form inner leads 3 (the first metal layer 13). The inner leads 3 may be formed corresponding to the I/O pads 1 and may also be arranged in a corresponding shape (e.g., a rectangle) and configuration (e.g., a single ring configuration). Other shapes and configurations may also be used.

Because the inner leads 3 are formed by the plating process, the lead pitch of the inner leads 3 and the distance between the inner leads 3 and the die 4 may be substantially reduced. For example, the inner leads 3 may be formed by a thin-line plating method on the top surface of the metal substrate 10. The width of the inner leads 3 may be approximately 25 µm, and the lead pitch of the inner leads 3 may also be approximately 25 µm. Comparing the lead pitch of
about 10 \(\mu \text{m} \) in conventional lead frames, the width of the inner leads 3 and the lead pitch of the inner leads 3 may be significantly reduced, which may achieve high density for inner leads 3. Further, the inner leads 3 may extend to the proximity of the die 4 via lead traces. Using the plating process, the distance between the die and the inner leads 3 can also be significantly reduced such that the inner leads 3 can extend substantially close to the die 4, which can substantially reduce the package size.

[0059] The first metal layer 13 (e.g., the inner leads 3) may include any appropriate number of layers of metal materials and/or metal layer structure. For example, the first metal layer 13 may include, from bottom to the top, a total of five layers of nickel, copper, nickel, palladium, and gold, respectively, or a total of three layers of nickel, copper, and silver. Other materials and number of layers and/or layer structures may also be used.

[0060] Different metal layers in the first metal layer 13 may provide different functionalities. For example, in a five-layer structure (nickel, copper, nickel, palladium, and gold), the bottom layer of nickel may be used as an erosion resistant and barrier layer, the middle layers of copper, nickel and palladium may be used to increase the thickness of the first metal layer 13, and the top layer of gold may be used for wire bonding. Other functionalities may also be provided and other metal layer structures may also be used.

[0061] Further, as shown in Figure 5, the remaining top surface photoresist film 11 is removed and inner leads 3 are formed on the metal substrate 10. The back surface photoresist film 12 is also removed.
After removing the photoresist films, the die 4 may be mounted on a predetermined die area of the metal substrate 10 using the conductive or non-conductive adhesive material 7, as shown in Figure 6, in a die attaching process. The predetermined die area of the metal substrate 10 may correspond to the area for attaching the die 4. More particularly, the die 4 may be mounted or attached to an area among the inner leads 3 or surrounded by the inner leads 3. The top surface of die 4 and the top surface of the inner leads 3 are connected with metal wires 5 in a wire bonding process, as shown in Figure 7.

The inner leads 3, the die 4, and the metal wires 5 are then encapsulated using encapsulation material 6, as shown in Figure 8. For example, molding equipment may be used to seal or encapsulate the metal substrate 10 completed die attaching and wire bonding by a molding compound. Post-molding curing may also be performed such that the molding compound or other encapsulation materials may also be cured before the next manufacturing process.

As shown in Figure 9, after the encapsulation process (e.g., molding and post-molding curing), a layer of photoresist film 12 may be formed on the top surface of the metal substrate 10 and another layer of photoresist film 12 may be formed on the back surface of the metal substrate 10. The photoresist films may be used to protect the metal substrate 10 in subsequent etching processes, and the photoresist films may include a dry photoresist film or a wet photoresist film. Other types of photoresist films may also be used.

Further, portion of the photoresist film 12 on the back surface of the metal substrate 10 may be removed to form a pattern using photolithography.
As shown in Figure 10, photolithography equipment may be used to perform exposure, development, and etching on the photoresist film 12 on the back surface of the metal substrate 10 using a corresponding mask to form an etching pattern in the photoresist film 12. The etching pattern may expose the predetermined areas on the back surface of the metal substrate 10 for subsequent etching process to form I/O pads 1, i.e., the I/O pad pattern.

After forming the etching pattern, as shown in Figure 11, an etching process may be performed on the areas of the metal substrate 10 exposed by the etching pattern in the photoresist film 12. In other words, the etching process is performed on the metal substrate 10 using the pattern in the photoresist film 12 as a mask. The etching process may be full etching or half etching. Etched areas are thus formed on the back surface of the metal substrate 10, and the I/O pads 1 are also formed after the etching process.

Further, as shown in Figure 12, after the etching process, the remaining photoresist film 12 on the back surface of the metal substrate 10 is removed to expose the etched areas on the back surface of the metal substrate 10 including the peripheral areas of the I/O pads 1 and the areas between leads of the I/O pads 1. The photoresist film 12 on the top surface of the metal substrate 10 is also removed.

Afterwards, as shown in Figure 13, the etched areas on the back surface of the metal substrate 10 are filled with sealant 9 using filling equipment. Post-molding curing may be performed on the sealant 9. The sealant 9 may include any appropriate sealant, such as a filler sealant or a no-filler sealant, and
may also be filled at a certain height. Thus, the I/O pads 1 may be supported by both the molding compound 6 and the sealant 9. The sealant 9 may include any appropriate sealant, such as a no-filler compound or a small-filler compound.

[0069] As shown in Figure 14, a plating process may be performed on the back surface of the I/O pads 1 to form a second metal layer 8. The second metal layer 8 may be made from various materials, such as gold, nickel, copper, palladium, silver or tin, etc.

[0070] Thus, a no-exposed-pad QFN packaging structure with single lead ring may be formed. Afterwards, as shown in Figure 15, the plurality of encapsulated components formed on the metal substrate 10 may be individually cut to obtain individual packaged ICs or individual no-exposed-pad QFN packaging structures in a package sawing process. Other cutting methods may also be used.

[0071] Further, the no-exposed-pad QFN packaging structure may also include various different structures and configurations. For example, Figure 17(A) and Figure 17(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 17(A) is a cross-section view of Figure 17(B).

[0072] As shown in Figure 17(A) and Figure 17(B), the no-exposed-pad QFN packaging structure in Figure 17(A) and Figure 17(B) is similar to the no-exposed-pad QFN packaging structure in Figure 16(A) and Figure 16(B). However, the no-exposed-pad QFN packaging structure in Figure 17(A) also includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be
formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad and single lead ring may be formed.

[0073] Figure 18(A) and Figure 18(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 18(A) is a cross-section view of Figure 18(B).

[0074] As shown in Figure 18(A) and Figure 18(B), the no-exposed-pad QFN packaging structure in Figure 18(A) and Figure 18(B) is similar to the no-exposed-pad QFN packaging structure in Figure 16(A) and Figure 16(B). However, the no-exposed-pad QFN packaging structure in Figure 18(A) also includes one or more passive device 14 coupled between inner leads 3 using conductive or non-conductive adhesive material 7. The passive device 14 may be coupled between inner leads 3 before the die 4 is attached or during the die attaching process. Thus, a no-exposed-pad QFN packaging structure with single lead ring coupled with passive device may be formed.

[0075] Figure 19(A) and Figure 19(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 19(A) is a cross-section view of Figure 19(B).

[0076] As shown in Figure 19(A) and Figure 19(B), the no-exposed-pad QFN packaging structure in Figure 19(A) and Figure 19(B) is similar to the no-exposed-pad QFN packaging structure in Figure 18(A) and Figure 18(B).
However, the no-exposed-pad QFN packaging structure in Figure 19(A) also includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad and single lead ring coupled with passive device may be formed.

[0077] Figure 20(A) and Figure 20(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 20(A) is a cross-section view of Figure 20(B).

[0078] As shown in Figure 20(A) and Figure 20(B), the no-exposed-pad QFN packaging structure in Figure 20(A) and Figure 20(B) is similar to the no-exposed-pad QFN packaging structure in Figure 16(A) and Figure 16(B). However, the no-exposed-pad QFN packaging structure in Figure 20(A) and Figure 20(B) also includes an outer electrostatic discharge ring 15, and an inner electrostatic discharge ring 16 may be formed on the top surface of the outer electrostatic discharge ring 15 within the I/O pad ring. That is, the inner electrostatic discharge ring 16 may also be formed by the multi-layer plating process for forming the first metal layer 13. More particularly, the inner electrostatic discharge ring 16 may be arranged between the die 4 and inner leads 3 and in any appropriate shape, such as a rectangle or square. Further, the top
surface of the die 4 is connected to the top surface of the inner electrostatic discharge ring 16 by the metal wire 5 such that the die 4 may be protected from the static by the internal and outer electrostatic discharge rings 15 and 16. Both the outer electrostatic discharge ring 15 and the inner electrostatic discharge ring 16 may be in any appropriate shape, such as a rectangle ring, etc. Thus, a no-exposed-pad QFN packaging structure with inner die pad, single lead ring, and electrostatic discharge ring may be formed.

[0079] Figure 21(A) and Figure 21(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 21(A) is a cross-section view of Figure 21(B).

[0080] As shown in Figure 21 (A) and Figure 21 (B), the no-exposed-pad QFN packaging structure in Figure 21(A) and Figure 21(B) is similar to the no-exposed-pad QFN packaging structure in Figure 20(A) and Figure 20(B). However, the no-exposed-pad QFN packaging structure in Figure 21(A) also includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad, single lead ring, and electrostatic discharge ring may be formed.
[0081] Figure 22(A) and Figure 22(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 22(A) is a cross-section view of Figure 22(B).

[0082] As shown in Figure 22(A) and Figure 22(B), the no-exposed-pad QFN packaging structure in Figure 22(A) and Figure 22(B) is similar to the no-exposed-pad QFN packaging structure in Figure 20(A) and Figure 20(B). However, the no-exposed-pad QFN packaging structure in Figure 22(A) also includes one or more passive device 14 coupled between inner leads 3 using conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with single lead ring coupled with passive device and electrostatic discharge ring may be formed.

[0083] Figure 23(A) and Figure 23(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 23(A) is a cross-section view of Figure 23(B).

[0084] As shown in Figure 23(A) and Figure 23(B), the no-exposed-pad QFN packaging structure in Figure 23(A) and Figure 23(B) is similar to the no-exposed-pad QFN packaging structure in Figure 22(A) and Figure 22(B). However, the no-exposed-pad QFN packaging structure in Figure 23(A) also includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-
conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad, single lead ring coupled with passive device, and electrostatic discharge ring may be formed.

[0085] Figure 24(A) and Figure 24(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 24(A) is a cross-section view of Figure 24(B).

[0086] As shown in Figure 24(A) and Figure 24(B), the no-exposed-pad QFN packaging structure in Figure 24(A) and Figure 24(B) is similar to the no-exposed-pad QFN packaging structure in Figure 16(A) and Figure 16(B). However, the no-exposed-pad QFN packaging structure in Figure 24(A) and 24(B) includes multiple rings of I/O pads 1. In other words, I/O pads 1 are arranged in a multiple-ring configuration, and the leads in the multiple rings may be arranged in a staggered or zigzag way such that the leads and lead traces can be closely placed to the die 4. Further, multiple rings of inner leads 3 may be formed on the top surface of the I/O pads 1. That is, multiple rings of inner leads 3 may also be formed by the multi-layer plating process for forming the first metal layer 13. Because the multiple rings of inner leads 3 are formed by the multi-layer plating process, the lead pitch of inner leads from a same ring and the lead pitch of inner leads from different rings may be significantly reduced. Thus, a no-exposed-pad QFN packaging structure with multiple lead rings may be formed.

[0087] Figure 25(A) and Figure 25(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 25(A) is a cross-section view of Figure 25(B).
As shown in Figure 25(A) and Figure 25(B), the no-exposed-pad QFN packaging structure in Figure 25(A) and Figure 25(B) is similar to the no-exposed-pad QFN packaging structure in Figure 24(A) and Figure 24(B). However, the no-exposed-pad QFN packaging structure in Figure 25(A) and 25(B) includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad and multiple lead rings may be formed.

Figure 26(A) and Figure 26(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 26(A) is a cross-section view of Figure 26(B).

As shown in Figure 26(A) and Figure 26(B), the no-exposed-pad QFN packaging structure in Figure 26(A) and Figure 26(B) is similar to the no-exposed-pad QFN packaging structure in Figure 24(A) and Figure 24(B). However, the no-exposed-pad QFN packaging structure in Figure 26(A) and 26(B) includes one or more passive device 14 coupled between inner leads 3 using conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple lead rings coupled with passive device may be formed.
[0091] Figure 27(A) and Figure 27(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 27(A) is a cross-section view of
Figure 27(B).

[0092] As shown in Figure 27(A) and Figure 27(B), the no-exposed-pad
QFN packaging structure in Figure 27(A) and Figure 27(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 26(A) and Figure 26(B).
However, the no-exposed-pad QFN packaging structure in Figure 27(A) and 27(B)
includes an inner die pad 2 formed on the predetermined area for attaching the die
4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be
formed by the multi-layer plating process for forming the inner leads 3. Thus, the
inner die pad 2 may also be included in the first metal layer 13. Further, the die 4
is attached at the top surface of the inner die pad 2 via the conductive or non-
conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging
structure with inner die pad and multiple lead rings coupled with passive device
may be formed.

[0093] Figure 28(A) and Figure 28(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 28(A) is a cross-section view of
Figure 28(B).

[0094] As shown in Figure 28(A) and Figure 28(B), the no-exposed-pad
QFN packaging structure in Figure 28(A) and Figure 28(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 24(A) and Figure 24(B).
However, the no-exposed-pad QFN packaging structure in Figure 28(A) and 28(B)
includes an outer electrostatic discharge ring 15, and an inner electrostatic
discharge ring 16 may be formed on the top surface of the outer electrostatic
discharge ring 15 within the I/O pad ring. That is, the inner electrostatic
discharge ring 16 may also be formed by the multi-layer plating process for
forming the first metal layer 13. More particularly, the inner electrostatic
discharge ring 16 may be arranged between the die 4 and inner leads 3. Further,
the top surface of the die 4 is connected to the top surface of the inner electrostatic
discharge ring 16 by the metal wire 5 such that the die 4 may be protected from
the static by the internal and outer electrostatic discharge rings 16 and 17. Second
metal layer 8 may also be formed on the back surface of the outer electrostatic
discharge ring 16. Thus, a no-exposed-pad QFN packaging structure with
multiple lead rings and electrostatic discharge ring may be formed.

[0095] Figure 29(A) and Figure 29(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 29(A) is a cross-section view of
Figure 29(B).

[0096] As shown in Figure 29(A) and Figure 29(B), the no-exposed-pad
QFN packaging structure in Figure 29(A) and Figure 29(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 28(A) and Figure 28(B).
However, the no-exposed-pad QFN packaging structure in Figure 29(A) and 29(B)
includes an inner die pad 2 formed on the predetermined area for attaching the die
4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be
formed by the multi-layer plating process for forming the inner leads 3. Thus, the
inner die pad 2 may also be included in the first metal layer 13. Further, the die 4
is attached at the top surface of the inner die pad 2 via the conductive or non-
conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad, multiple lead rings, and electrostatic discharge ring may be formed.

[0097] Figure 30(A) and Figure 30(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 30(A) is a cross-section view of Figure 30(B).

[0098] As shown in Figure 30(A) and Figure 30(B), the no-exposed-pad QFN packaging structure in Figure 30(A) and Figure 30(B) is similar to the no-exposed-pad QFN packaging structure in Figure 28(A) and Figure 28(B). However, the no-exposed-pad QFN packaging structure in Figure 30(A) and 30(B) includes one or more passive device 14 coupled between inner leads 3 using conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple lead rings coupled with passive device, and electrostatic discharge ring may be formed.

[0099] Figure 31(A) and Figure 31(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 31(A) is a cross-section view of Figure 31(B).

[0100] As shown in Figure 31(A) and Figure 31(B), the no-exposed-pad QFN packaging structure in Figure 31(A) and Figure 31(B) is similar to the no-exposed-pad QFN packaging structure in Figure 30(A) and Figure 30(B). However, the no-exposed-pad QFN packaging structure in Figure 31(A) and 31(B) includes an inner die pad 2 formed on the predetermined area for attaching the die 4 or within a ring or rings of inner leads 3. The inner die pad 2 may also be
formed by the multi-layer plating process for forming the inner leads 3. Thus, the inner die pad 2 may also be included in the first metal layer 13. Further, the die 4 is attached at the top surface of the inner die pad 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with inner die pad, multiple lead rings coupled with passive device, and electrostatic discharge ring may be formed.

[00101] Figure 32(A) and Figure 32(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 32(A) is a cross-section view of Figure 32(B).

[00102] As shown in Figure 32(A) and Figure 32(B), the no-exposed-pad QFN packaging structure in Figure 32(A) and Figure 32(B) is similar to the no-exposed-pad QFN packaging structure in Figure 16(A) and Figure 16(B). However, the no-exposed-pad QFN packaging structure in Figure 32(A) and 32(B) includes a plurality of dies 4. Each of the plurality of dies 4 is attached on predetermined areas on the substrate or other planar supporting structure or within the ring or rings of inner leads 3 by conductive or non-conductive adhesive material 7. For example, a second die 4 is arranged in a side-by-side configuration with respect to the first die 4, and both dies 4 are arranged within the ring or rings of inner leads 3. Further, the top surface of each die 4 may be connected by metal wires 5. Thus, a no-exposed-pad QFN packaging structure with multiple dies and single lead ring may be formed.
Figure 33(A) and Figure 33(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 33(A) is a cross-section view of Figure 33(B).

As shown in Figure 33(A) and Figure 33(B), the no-exposed-pad QFN packaging structure in Figure 33(A) and Figure 33(B) is similar to the no-exposed-pad QFN packaging structure in Figure 32(A) and Figure 32(B). However, the no-exposed-pad QFN packaging structure in Figure 33(A) and 33(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple inner die pads, and single lead ring may be formed.

Figure 34(A) and Figure 34(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 34(A) is a cross-section view of Figure 34(B).

As shown in Figure 34(A) and Figure 34(B), the no-exposed-pad QFN packaging structure in Figure 34(A) and Figure 34(B) is similar to the no-exposed-pad QFN packaging structure in Figure 18(A) and Figure 18(B). However, the no-exposed-pad QFN packaging structure in Figure 34(A) and 34(B)
includes a plurality of dies 4. Each of the plurality of dies 4 is attached on predetermined areas on the substrate or other planar supporting structure or within the ring or rings of inner leads 3 by conductive or non-conductive adhesive material 7. For example, a second die 4 is arranged in a side-by-side configuration with respect to the first die 4, and both dies 4 are arranged within the ring or rings of inner leads 3. Further, the top surface of each die 4 may be connected by metal wires 5. Other configurations may also be used. Thus, a no-exposed-pad QFN packaging structure with multiple dies and single lead ring coupled with passive device may be formed.

[00107] Figure 35(A) and Figure 35(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 35(A) is a cross-section view of Figure 35(B).

[00108] As shown in Figure 35(A) and Figure 35(B), the no-exposed-pad QFN packaging structure in Figure 35(A) and Figure 35(B) is similar to the no-exposed-pad QFN packaging structure in Figure 34(A) and Figure 34(B). However, the no-exposed-pad QFN packaging structure in Figure 35(A) and 35(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN
packaging structure with multiple dies, multiple inner die pads, and single lead ring coupled with passive device may be formed.

[00109] Figure 36(A) and Figure 36(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 36(A) is a cross-section view of Figure 36(B).

[00110] As shown in Figure 36(A) and Figure 36(B), the no-exposed-pad QFN packaging structure in Figure 36(A) and Figure 36(B) is similar to the no-exposed-pad QFN packaging structure in Figure 20(A) and Figure 20(B). However, the no-exposed-pad QFN packaging structure in Figure 36(A) and 36(B) includes a plurality of dies 4. Each of the plurality of dies 4 is attached on predetermined areas on the substrate or other planar supporting structure or within the ring or rings of inner leads 3 by conductive or non-conductive adhesive material 7. For example, a second die 4 is arranged in a side-by-side configuration with respect to the first die 4, and both dies 4 are arranged within the ring or rings of inner leads 3. Further, the top surface of each die 4 may be connected by metal wires 5. Other configurations may also be used. Thus, a no-exposed-pad QFN packaging structure with multiple dies, single lead ring, and electrostatic discharge ring may be formed.

[00111] Figure 37(A) and Figure 37(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 37(A) is a cross-section view of Figure 37(B).

[00112] As shown in Figure 37(A) and Figure 37(B), the no-exposed-pad QFN packaging structure in Figure 37(A) and Figure 37(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 36(A) and Figure 36(B).

However, the no-exposed-pad QFN packaging structure in Figure 37(A) and 37(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple inner die pads, single lead ring, and electrostatic discharge ring may be formed.

[0013] Figure 38(A) and Figure 38(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 38(A) is a cross-section view of Figure 38(B).

[0014] As shown in Figure 38(A) and Figure 38(B), the no-exposed-pad QFN packaging structure in Figure 38(A) and Figure 38(B) is similar to the no-exposed-pad QFN packaging structure in Figure 22(A) and Figure 22(B). However, the no-exposed-pad QFN packaging structure in Figure 38(A) and 38(B) includes a plurality of dies 4. Each of the plurality of dies 4 is attached on predetermined areas on the substrate or other planar supporting structure or within the ring or rings of inner leads 3 by conductive or non-conductive adhesive material 7. For example, a second die 4 is arranged in a side-by-side configuration with respect to the first die 4, and both dies 4 are arranged within
the ring or rings of inner leads 3. Further, the top surface of each die 4 may be
connected by metal wires 5. Other configurations may also be used. Thus, a no-
exposed-pad QFN packaging structure with multiple dies, single lead ring coupled
with passive device, and electrostatic discharge ring may be formed.

[0015] Figure 39(A) and Figure 39(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 39(A) is a cross-section view of
Figure 39(B).

[0016] As shown in Figure 39(A) and Figure 39(B), the no-exposed-pad
QFN packaging structure in Figure 39(A) and Figure 39(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 38(A) and Figure 38(B).
However, the no-exposed-pad QFN packaging structure in Figure 39(A) and 39(B)
includes a plurality of inner die pads 2 formed on the predetermined areas for
attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of
inner die pads 2 may also be formed by the multi-layer plating process for
forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be
included in the first metal layer 13. Further, the plurality of dies 4 are attached at
the top surface of the corresponding plurality of inner die pads 2 via the
conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN
packaging structure with multiple dies, multiple inner die pads, single lead ring
coupled with passive device, and electrostatic discharge ring may be formed.

[0017] Figure 40(A) and Figure 40(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 40(A) is a cross-section view of
Figure 40(B).
As shown in Figure 40(A) and Figure 40(B), the no-exposed-pad QFN packaging structure in Figure 40(A) and Figure 40(B) is similar to the no-exposed-pad QFN packaging structure in Figure 32(A) and Figure 32(B). However, the no-exposed-pad QFN packaging structure in Figure 40(A) and 40(B) includes multiple rings of I/O pads 1. In other words, I/O pads 1 are arranged in a multiple-ring configuration. Further, multiple rings of inner leads 3 may be formed on the top surface of the I/O pads 1. That is, multiple rings of inner leads 3 may also be formed by the multi-layer plating process for forming the first metal layer 13. Because the multiple rings of inner leads 3 are formed by the multi-layer plating process, the lead pitch of inner leads from a same ring and the lead pitch of inner leads from different rings may be significantly reduced. Thus, a no-exposed-pad QFN packaging structure with multiple dies and multiple lead rings may be formed.

Figure 41(A) and Figure 41(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 41(A) is a cross-section view of Figure 41(B).

As shown in Figure 41(A) and Figure 41(B), the no-exposed-pad QFN packaging structure in Figure 41(A) and Figure 41(B) is similar to the no-exposed-pad QFN packaging structure in Figure 40(A) and Figure 40(B). However, the no-exposed-pad QFN packaging structure in Figure 41(A) and 41(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for
forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple inner die pads, and multiple lead rings may be formed.

[00121] Figure 42(A) and Figure 42(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 42(A) is a cross-section view of Figure 42(B).

[00122] As shown in Figure 42(A) and Figure 42(B), the no-exposed-pad QFN packaging structure in Figure 42(A) and Figure 42(B) is similar to the no-exposed-pad QFN packaging structure in Figure 34(A) and Figure 34(B). However, the no-exposed-pad QFN packaging structure in Figure 42(A) and 42(B) includes multiple rings of I/O pads 1. In other words, I/O pads 1 are arranged in a multiple-ring configuration. Further, multiple rings of inner leads 3 may be formed on the top surface of the I/O pads 1. That is, multiple rings of inner leads 3 may also be formed by the multi-layer plating process for forming the first metal layer 13. Because the multiple rings of inner leads 3 are formed by the multi-layer plating process, the lead pitch of inner leads from a same ring and the lead pitch of inner leads from different rings may be significantly reduced. Thus, a no-exposed-pad QFN packaging structure with multiple dies and multiple lead rings coupled with passive device may be formed.
[00123] Figure 43(A) and Figure 43(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 43(A) is a cross-section view of Figure 43(B).

[00124] As shown in Figure 43(A) and Figure 43(B), the no-exposed-pad QFN packaging structure in Figure 43(A) and Figure 43(B) is similar to the no-exposed-pad QFN packaging structure in Figure 42(A) and Figure 42(B). However, the no-exposed-pad QFN packaging structure in Figure 43(A) and 43(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple inner die pads, and multiple lead rings coupled with passive device may be formed.

[00125] Figure 44(A) and Figure 44(B) illustrate another exemplary no-
exposed-pad QFN packaging structure. Figure 44(A) is a cross-section view of Figure 44(B).

[00126] As shown in Figure 44(A) and Figure 44(B), the no-exposed-pad QFN packaging structure in Figure 44(A) and Figure 44(B) is similar to the no-exposed-pad QFN packaging structure in Figure 36(A) and Figure 36(B). However, the no-exposed-pad QFN packaging structure in Figure 44(A) and 44(B)
includes multiple rings of I/O pads 1. In other words, I/O pads 1 are arranged in a multiple-ring configuration. Further, multiple rings of inner leads 3 may be formed on the top surface of the I/O pads 1. That is, multiple rings of inner leads 3 may also be formed by the multi-layer plating process for forming the first metal layer 13. Because the multiple rings of inner leads 3 are formed by the multi-layer plating process, the lead pitch of inner leads from a same ring and the lead pitch of inner leads from different rings may be significantly reduced. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple lead rings, and electrostatic discharge ring may be formed.

[00127] Figure 45(A) and Figure 45(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 45(A) is a cross-section view of Figure 45(B).

[00128] As shown in Figure 45(A) and Figure 45(B), the no-exposed-pad QFN packaging structure in Figure 45(A) and Figure 45(B) is similar to the no-exposed-pad QFN packaging structure in Figure 44(A) and Figure 44(B). However, the no-exposed-pad QFN packaging structure in Figure 45(A) and 45(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN

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packaging structure with multiple dies, multiple inner die pads, multiple lead rings, and electrostatic discharge ring may be formed.

[00129] Figure 46(A) and Figure 46(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 46(A) is a cross-section view of Figure 46(B).

[00130] As shown in Figure 46(A) and Figure 46(B), the no-exposed-pad QFN packaging structure in Figure 46(A) and Figure 46(B) is similar to the no-exposed-pad QFN packaging structure in Figure 38(A) and Figure 38(B). However, the no-exposed-pad QFN packaging structure in Figure 46(A) and 46(B) includes multiple rings of I/O pads 1. In other words, I/O pads 1 are arranged in a multiple-ring configuration. Further, multiple rings of inner leads 3 may be formed on the top surface of the I/O pads 1. That is, multiple rings of inner leads 3 may also be formed by the multi-layer plating process for forming the first metal layer 13. Because the multiple rings of inner leads 3 are formed by the multi-layer plating process, the lead pitch of inner leads from a same ring and the lead pitch of inner leads from different rings may be significantly reduced. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple lead rings coupled with passive device, and electrostatic discharge ring may be formed.

[00131] Figure 47(A) and Figure 47(B) illustrate another exemplary no-exposed-pad QFN packaging structure. Figure 47(A) is a cross-section view of Figure 47(B).

[00132] As shown in Figure 47(A) and Figure 47(B), the no-exposed-pad QFN packaging structure in Figure 47(A) and Figure 47(B) is similar to the no-
exposed-pad QFN packaging structure in Figure 46(A) and Figure 46(B).

However, the no-exposed-pad QFN packaging structure in Figure 47(A) and 47(B) includes a plurality of inner die pads 2 formed on the predetermined areas for attaching the dies 4 or within a ring or rings of inner leads 3. The plurality of inner die pads 2 may also be formed by the multi-layer plating process for forming the inner leads 3. Thus, the plurality of inner die pads 2 may also be included in the first metal layer 13. Further, the plurality of dies 4 are attached at the top surface of the corresponding plurality of inner die pads 2 via the conductive or non-conductive adhesive material 7. Thus, a no-exposed-pad QFN packaging structure with multiple dies, multiple inner die pads, multiple lead rings coupled with passive device, and electrostatic discharge ring may be formed.

[00133] By using the disclosed methods, processes, and devices, various advantageous applications may be implemented. For example, using the disclosed processes and devices, separate etching processes on both sides of the metal substrate can be avoided, and the process cost, time, personnel, power, and materials can be reduced. At the same time, the amount of potential environment-harmful substances generated in the etching processes can also be reduced. Further, because the use of the thin-line plating method on the top surface of the substrate, the minimum width of the inner leads may be approximately 25µm, and the lead pitch of the inner leads may be as small as approximately 25µm. Thus, the lead density in the lead frame can be significantly increased.

[00134] By using the disclosed processes and devices, only lead frame is involved in the die attaching process and wire bonding process, without any film
or soft materials attached. Thus, the lead frame may be tolerant substantially high temperature, such as in a range of approximately 380 - 420 Celsius degrees, without warping.

[00135] It is understood that the disclosed embodiments may be applied to packaging any semiconductor devices. Various alternations, modifications, or equivalents to the technical solutions of the disclosed embodiments can be obvious to those skilled in the art.
What is claimed is:

1. A no-exposed-pad quad flat no-lead (QFN) packaging structure, comprising:
   a metal substrate;
   a first die coupled to a top surface of the metal substrate;
   a plurality of I/O pads formed based on the metal substrate;
   a first metal layer, containing a plurality of inner leads corresponding to the plurality of I/O pads and extending to proximity of the die, formed on the metal substrate by a multi-layer electrical plating process such that a lead pitch of the plurality of inner leads is significantly reduced;
   metal wires connecting the die and the plurality of inner leads; and
   a second metal layer formed on a back surface of the plurality of I/O pads, wherein the die, the plurality of inner leads, and metal wires are sealed with a molding compound.

2. The no-exposed-pad QFN packaging structure according to claim 1, wherein:
   the die is attached by an adhesive material.

3. The no-exposed-pad QFN packaging structure according to claim 1, wherein:
   a width of the inner leads is approximately 25im; and
   the lead pitch is approximately 25im.

4. The no-exposed-pad QFN packaging structure according to claim 1, further including:
   an inner die pad formed by the multi-layer electrical plating process, wherein the die is attached to a top surface of the inner die pad by an adhesive material.
5. The no-exposed-pad QFN packaging structure according to claim 1, wherein:
   the plurality of I/O pads are arranged in a single-ring configuration; and
   the plurality of inner leads are also arranged in a corresponding single-ring configuration.

6. The no-exposed-pad QFN packaging structure according to claim 1, wherein:
   the plurality of I/O pads are arranged in a multi-ring configuration; and
   the plurality of inner leads are also arranged in a corresponding multi-ring configuration.

7. The no-exposed-pad QFN packaging structure according to claim 1, further including:
   one or more passive devices coupled between leads of the plurality of inner leads by an adhesive material.

8. The no-exposed-pad QFN packaging structure according to claim 1, further including:
   an outer electrostatic discharge ring formed based on the metal substrate; and
   an inner electrostatic discharge ring formed at a top surface of the outer electrostatic discharge ring, arranged between the die and the plurality of inner leads, and connected to the die.

9. The no-exposed-pad QFN packaging structure according to claim 1, further including:
   sealant filled in peripheral areas of the I/O pads and areas between the I/O pads at a back surface of the metal substrate.

10. The no-exposed-pad QFN packaging structure according to claim 1, further including:
    a second die coupled to the top surface of the metal substrate, wherein the first die and the second die are connected with a metal wire.
11. A method for manufacturing a no-exposed-pad quad flat no-lead (QFN) packaging structure, comprising:

providing a metal substrate;

forming a first photoresist film on a top surface of the metal substrate;

forming a plating pattern in the first photoresist film using photolithography;

forming a first metal layer containing a plurality of inner leads by a multi-layer electrical plating process using the plating pattern in the first photoresist film as a mask, such that a lead pitch of the plurality of inner leads is significantly reduced;

attaching at least one die in a predetermined region on the top surface of the metal substrate;

connecting the die and the plurality of inner leads using metal wires by a wire bonding process;

sealing the die, the plurality of inner leads, and metal wires with a molding compound;

etching the metal substrate from a back surface of the metal substrate to form a plurality of I/O pads corresponding to the plurality of inner leads; and

forming a second metal layer on a back surface of the plurality of I/O pads.

12. The method according to claim 11, wherein forming the first photoresist film further includes:

forming a second photoresist film on the back surface of the metal substrate to protect the metal substrate during the multi-layer electrical plating process.

13. The method according to claim 11, wherein forming the metal layer further includes:

removing the first photoresist film and the second photoresist film.
14. The method according to claim 11, wherein etching the metal substrate further includes:

   forming a third photoresist film on the back surface of the metal substrate;
   forming an etching pattern in the third photoresist film using photolithography; and
   etching the metal substrate using the etching pattern in the third photoresist film on the back surface of the metal substrate.

15. The method according to claim 14, wherein forming the third photoresist further includes:

   forming a fourth photoresist film on top of the metal substrate including the encapsulation material to protect the metal substrate from the etching process.

16. The method according to claim 15, wherein etching the metal substrate further includes:

   removing the third photoresist film and the fourth photoresist film after the metal substrate is etched.

17. The method according to claim 11, further including:

   filling sealant in peripheral areas of the I/O pads and areas between the I/O pads on the back surface of the metal substrate.

18. The method according to claim 11, wherein attaching the die further includes:

   attaching the die in the predetermined region on the top surface of the metal substrate using an adhesive material.

19. The method according to claim 11, further including:

   forming an inner die pad by the multi-layer electrical plating process, wherein the die is attached to the inner die pad by an adhesive material.
20. The method according to claim 11, wherein:

the plurality of I/O pads are arranged in a single-ring configuration; and
the plurality of inner leads are also arranged in a corresponding single-ring configuration.

21. The method according to claim 11, wherein:

the plurality I/O pads are arranged in a multi-ring configuration; and
the plurality of inner leads are also arranged in a corresponding multi-ring configuration.

22. The method according to claim 11, further including:

one or more passive devices coupled between the plurality of inner leads by an adhesive material.

23. The method according to claim 10, further including:

forming an outer electrostatic discharge ring based on the metal substrate;
forming an inner electrostatic discharge ring at a top surface of the outer electrostatic discharge ring and between the die and the plurality of inner leads; and
connecting the inner electrostatic discharge ring and the die.

24. The method according to claim 11, further including:

forming a plurality of inner die pads by the multi-layer electrical plating process, wherein the at least one die includes a plurality of dies, and each is attached to a corresponding inner die pad of the plurality of inner die pads by an adhesive material.
FIG. 49 (Prior Art)

FIG. 50 (Prior Art)
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNKI, VEN: metal substrate, lead, pin, quad flat no-lead, QFN, package, packaging, chip, die, etch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>CN201838582U (Jiangsu Changjihang Electronics Technology Co Ltd) 18 May 2011 (18.05.2011) Paragraphs [0014]-[0026] of description, figures. 1-5</td>
<td>1-10</td>
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<td>E</td>
<td>CN102420206A (Jiangsu Changjihang Electronics Technology Co Ltd) 18 Apr. 2012(18.04.2012) the whole document</td>
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Date of the actual completion of the international search
18 Aug. 2012 (18.08.2012)

Date of mailing of the international search report
06 Sep. 2012 (06.09.2012)

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<th>Patent Documents referred in the Report</th>
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**INTERNATIONAL SEARCH REPORT**

**International application No.**
PCT/CN2012/000021

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