

second mold compound is applied to substantially fill the opening and directly contact the top surface of the first thinned die.

[0028a] In view of the above, according to an aspect of the present disclosure, there is provided an apparatus. The apparatus comprises: a first thinned die
5 comprising a first device layer and a first dielectric layer over the first device layer, wherein the first device layer comprises a plurality of first die contacts at a bottom surface of the first device layer; a multilayer redistribution structure comprising at least one first support pad, a plurality of package contacts, and redistribution interconnects, wherein: the first thinned die resides over a top
10 surface of the multilayer redistribution structure; the at least one first support pad is on a bottom surface of the multilayer redistribution structure and vertically aligned with the first thinned die, such that the at least one first support pad is placed vertically below the first thinned die; the plurality of package contacts are on the bottom surface of the multilayer redistribution structure; and the
15 redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts, wherein the at least one first support pad is not in contact with the plurality of package contacts and the redistribution interconnects, and is electrically isolated from the plurality of package contacts, the redistribution interconnects, and the plurality of first die contacts; a first mold
20 compound residing over the multilayer redistribution structure and around the first thinned die, and extending beyond a top surface of the first thinned die to define an opening within the first mold compound and over the first thinned die, wherein the top surface of the first thinned die is exposed at a bottom of the opening; and a second mold compound filling the opening and in contact with the top surface
25 of the first thinned die.

[0028b] In view of the above, according to another aspect of the present disclosure, there is provided an apparatus. The apparatus comprises: a first thinned die comprising a first device layer and a first dielectric layer over the first device layer, wherein the first device layer comprises a plurality of first die
30 contacts at a bottom surface of the first device layer; a multilayer redistribution structure comprising at least one structure pad, a plurality of package contacts,

and redistribution interconnects, wherein: the first thinned die resides over a top surface of the multilayer redistribution structure; the plurality of package contacts are on a bottom surface of the multilayer redistribution structure; the redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts; the at least one structure pad and the redistribution interconnects are formed from a common electrically conductive layer; and the at least one structure pad is vertically below the first thinned die, and electrically isolated from the redistribution interconnects and the plurality of first die contacts; a first mold compound residing over the multilayer redistribution structure and around the first thinned die, and extending beyond a top surface of the first thinned die to define an opening within the first mold compound and over the first thinned die, wherein the top surface of the first thinned die is exposed at a bottom of the opening; and a second mold compound filling the opening and in contact with the top surface of the first thinned die.

[0028c] In view of the above, according to yet another aspect of the present disclosure, there is provided a method. The method comprises: providing a mold wafer having a first die and a first mold compound, wherein: the first die comprises a first device layer, a first dielectric layer over the first device layer, and a first silicon substrate over the first dielectric layer, wherein the first device layer comprises a plurality of first die contacts at a bottom surface of the first device layer; a top surface of the first die is a top surface of the first silicon substrate and a bottom surface of the first die is the bottom surface of the first device layer; and the first mold compound encapsulates the sides and the top surface of the first die, wherein the bottom surface of the first device layer is exposed; forming a multilayer redistribution structure underneath the mold wafer, wherein: the multilayer redistribution structure comprises at least one first support pad, a plurality of package contacts, and redistribution interconnects; the at least one first support pad is on a bottom surface of the multilayer redistribution structure and vertically aligned with the first die, such that the at least one first support pad is placed vertically below the first die; the plurality of package contacts are on the bottom surface of the multilayer redistribution structure; and

the redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts, wherein the at least one first support pad is not in contact with the plurality of package contacts and the redistribution interconnects, and is electrically isolated from the plurality of package contacts, the redistribution interconnects, and the plurality of first die contacts; thinning down the first mold compound to expose the top surface of the first silicon substrate; removing substantially the first silicon substrate of the first die to provide a first thinned die and form an opening within the first mold compound and over the first thinned die, wherein the at least one first support pad is vertically below the first thinned die, and the first thinned die has a top surface exposed at a bottom of the opening; and applying a second mold compound to substantially fill the opening and directly contact the top surface of the first thinned die.

[0029] Those skilled in the art will appreciate the scope of the present disclosure and realize additional aspects thereof after reading the following detailed description of the preferred embodiments in association with the accompanying drawing figures.

Brief Description of the Drawing Figures

[0030] The accompanying drawing figures incorporated in and forming a part of this specification illustrate several aspects of the disclosure, and together with the description serve to explain the principles of the disclosure.

[0031] Figure 1 shows an exemplary wafer-level package according to one embodiment of the present disclosure.

[0032] Figure 2 shows an alternative wafer-level package according to another embodiment of the present disclosure.

[0033] Figure 3 shows an alternative wafer-level package according to another embodiment of the present disclosure.

[0034] Figures 4-18 provide exemplary steps that illustrate a process to fabricate the exemplary wafer-level package shown in Figure 1.

[0035] It will be understood that for clear illustrations, Figures 1-18 may not be drawn to scale.

Detailed Description

- 5 **[0036]** The embodiments set forth below represent the necessary information to enable those skilled in the art to practice the embodiments and illustrate the best mode of practicing the embodiments. Upon reading the following description in light of the accompanying drawing figures, those skilled in the art will understand the concepts of the disclosure and will recognize applications of
- 10 these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the disclosure and the accompanying claims.

CLAIMS

What is claimed is:

1. An apparatus comprising:
 - a first thinned die comprising a first device layer and a first dielectric layer over the first device layer, wherein the first device layer comprises a plurality of first die contacts at a bottom surface of the first device layer;
 - a multilayer redistribution structure comprising at least one first support pad, a plurality of package contacts, and redistribution interconnects, wherein:
 - the first thinned die resides over a top surface of the multilayer redistribution structure;
 - the at least one first support pad is on a bottom surface of the multilayer redistribution structure and vertically aligned with the first thinned die, such that the at least one first support pad is placed vertically below the first thinned die;
 - the plurality of package contacts are on the bottom surface of the multilayer redistribution structure; and
 - the redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts, wherein the at least one first support pad is not in contact with the plurality of package contacts and the redistribution interconnects, and is electrically isolated from the plurality of package contacts, the redistribution interconnects, and the plurality of first die contacts;
 - a first mold compound residing over the multilayer redistribution structure and around the first thinned die, and extending beyond a top surface of the first thinned die to define an opening within the first mold compound and over the first thinned die, wherein the top surface of the first thinned die is exposed at a bottom of the opening; and
 - a second mold compound filling the opening and in contact with the top surface of the first thinned die.

2. The apparatus of claim 1 wherein the plurality of package contacts and the at least one first support pad are formed from a common electrically conductive layer.
3. The apparatus of claim 1 wherein a bottom surface of the at least one first support pad and a bottom surface of each of the plurality of package contacts are in a same flat plane.
4. The apparatus of claim 1 further comprising at least one second support pad on the bottom surface of the multilayer redistribution structure and not placed vertically below the first thinned die, wherein the at least one second support pad is electrically isolated from the plurality of package contacts and the redistribution interconnects.
5. The apparatus of claim 4 wherein the at least one first support pad and the at least one second support pad are separate.
6. The apparatus of claim 4 wherein the at least one first support pad and the at least one second support pad are connected together.
7. The apparatus of claim 1 wherein the first thinned die provides a microelectromechanical systems (MEMS) component.
8. The apparatus of claim 1 wherein the first thinned die is formed from a silicon-on-insulator (SOI) structure, wherein the first device layer of the first thinned die is formed from a silicon epitaxy layer of the SOI structure, and the first dielectric layer of the first thinned die is a buried oxide layer of the SOI structure.
9. The apparatus of claim 1 further comprising a second intact die residing over the top surface of the multilayer redistribution structure, wherein:

- the second intact die has a second device layer and an intact silicon substrate over the second device layer; and
- the first mold compound encapsulates the second intact die.

10. The apparatus of claim 9 wherein the first thinned die provides a MEMS component and the second intact die provides a complementary metal-oxide-semiconductor (CMOS) controller that controls the MEMS component.

11. The apparatus of claim 9 further comprising a third thinned die residing over the top surface of the multilayer redistribution structure, wherein:

- the third thinned die has a third device layer and a second dielectric layer over the third device layer;
- the first mold compound extends beyond a top surface of the third thinned die to define a second opening within the first mold compound and over the third thinned die, wherein the top surface of the third thinned die is exposed at a bottom of the second opening; and
- the second mold compound fills the second opening and is in contact with the top surface of the third thinned die.

12. The apparatus of claim 11 further comprising at least one second support pad and at least one third support pad, wherein:

- the at least one second support pad and the at least one third support pad are on the bottom surface of the multilayer redistribution structure;
- the at least one second support pad and the at least one third support pad are electrically isolated from the plurality of package contacts and the redistribution interconnects;
- the at least one second support pad is not placed vertically below the first thinned die and not placed vertically below the third thinned die; and

- the at least one third support pad is vertically aligned with the third thinned die, such that the at least one third support pad is placed vertically below the third thinned die.

13. The apparatus of claim 11 wherein the first thinned die provides a MEMS component, the second intact die provides a CMOS controller that controls the MEMS component, and the third thinned die is formed from an SOI structure, wherein the third device layer of the third thinned die is formed from a silicon epitaxy layer of the SOI structure, and the second dielectric layer of the third thinned die is a buried oxide layer of the SOI structure.

14. The apparatus of claim 1 wherein the multilayer redistribution structure further comprises at least one structure pad, wherein:

- the at least one structure pad and the redistribution interconnects are formed from a common electrically conductive layer; and
- the at least one structure pad is vertically below the first thinned die, and electrically isolated from the redistribution interconnects and the plurality of first die contacts.

15. The apparatus of claim 1 wherein the second mold compound has a thermal conductivity greater than $2 \text{ W/m}\cdot\text{K}$.

16. The apparatus of claim 1 wherein the second mold compound has an electrical resistivity greater than $1\text{E}6 \text{ Ohm}\cdot\text{cm}$.

17. The apparatus of claim 1 wherein the first mold compound is formed from a same material as the second mold compound.

18. The apparatus of claim 1 wherein the first mold compound and the second mold compound are formed from different materials.

19. The apparatus of claim 1 wherein the multilayer redistribution structure is free of glass fiber.
20. The apparatus of claim 1 wherein connections between the redistribution interconnects and the plurality of first die contacts are solder-free.
21. An apparatus comprising:
- a first thinned die comprising a first device layer and a first dielectric layer over the first device layer, wherein the first device layer comprises a plurality of first die contacts at a bottom surface of the first device layer;
 - a multilayer redistribution structure comprising at least one structure pad, a plurality of package contacts, and redistribution interconnects, wherein:
 - the first thinned die resides over a top surface of the multilayer redistribution structure;
 - the plurality of package contacts are on a bottom surface of the multilayer redistribution structure;
 - the redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts;
 - the at least one structure pad and the redistribution interconnects are formed from a common electrically conductive layer; and
 - the at least one structure pad is vertically below the first thinned die, and electrically isolated from the redistribution interconnects and the plurality of first die contacts;
 - a first mold compound residing over the multilayer redistribution structure and around the first thinned die, and extending beyond a top surface of the first thinned die to define an opening within the first mold compound and over the first thinned die, wherein the top surface of the first thinned die is exposed at a bottom of the opening; and

- a second mold compound filling the opening and in contact with the top surface of the first thinned die.

22. A method comprising:

- providing a mold wafer having a first die and a first mold compound, wherein:
 - the first die comprises a first device layer, a first dielectric layer over the first device layer, and a first silicon substrate over the first dielectric layer, wherein the first device layer comprises a plurality of first die contacts at a bottom surface of the first device layer;
 - a top surface of the first die is a top surface of the first silicon substrate and a bottom surface of the first die is the bottom surface of the first device layer; and
 - the first mold compound encapsulates the sides and the top surface of the first die, wherein the bottom surface of the first device layer is exposed;
- forming a multilayer redistribution structure underneath the mold wafer, wherein:
 - the multilayer redistribution structure comprises at least one first support pad, a plurality of package contacts, and redistribution interconnects;
 - the at least one first support pad is on a bottom surface of the multilayer redistribution structure and vertically aligned with the first die, such that the at least one first support pad is placed vertically below the first die;
 - the plurality of package contacts are on the bottom surface of the multilayer redistribution structure; and
 - the redistribution interconnects connect the plurality of package contacts to certain ones of the plurality of first die contacts, wherein the at least one first support pad is not in contact with the plurality of package contacts and the redistribution interconnects, and is electrically isolated

from the plurality of package contacts, the redistribution interconnects, and the plurality of first die contacts;

- thinning down the first mold compound to expose the top surface of the first silicon substrate;
- removing substantially the first silicon substrate of the first die to provide a first thinned die and form an opening within the first mold compound and over the first thinned die, wherein the at least one first support pad is vertically below the first thinned die, and the first thinned die has a top surface exposed at a bottom of the opening; and
- applying a second mold compound to substantially fill the opening and directly contact the top surface of the first thinned die.