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SEMICONDUCTOR PACKAGE STRUCTURE HAVING RING PORTION WITH RECESS FOR ADHESIVE

Abstract

A package structure is provided. The package structure includes a substrate, a cover element disposed on the substrate and having a recess formed from a first surface of the cover element, a semiconductor device disposed on the substrate, a protruding element extending from a second surface of the substrate, and surrounding the semiconductor device in a top view, wherein the first surface faces the second surface, and the recess overlaps the protruding element in the top view, and an electrical connector disposed between the first surface of the substrate and the semiconductor device.

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Background/Summary

PRIORITY CLAIM AND CROSS-REFERENCE [0001] This application is a Continuation application of U.S. patent application Ser. No. 18/351,713, filed on Jul. 13, 2023, which is a Continuation application of U.S. Pat. No. 11,749,575 B2, filed on Aug. 31, 2021, the entirety of which are incorporated by reference herein.

BACKGROUND
[0002] Semiconductor devices are used in a variety of electronic applications, such as personal computers, cell phones, digital cameras, and other electronic equipment. Semiconductor devices are fabricated by sequentially depositing insulating or dielectric layers, conductive layers, and semiconductor layers over a semiconductor substrate, and patterning the various material layers using lithography and etching processes to form circuit components and elements thereon. Many integrated circuits (ICs) are typically manufactured on a single semiconductor wafer, and individual dies on the wafer are singulated by sawing between the integrated circuits along a scribe line. The individual dies are typically packaged separately, in multi-chip modules, for example, or in other types of packaging.
[0003] A package (structure) not only provides protection for semiconductor devices from environmental contaminants, but also provides a connection interface for the semiconductor devices packaged therein. Smaller package structures, which take up less area or are lower in height, have been developed to package the semiconductor devices.
[0004] Although existing packaging structures and methods for fabricating package structure have generally been adequate for their intended purposes, they have not been entirely satisfactory in all respects.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0005] Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It is noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.
[0006] FIG. **1**A is a schematic view of a package structure in accordance with some embodiments of the present disclosure.
[0007] FIG. **1**B is an exploded view of the package structure in accordance with some embodiments of the present disclosure.
[0008] FIG. **1**C is a top view of the package structure in accordance with some embodiments of the present disclosure.
[0009] FIG. **1**D is a cross-sectional view of a package structure in some embodiments of the present disclosure.
[0010] FIG. **1**E is a cross-sectional view of a package structure in some embodiments of the present disclosure.
[0011] FIG. **2**A to FIG. **2**E are cross-sectional views of some package structures having cover

elements in accordance with some embodiments of the present disclosure.

[0012] FIG. **3**A is a cross-sectional view of a package structure in some embodiments of the present disclosure.

[0013] FIG. **3**B is a cross-sectional view of a package structure in some embodiments of the present disclosure.

[0014] FIG. **4** is a cross-sectional view of a package structure in some embodiments of the present disclosure.

[0015] FIG. **5**A to FIG. **5**D are top views showing different protruding elements in some embodiments of the present disclosure.

[0016] FIG. **5**E is a perspective view showing a package structure having a protruding element.

[0017] FIG. **6**A to FIG. **6**C are top views showing different cover elements in some embodiments of the present disclosure.

[0018] FIG. **6**D is a schematic view showing the combination of the cover element and the substrate having the protruding element in some embodiments of the present disclosure.

[0019] FIG. **6**E, FIG. **6**F, and FIG. **6**G are top views of cover elements in some embodiments of the present disclosure.

[0020] FIG. **7** is a flow chart of a method for forming the package structure in some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0021] The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, such that the first and second features may not be in direct contact. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0022] Further, spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. The spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly.

[0023] The term “substantially” in the description, such as in “substantially flat” or in “substantially coplanar”, etc., will be understood by the person skilled in the art. In some embodiments the adjective substantially may be removed. Where applicable, the term “substantially” may also include embodiments with “entirely”, “completely”, “all”, etc. Where applicable, the term “substantially” may also relate to 90% or higher, such as 95% or higher, especially 99% or higher, including 100%. Furthermore, terms such as “substantially parallel” or “substantially perpendicular” are to be interpreted as not to exclude insignificant deviation from the specified arrangement and may include for example deviations of up to 10°. The word “substantially” does not exclude “completely” e.g. a composition which is “substantially free” from Y may be completely free from Y.

[0024] Terms such as “about” in conjunction with a specific distance or size are to be interpreted so as not to exclude insignificant deviation from the specified distance or size and may include for example deviations of up to 10%. The term “about” in relation to a numerical value x may mean x±5 or 10%. The terms “each” in the description are to be interpreted so as not to exclude variations among units and not to exclude an omission of a part of the units.

[0025] A package structure and the method for forming the same are provided in accordance with various embodiments. Some variations of some embodiments are discussed. Throughout the various views and illustrative embodiments, like reference numbers are used to designate like elements. In accordance with some embodiments of the present disclosure, a package structure includes a cover element (stress-relief structure) for controlling warpage of a package substrate, such as a ring structure or a lid structure. In some embodiments, the cover element is disposed on a substrate with a protruding element. The protruding element provides a higher contact area for the adhesive element disposed between the cover element and the substrate, and the flow of the adhesive element may be constrained by the protruding element as well, thereby reducing stress concentration or cracking in certain areas of the package, which will be described in detail below. Accordingly, the reliability of the entire package structure is improved.

[0026] Embodiments will be described with respect to a specific context, namely a packaging technique with an interposer substrate or other active chip in a two and a half dimensional integrated circuit (2.5 DIC) structure or a three dimensional IC (3 DIC) structure. Embodiments discussed herein are to provide examples to enable making or using the subject matter of this disclosure, and a person having ordinary skill in the art will readily understand modifications that can be made while remaining within contemplated scopes of different embodiments. Although method embodiments may be discussed below as being performed in a particular order, other method embodiments contemplate steps that are performed in any logical order.

[0027] Embodiments of the disclosure may relate to 3D packaging or 3D-IC devices. Other features and processes may also be included. For example, testing structures may be included to aid in the verification testing of the 3D packaging or 3D-IC devices. The testing structures may include, for example, test pads formed in a redistribution layer or on a substrate that allows the testing of the 3D packaging or 3D-IC, the use of probes and/or probe cards, and the like. The verification testing may be performed on intermediate structures as well as the final structure. Additionally, the structures and methods disclosed herein may be used in conjunction with testing methodologies that incorporate intermediate verification of known good dies to increase the yield and decrease costs.

[0028] FIG. **1**A is a schematic view of a package structure **1000** in accordance with some embodiments of the present disclosure. FIG. **1**B is an exploded view of the package structure **1000**. FIG. **1**C is a top view of the package structure **1000**. As shown in FIGS. **1**A to **1**C, The package structure **1000** includes a substrate **100**, a semiconductor device **200**, a cover element **300**, a protruding element **400**, and an adhesive element **500**. Additional features can be added to the package structure **1000**, and/or some of the features described below can be replaced or eliminated in other embodiments. FIG. **1**D and FIG. **1**E are cross-sectional views of package structures **1000**A and **1000**B illustrated along line A-A. In some embodiments, the package structures **1000**A or **1000**B may have similar elements to the package structure **1000**.

[0029] The substrate **100** is used to provide electrical connection between semiconductor devices packaged in the package structure **1000** and an external electronic device (not shown). In some embodiments, the substrate **100** is a semiconductor substrate. By way of example, the material of the substrate **100** may include elementary semiconductor such as silicon or germanium; a compound semiconductor such as silicon germanium, silicon carbide, gallium arsenic, gallium phosphide, indium phosphide or indium arsenide; or combinations thereof. Alternatively, the substrate **100** may be a silicon-on-insulator (SOI) substrate, a germanium-on-insulator (GOI) substrate, or the like. In some other embodiments, the substrate **100** is a printed circuit board (PCB), a ceramic substrate, or another suitable package substrate. The substrate **100** may be a core or a core-less substrate.

[0030] In some embodiments, the substrate **100** has various device elements (not shown).

Examples of device elements that are formed in or on the substrate **100** may include transistors (e.g., metal oxide semiconductor field effect transistors (MOSFET), complementary metal oxide semiconductor (CMOS) transistors, bipolar junction transistors (BJT), high voltage transistors, high-frequency transistors, p-passage and/or n-passage field-effect transistors (PFETs/NFETs), etc.), diodes, resistors, capacitors, inductors, and/or other applicable device elements. Various processes can be performed to form the device elements, such as deposition, etching, implantation, photolithography, annealing, and/or other suitable processes. The substrate **100** may also have one or more circuit layers (not shown) used to electrically connect the device elements and semiconductor devices that are subsequently attached.

[0031] The substrate **100** generally has a rectangular (or square) shape in a top view (see FIG. **1**C), depending on design requirements, although other shapes may also be used. Also, the substrate **100** has opposite surfaces **100**A and **100**B (shown in FIG. **1**D), which may be substantially parallel to each other. The surface **100**A (the upper surface shown) may be used to receive and bond other package components of the package, which will be described further below. Several electrical connectors (not shown) may be provided on the surface **100**B (the lower surface shown) to enable electrical connection between the package structure **1000** and an external electronic device such as a PCB (not shown). The electrical connectors may be or include solder balls such as tin-containing solder balls.

[0032] In some embodiments, one semiconductor device **200** is disposed over a surface **100**A (e.g., the upper surface shown) of the substrate **100**, such as arranged along a main axis M, although more semiconductor devices may also be used. In some embodiments, the semiconductor device **200** is a functional integrated circuit (IC) die such as a semiconductor die, an electronic die, a Micro-Electro Mechanical Systems (MEMS) die, or a combination thereof. The functional IC die may include one or more application processors, logic circuits, memory devices, power management integrated circuits, analog circuits, digital circuits, mixed signal circuits, one or more other suitable functional integrated circuits, or a combination thereof, depending on actual needs. In some alternative embodiments, the semiconductor device **200** is a package module that has one or more semiconductor dies and an interposer substrate carrying these semiconductor dies. These structures of the semiconductor device **200** are well known in the art and therefore not described herein. The semiconductor device **200** can be fabricated by various processes such as deposition, etching, implantation, photolithography, annealing, and/or other suitable processes.

[0033] After being fabricated, the semiconductor device **200** may be placed in a desired location above the substrate **100** using, for example, a pick-and-place tool. In some embodiments, the semiconductor device **200** is placed eccentrically with respect to the substrate **100** depending on design requirements (such as consideration of space arrangements).

[0034] In some embodiments, the semiconductor device **200** is mounted on the substrate **100** through flip-chip bonding, although other suitable bonding techniques may also be used. As shown in FIG. **1**D, the semiconductor device **200** is placed so that its active surface (e.g., the surface shown) faces the surface **100**A of the substrate **100**, and then is bonded onto the contact pads (not shown for simplicity) exposed at the surface **100**A via electrical connectors **210**. The electrical connectors **210** are used for electrically interconnecting the semiconductor device **200** with the substrate **100**. The electrical connectors **210** may include conductive pillars, solder balls, controlled collapse chip connection (C4) bumps, micro bumps, one or more other suitable bonding structures, or a combination thereof.

[0035] In some embodiments, the electrical connectors **210** are made of or include a metal material, such as copper, aluminum, gold, nickel, silver, palladium, or the like, or a combination thereof. The electrical connectors **210** may be formed using an electroplating process, an electroless plating process, a placement process, a printing process, a physical vapor deposition (PVD) process, a chemical vapor deposition (CVD) process, a photolithography process, one or more other applicable processes, or a combination thereof. In some other embodiments, the electrical connectors **210** are made of or include a tin-containing material. The tin-containing material may further include copper, silver, gold, aluminum, lead, one or more other suitable materials, or a combination thereof. In some other embodiments, the electrical connectors **210** are lead-free. A reflow process may be performed in order to shape the tin-containing material into the desired bump or ball shapes.

[0036] In some embodiments, an underfill layer **220** is also formed to surround and protect the electrical connectors **210**, and enhances the connection between the semiconductor device **200** and the substrate **100**, as shown in FIG. **1**D. The underfill layer **220** may be made of or include an insulating material such as an underfill material. The underfill material may include an epoxy, a resin, a filler material, a stress release agent (SRA), an adhesion promoter, another suitable material, or a combination thereof.

[0037] In some embodiments, an underfill material in liquid state is dispensed into a gap between the semiconductor device **200** and the substrate **100** to reinforce the strength of the electrical connectors **210** and therefore the overall package structure. After the dispensing, the underfill material is cured to form the underfill layer **220**. In some other embodiments, the underfill layer **220** is not formed.

[0038] In some embodiments, the package structure **1000** also includes electrical connectors, such as solder balls (not shown for simplicity), formed over the surface **100**B (e.g., the lower surface shown) of the substrate **100**. The solder balls are electrically connected to the electrical connectors **210** through the circuit layer(s) of the substrate **100**. The solder balls enable an electrical connection to be made between the package structure **1000** and an external electronic device such as a PCB (not shown).

[0039] In some embodiments, the cover element **300** is disposed over the surface **100**A of the substrate **100**, and is arranged along the periphery of the substrate **100**. In some embodiments, the cover element **300** has a rectangular or square ring shape in a top view, depending on the shape of the substrate **100**. In some embodiments, the cover element of the package structure is a lid structure. For example, FIG. **1**D is a cross-sectional view of a package structure **1000**A in some embodiments of the present disclosure. In some embodiments, the package structure **1000**A has a cover element **300** that has a ring portion **306** and a main body **350** surrounded by the ring portion **306**. In some embodiments, the main body **350** covers the semiconductor device **200** in the Z direction, and the second channel **332** penetrated from the recess **310** to the third surface **323**.

[0040] In some embodiments, the ring portion **306** surrounds a space S, and the semiconductor device **200** is disposed in the space S. In some embodiments, the ring portion **306** has a first surface **321**, a second surface **322**, a third surface **323**, and a fourth surface **324**, and the space S is surrounded by the fourth surface **324**. The first surface **321** faces the surface **100**A of the substrate **100**, and the third surface **323** faces away from the surface **100**A of the substrate **100** and may be parallel to the first surface **321**. The second surface **322** may be substantially aligned with the edge **100**C of the substrate **100**, and the fourth surface **324** of the cover element **300** may be adjacent to and surround sidewalls of the semiconductor device **200**, as shown in FIG. **1**D. The cover element **300** may be configured as a stiffener ring or a lid structure, and used to constrain the substrate **100** to alleviate its warpage and/or to enhance robustness of the substrate **100**. In some embodiments, the material of the cover element **300** may include metal such as copper, stainless steel, stainless steel/Ni, or the like, but is not limited thereto. In some embodiments, the ring portion **306** and the main body **350** of the package structure **1000**A in FIG. **1**D are formed as one piece.

[0041] In some embodiments, the cover element is formed by combining a ring portion and a cover lying on the ring portion. For example, FIG. **1**E is a cross-sectional view of a package structure **1000**B in some embodiments of the present disclosure. As shown in FIG. **1**E, the cover element **300** includes a ring portion **361** and a cover **362** lying on the ring portion **361**. In some embodiments, the ring portion **361** and the cover **362** are formed separately and then combined by, for example, adhesive.

[0042] In some embodiments, an adhesive element **500** is interposed between the first surface **321** of the cover element **300** and the surface **100**A of the substrate **100**. The adhesive element **500** may be configured to bond the cover element **300** to the substrate **100**. The adhesive element **500** may be applied to the surface **100**A and/or the first surface **321** before installing the cover element **300** on the substrate **100**. Examples of the material for the adhesive element **500** may include organic adhesive material such as epoxy, polyimide (PI), polybenzoxazole (PBO), benzo-cyclo-butene (BCB), but are not limited thereto.

[0043] The above-mentioned various package components and substrate materials used in the package structure **1000** may have different coefficient of thermal expansions (CTEs). Hence, when the package undergoes thermal cycling during package assembly, reliability testing, or filed operation, the package components and substrate materials may expand at different rates, causing the substrate **100** tends to warp. The cover element **300** may reduce some extent this warpage, but since the cover element **300** constrains the substrate **100**, this constraining force produces stress in the substrate **100**. It has been observed that the generated stress is typically concentrated in die corner areas and the die-to-die areas, which will cause cracks to easily occur in the used underfill element(s) and/or the used molding layer corresponding to these areas, thereby inducing the reliability issues.

[0044] Therefore, what is needed is a package structure that can address the above issue of stress concentration in specific areas (especially in the die corner areas and the die-to-die areas) of the package. The following will describe package structure design provided in accordance with some embodiments, which can be used to relieve stress generated in these areas of the package during thermal cycling.

[0045] In some embodiments, the cover element **300** includes a recess **310** formed on the first surface **321** of the cover element **300**. The protruding element **400** is extending from the surface **100**A of the substrate **100** and having a top surface **401** facing the cover element **300**, and the protruding element **400** is disposed in the recess **310**. As shown in FIG. **1**C, the semiconductor device **200** is surrounded by the recess **310** and the protruding element **400**. The protruding element **400** may have a stud-liked or a wall-liked structure, and the material of the protruding element **400** includes metal. A portion of the protruding element **400** may be embedded in the substrate **100** (not shown), and the protruding element **400** is separated from the cover element **300**. For example, the cover element **300** and the protruding element **400** are separated by the adhesive element **500**. In some embodiments, the adhesive element **500** is in contact with a side surface **402** of the protruding element **400** to separate the protruding element **400** from the cover element **300**.

[0046] In some embodiments, the recess **310** has a width W**1**, and the protruding element **400** has a width W**2** in a first direction (the X direction). The width W**1** is greater than the width W**2** to ensure the protruding element **400** is accommodated in the recess **310**. In some embodiments, the width W**1** is greater than 150 μm, and the width W**2** is greater than 50 μm and less than 500 μm to let the protruding element **400** being accommodated in the recess **310**. In some embodiments, the recess **310** may be replaced by holes.

[0047] In some embodiments, the adhesive element **500** includes an inner portion **510** and an outer portion **520** separated by the protruding element **400**. Either the inner portion **510** or the outer portion **520** has a portion directly under the first surface **321** of the cover element **300** and another portion in the recess **310**. For example, the inner portion **510** includes a first inner portion **511** and a second inner portion **512**. The first inner portion **511** is in contact with the side surface **402** of the protruding element **400**, and the second inner portion **512** is separated from the side surface **402** of the protruding element **400** by the first inner portion **511**. The first inner portion **511** has a height H**1**, and the second inner portion **512** has a height H**2**. In some embodiments, the height H**1** is greater than the height H**2**. In some embodiments, the protruding element **400** has a height H**3**, and the height H**3** is greater than the height H**1** and the height H**2**. Therefore, the top surface **401** and a portion of the side surface **402** of the protruding element **400** are exposed from the adhesive element **500** in some embodiments. In some embodiments, the height H**3** is greater than 100 μm to for providing a higher contact area with the adhesive element **500**.

[0048] In some embodiments, the recess **310** includes a recess bottom surface **311**, and a distance between the adhesive element **500** (e.g. the second inner portion **512**) and the recess bottom surface **311** in the normal direction of the substrate **100** (i.e. the Z direction) is D**1**. The distance D**1** is greater than zero, which means the adhesive element **500** is separated from the recess bottom surface **311**, and the space in the recess **310** is not totally filled by the adhesive element **500**.

[0049] In some embodiments, additional channels may be provided on the cover element **300** to connect the recess **310** to external environments. For example, as shown in FIGS. **1**A to **1**E, the cover element **300** includes first channels **331**, second channels **332**, and third channels **333**. The first channels **331** connect the recess **310** and the second surface **322** of the cover element **300**. The second channels **332** connect the recess **310** and the third surface **323** of the cover element **300**. The third channels **333** connect the recess **310** and the fourth surface **324** of the cover element **300**. Therefore, the recess **310** is in fluid connect with external environment, so when the cover element **300** is installed on the substrate **100**, air in the recess **310** may be exhausted, so the adhesive element **500** may have better coverage.

[0050] In some embodiments, the cover element is a ring structure. FIG. **2**A is a cross-sectional view of a package structure **1001**. In some embodiments, a cover element **300**A of the package structure **1001** is a ring structure, and the semiconductor device **200** is exposed from and surrounded by the cover element **300**A. In some embodiments, the cover element **300**A includes first channels **331**, second channels **332**, and third channels **333** connected to the recess **310** to allow the recess **310** in fluid connect with external environment.

[0051] In some embodiments, some of the first channels **331**, the second channels **332**, or the third channels **333** may be omitted. For example, FIG. **2**B to FIG. **2**E are cross-sectional views of other package structures having cover elements different from the cover element **300** or the cover element **300**A described in the aforementioned embodiments.

[0052] As shown in FIG. **2**B, a cover element **300**B of a package structure **1002** includes first channels **331**, but the second channels **332** and the third channels **333** are omitted. As shown in FIG. **2**C, a cover element **300**C of a package structure **1003** includes second channels **332**, but the first channels **331** and the third channels **333** are omitted. As shown in FIG. **2**D, a cover element **300**D of a package structure **1004** includes third channels **333**, but the first channels **331** and the second channels **332** are omitted. As shown in FIG. **2**E, no channel is provided to connect the recess **310** and the external environment.

[0053] In some embodiments, the first channels **331**, the second channels **332**, and the third channels **333** may be separated from the adhesive element **500** by the cover element **300**A. In other words, the first channels **331**, the second channels **332**, and the third channels **333** may be kept in fluid communication with external environment.

[0054] In some embodiments, the adhesive **500** covers a portion of the top surface **401** of the protruding element **400**. FIG. **3**A is a cross-sectional view of a package structure **1006** in some embodiments of the present disclosure. As shown in FIG. **3**A, a first portion **441** of the top surface **401** is exposed from the adhesive element **500**, and the adhesive element **500** covers a second portion **442** of the top surface **401**.

[0055] In some embodiments, the adhesive element **500** covers the entire top surface **401** of the protruding portion **400** which faces the cover element **300**A. For example, FIG. **3**B is a cross-sectional view of a package structure **1006** in some embodiments of the present disclosure. As shown in FIG. **3**B, the entire top surface **401** of the protruding element **400** is covered by the adhesive element **500**. It should be noted that the adhesive element **500** is not in the first channels **331**, the second channels **332**, or the third channels **333** to ensure air in the recess **310** is in fluid connect with external environment.

[0056] FIG. **4** is a cross-sectional view of a package structure **1008** in some embodiments of the present disclosure. In some embodiments, an opening **312** of the recess **310** formed on the first surface **321** and the recess bottom surface **311** face an identical direction (e.g. −Z direction). In some embodiments, the opening **312** has a first width W**3** in a first direction (e.g. X direction), the recess bottom surface **311** has a second width W**4** in the first direction, and the first width W**3** is greater than the second width W**4**. In other words, the recess **310** has a trapezoidal shape in cross-sectional view in some embodiments of the present disclosure.

[0057] FIG. **5**A to FIG. **5**D are top views showing different protruding elements in some embodiments of the present disclosure. In FIG. **5**A, the protruding element **400** has a continuous structure that surrounds the semiconductor device **200**. In some embodiments, the shape of the protruding element **400** includes rectangular or circle.

[0058] FIG. **5**B shows the configuration of a protruding element **410** in some embodiments of the present disclosure. The protruding element **410** has several protruding portions extending in various directions. For example, the protruding element **410** has a first protruding portion **411**, a second protruding portion **412**, a third protruding portion **413**, and a fourth protruding portion **414**. The first protruding portion **411** and the third protruding portion **413** extend in a first direction (e.g. the X direction), and the second protruding portion **412** and the fourth protruding portion **414** extend in a second direction (e.g. the Y direction).

[0059] In some embodiments, the semiconductor device **200** is surrounded by the first protruding portion **411**, the second protruding portion **412**, the third protruding portion **413**, and the fourth protruding portion **414** of the protruding element **410**. In some embodiments, the first protruding portion **411**, the second protruding portion **412**, the third protruding portion **413**, and the fourth protruding portion **414** are continuous lines, and each of the lengths of the first protruding portion **411**, the second protruding portion **412**, the third protruding portion **413**, and the fourth protruding portion **414** is greater than the length of the semiconductor device **200**. For example, the first protruding portion **411** has a length L**1** in the X direction, the semiconductor device **200** has a length L**2** in the X direction, and the length L**1** is greater than the length L**2**. Therefore, the semiconductor device **200** is surrounded by the protruding element **410**.

[0060] In some embodiments, the protruding element has a combination of discontinue lines. For example, FIG. **5**C shows the configuration of protruding element **420**. The protruding element **420** has first protruding portions **421** and second protruding portions **422**. Each of the first protruding portions **421** and the second protruding portions **422** has several sub-portions that extend in an identical direction. For example, the first protruding portion **421** has sub-portions **421**A, **421**B, **421**C, **421**D, **421**E, and **421**F extending in the X direction. In some embodiments, the sub-portions are spaces apart with different gaps. For examples, a gap G**1** is between the sub-portions **421**B and **421**C, a gap G**2** is between the sub-portions **421**C and **421**D, and the gap G**1** and the gap G**2** are different. For example, the gap G**2** is greater than the gap G**1** in some embodiments of the present disclosure. In some embodiments, the length of each of the sub-portions is greater than 50 μm. For example, the sub-portion **421**A has a length L**3** in the X direction, and the length L**3** is greater than 50 μm to increase the contact area with the adhesive element **500**.

[0061] In some embodiments, a protruding portion that has two ends extending in different directions may be provided in some embodiments of the present disclosure. For example, FIG. **5**D is a top view showing the configuration of a protruding element **430**, and FIG. **5**E is a perspective view showing a package structure **1009** having the protruding element **430**. The protruding element **430** has a first protruding portion **431**, a second protruding portion **432**, and a third protruding portion **433**. The first protruding portion **431** and the second protruding portion **432** are linear-shaped, the first protruding portion **431** extends in the X direction, and the second protruding portion **432** extends in the Y direction. The third protruding portion **433** is disposed between the first protruding portion **431** and the second protruding portion **432**, and has a first end **433**A and a second end **433**B. The first end **433**A and the second end **433**B extend in different directions. For example, the first end **433**A extends in the X direction, and the second end **433**B extends in the Y direction the in some embodiments of the present disclosure. In some embodiments, the first protruding portion **431** and the first end **433**A of the third protruding portion **433** are aligned in the X direction, and the second protruding portion **432** and the second end **433**B of the third protruding portion **433** are aligned in the Y direction.

[0062] In some embodiments, the first protruding portion **431** has sub-portions **431**A, **431**B, **431**C, and **431**D sequentially arranged in the X direction. In some embodiments, a gap G**3** is between the sub-portion **431**A and the sub-portion **431**B, a gap G**4** is between the sub-portion **431**B and the sub-portion **431**C, and the gap G**3** and the gap G**4** are different. For example, the gap G**4** may be greater than the gap G**3**. In some embodiments, a gap G**5** is between the sub-portion **431**D of the first protruding portion **431** and the first end **433**A of the third protruding portion **433**, and the gap G**5** is different from the gap G**3** and the gap G**4** the in some embodiments of the present disclosure. For example, the gap G**5** is greater than the gap G**3** and less than the gap G**4** in some embodiments of the present disclosure. The third protruding portion **433** at the corners of the substrate **100** allows the stress concentrated at the corners of the substrate **100** being released to enhance the reliability of the package structure.

[0063] FIG. **6**A to FIG. **6**C are top views showing different cover elements in some embodiments of the present disclosure. For example, FIG. **6**A is a top view of the cover element **300**A in some embodiments of the present disclosure. The recess **310**A of the cover element **300**A has a continuous rectangular shape or a circular shape that surrounds the main axis M in some embodiments of the present disclosure. The cover element **300**A has channels **341** and **342** that are in fluid connected to the recess **310**A. For example, the channel **341** or the channel **342** includes the first channel **331** and the third channel **333** in FIG. **2**A. The second channel **332** is omitted from the cover elements in FIG. **6**A to FIG. **6**C for simplicity, but it should be noted that the second channel **332** that extends in the Z direction is also applicable in the cover elements in the embodiments in FIG. **6**A to FIG. **6**C, depending on design requirement. In some embodiments, the channels **341** and **342** extend in different directions. For example, the channels **341** extend in the X direction, and the channels **342** extend in the Y direction. In some embodiments, the channels **341** and **342** are perpendicular to the recess **310**A in the top view. Therefore, the air in the recess **310**A is allowed to be exhausted from the channels **341** or the **342** when the cover element **300**A is disposed on the substrate.

[0064] In some embodiments, the recess of the cover element has a discontinuous structure. For example, FIG. **6**B shows a cover element **301** having a recess **310**B and channels **341** and **342** that are in fluid communication with the recess **310**B in some embodiments of the present disclosure. The recess **310**B includes first recess portions **313** and second recess portions **314**. The first recess portions **313** extend in the X direction, and the second recess portions **314** extend in the Y direction. The first recess portion **313** has a length L**4** in the X direction. In some embodiments, the length of the recess portion is greater than the protruding portion. For example, when the cover element **301** is assembled with the substrate **100** having the protruding element **410** in FIG. **5**B, the length L**4** of the first recess portion **313** is greater than the length of the first protruding portion **411** to allow the first protruding portion **411** being accommodated in the first recess portion **313**. In some embodiments, the length L**4** is greater than 50 μm. The second recess portion **314** and the second protruding portion **412** have similar structural relationship in some embodiments of the present disclosure, and it is not repeated. In some embodiments, the channel **341** extends in the first direction (X direction) and is connected to the second recess portion **314** extending in the Y direction, and the channel **342** extends in the second direction (Y direction) and is connected to the first recess portion **313** extending in the X direction.

[0065] In some embodiments, the recess of the cover element has a portion at corners of the cover element. For example, FIG. **6**C is a top view of a cover element **302** in some embodiments of the present disclosure. The cover element **302** has a recess **310**C and channels **341** and **342** that are in fluid communication with the recess **310**C in some embodiments of the present disclosure. The recess **310**C includes first recess portions **315**, second recess portions **316**, and third recess portions **317**. The first recess portions **315** extend in the X direction, the second recess portions **316** extend in the Y direction, and the third recess portions **317** are between the first recess portions **315** and the second recess portions **316**, and form at corners of the cover element **302**.

[0066] FIG. **6**D is a schematic view showing the combination of the cover element **302** and the substrate **100** having the protruding element **430** in some embodiments of the present disclosure, and some numerical references are omitted for simplicity. For example, as shown in FIG. **6**D, the first protruding portions **431** and the second protruding portions **432** may be accommodated in the first recess portion **315** or the second recess portion **316**, and the third protruding portions **433** may be accommodated in the third recess portions **317**. In other words, the first protruding portion **431** or the second protruding portion **432** overlaps the first recess portion **315** or the second recess portion **316**, and the third protruding portion **433** overlaps the third recess portion **313**. Therefore, the stress caused by the adhesive element **500** may be reduced by the protruding element **430** to enhance the reliability.

[0067] In some embodiments of the present disclosure, the cover element may be a lid structure. For example, FIG. **6**E, FIG. **6**F, and FIG. **6**G are top views of cover elements **303**, **304**, and **305** in some embodiments of the present disclosure. The cover elements **303**, **304**, and **305** are similar as the cover elements **300**A, **301** and **302** shown in FIG. **6**A to FIG. **6**C, and the difference is that the cover elements **303**, **304**, and **305** are lid structures (see FIG. **1**D and FIG. **1**E). Other similar features are not described again for simplicity.

[0068] In some embodiments, one of the substrate **100** with the protruding elements **400**, **410**, **420** or **430** and one of the cover elements **300**, **300**A, **300**B, **300**C, **300**D, **300**E, **300**F, **301**, **302**, **303**, **304**, or **305** may be combined with each other to form the package structure, depending on design requirement.

[0069] FIG. **7** is a flow chart of a method **600** for forming the package structure in some embodiments of the present disclosure. The method starts from an operation **602**, wherein a substrate **100** is provided. The substrate **100** includes a protruding element, such as the protruding elements **400**, **410**, **420**, or **430**. The method **600** than goes to an operation **604**, wherein a semiconductor device **200** is provided on the substrate **100**. After the operation **604**, the method **600** continues in an operation **606**. An adhesive element **500** is provided on the substrate **100**. Afterwards, in an operation **608**, a cover element, such as the cover elements **300**, **300**A, **300**B, **300**C, **300**D, **300**E, **300**F, **301**, **302**, **303**, **304**, or **305**, is provided on the substrate **100** to form the package structure. In some embodiments, the cover element includes a ring portion surrounding a space, and a recess is formed on a surface of the ring portion that faces the substrate. In some embodiments, the semiconductor device is disposed in the space surrounded by the ring portion, and the protruding element and the adhesive element are accommodated in the recess. In some embodiments, the semiconductor device is spaced apart from the recess by the ring portion.

[0070] In summary, a package structure is provided in some embodiments of the present disclosure. The package structure includes a protruding portion on the substrate and a recess on the cover element corresponding to the protruding portion. The adhesive element may be provided to in contact with the protruding portion and accommodated in the recess. The protruding portion improves the reliability and the coefficient of performance of the package structure, and reduces the stress of the package structure. Therefore, the yield of the package structure may be improved.

[0071] A package structure is provided in some embodiments of the present disclosure. The package structure includes a substrate, a cover element, a semiconductor device, a protruding element, an adhesive element, and an electrical connector. The cover element is disposed on the substrate and having a recess. The semiconductor device is disposed on the substrate and disposed in the space surrounded by the cover element. The protruding element extends from the substrate and disposed in the recess. The adhesive element is disposed in the recess. The electrical connector is in contact with the substrate and the semiconductor device.

[0072] A package structure is provided in some embodiments of the present disclosure. The package structure includes a substrate, a semiconductor device disposed on the substrate, a protruding element extending from the substrate, and a cover element disposed on the substrate and including a ring portion surrounding the semiconductor device, wherein the ring portion has a first surface facing the substrate, a recess is formed on the first surface, a first channel is formed on a second surface of the ring portion and connecting to the recess, and the first surface and the second surface face different directions.
[0073] A package structure is provided in some embodiments of the present disclosure. The package structure includes a substrate, a semiconductor device disposed on the substrate, a cover element disposed on the substrate and having a recess, and a protruding element extending from the substrate and disposed in the recess, wherein in a top view, the protruding element surrounds the semiconductor device.
[0074] The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of the present disclosure. Those skilled in the art should appreciate that they may readily use the present disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the present disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of the present disclosure.

Claims

1. A package structure, comprising: a substrate; a cover element disposed on the substrate and having a recess formed from a first surface of the cover element; a semiconductor device disposed on the substrate; a protruding element extending from a second surface of the substrate, and surrounding the semiconductor device in a top view, wherein the first surface faces the second surface, and the recess overlaps the protruding element in the top view; and an electrical connector disposed between the first surface of the substrate and the semiconductor device.
2. The package structure as claimed in claim 1, further comprising an underfill layer surrounding the electrical connector and disposed on the second surface.
3. The package structure as claimed in claim 1, further comprising an adhesive element surrounding the protruding element, wherein the protruding element extends over a top surface of the adhesive element.
4. The package structure as claimed in claim 1, wherein the cover element comprises sidewalls, the recess is surrounded by the sidewalls, the protruding element is accommodated in the recess, and a thickness of each of the sidewalls gradually increases in a direction perpendicular to the first surface.
5. The package structure as claimed in claim 1, wherein a distance between a top surface of the semiconductor device and the second surface is greater than a distance between a top surface of the protruding element and the second surface.
6. The package structure as claimed in claim 1, wherein the semiconductor device is exposed from the cover element in a top view.
7. The package structure as claimed in claim 6, wherein a distance between a top surface of the semiconductor device and the second surface is less than a distance between a top surface of the cover element and the second surface.
8. A package structure, comprising: a substrate **100**; a semiconductor device **200** disposed on the substrate; a cover element **300** disposed on the substrate, surrounding the semiconductor device, and comprising a first channel and a recess, the first channel connects to the recess, and the first channel and the recess are formed on different surfaces of the cover element.

9. The package structure as claimed in claim 8, wherein the cover element further comprises a second channel extending in an identical direction to the first channel.

10. The package structure as claimed in claim 8, wherein the cover element further comprises a third channel extending in a different direction to the first channel.

11. The package structure as claimed in claim 8, further comprising a protruding element disposed in the recess and extending in an identical direction to the first channel.

12. The package structure as claimed in claim 11, wherein the recess and the first channel are formed on opposite surfaces of the cover element.

13. The package structure as claimed in claim 8, wherein the recess has a plurality of sub-portions in a top view.

14. The package structure as claimed in claim 13, wherein one of the sub-portions comprises a first segment and a second segment extend in different directions.

15. A package structure, comprising: a substrate; a semiconductor device disposed on the substrate; a cover element disposed on the substrate and having a recess and a channel connected to the recess, wherein a size of the recess is greater than a size of the channel, and the channel and the recess extend in different directions; and a protruding element disposed in the recess.

16. The package structure as claimed in claim 15, wherein the channel extends in a first direction, and the protruding element extends in a second direction different from the first direction.

17. The package structure as claimed in claim 15, wherein the channel extends in a first direction, and the protruding element extends in the first direction.

18. The package structure as claimed in claim 15, wherein the protruding element comprises a first portion and a second portion separated from each other in a top view.

19. The package structure as claimed in claim 18, wherein the first portion and the second portion have different lengths.

20. The package structure as claimed in claim 18, wherein the first portion comprises a first sub-portion and a second sub-portion connected to each other, and the first sub-portion and the second sub-portion extend in different directions in a top view.