CLAIMS

WHAT IS CLAIMED IS:

1. A semiconductor device, comprising:

a first layer, a second layer, a first die between the first layer and the second layer, a second die, and a base die, the base die, the first layer, the first die, the second layer, and the second die are stacked together along a first direction, wherein each of the first die and the second die has a conductive layer, the first die and the second die are bonded through the second layer, and the base die and the first die are bonded through the first layer;

a first contact structure coupled to the conductive layer of the first die, wherein the first contact structure extends along the first direction and contacts the conductive layer of the first die without extending through the second layer; and

a second contact structure coupled to the conductive layer of the second die, wherein the second contact structure extends through the conductive layer of the first die and the second layer along the first direction and contacts the conductive layer of the second die without extending through the second die

wherein:

the first layer comprises a top bonding layer and a bottom bonding layer each comprising conductive bonding contacts and a dielectric material isolating the conductive bonding contacts;

the dielectric material of the top bonding layer of the first layer is bonded to the dielectric material of the bottom bonding layer of the first layer;

the conductive bonding contacts of the top bonding layer of the first layer are bonded to the conductive bonding contacts of the bottom bonding layer of the first layer;

the second layer comprises a top bonding layer and a bottom bonding layer each comprising a dielectric material and excluding a conductive bonding contact; and

the dielectric material of the top bonding layer of the second layer is bonded to the dielectric material of the bottom bonding layer of the second layer.

2. The semiconductor device of claim 1, wherein:

the base die comprises first vias extending along the first direction and being coupled to the conductive bonding contacts of the first layer; and

each of the first contact structure and the second contact structure is coupled to one of the first vias through one of the conductive bonding contacts of the first layer.

3. The semiconductor device of claim 2, further comprising a computing die and an interposer, wherein the base die and the computing die are integrated on different positions of the interposer along a second direction perpendicular to the first direction.

4. The semiconductor device of claim 3, wherein:

the first vias are coupled to first conductive terminals on a surface of the interposer;

the computing die is coupled to second conductive terminals on the surface of the interposer; and

the first conductive terminals and the second conductive terminals are coupled through conductive lines in the interposer.

5. The semiconductor device of claim 3, further comprising a computing die bonded to the base die through a third layer, wherein the computing die, the third layer, the base die, the first layer, the first die, the second layer, and the second die are stacked along the first direction.

6. The semiconductor device of claim 5, wherein:

the third layer comprises conductive bonding contacts and at least one dielectric material isolating the conductive bonding contacts.

7. The semiconductor device of claim 6, wherein:

the third layer comprises a top bonding layer and a bottom bonding layer, each comprising conductive bonding contacts and a dielectric material isolating the conductive bonding contacts;

the dielectric material of the top bonding layer of the third layer is bonded to the dielectric material of the bottom bonding layer of the third layer; and

the conductive bonding contacts of the top bonding layer of the third layer are bonded to the conductive bonding contacts of the bottom bonding layer of the third layer.

8. The semiconductor device of claim 6, wherein:

the base die comprises first vias coupled to the computing die;

the computing die comprises second vias extending along the first direction and being coupled to the conductive bonding contacts of the third layer; and

the first vias are coupled to the second vias through the conductive bonding contacts of the third layer.

9. The semiconductor device of any one of claims 5 to 8, further comprising an interposer, wherein the interposer, the computing die, the third layer, the base die, the first layer, the first die, the second layer, and the second die are stacked along the first direction.

10. A semiconductor device, comprising:

a base die, a first layer, a second layer, a first die between the first layer and the second layer, and a second die stacked together along a first direction, wherein:

each of the base die, the first die, and the second die has a conductive layer;

the base die and the first die are bonded through the first layer; and

the first die and the second die are bonded through the second layer;

a first contact structure coupled to the conductive layer of the base die, wherein the first contact structure extends along the first direction and contacts the conductive layer of the base die without extending through the first layer;

a second contact structure coupled to the conductive layer of the first die, wherein the second contact structure extends along the first direction and contacts the conductive layer of the first die without extending through the second layer; and

a third contact structure coupled to the conductive layer of the second die, wherein the third contact structure extends through the first layer, the conductive layer of the first die, and the second layer along the first direction and contacts the conductive layer of the second die without extending through the second die;

wherein:

the first layer comprises a top bonding layer and a bottom bonding layer each comprising a dielectric material and excluding a conductive bonding contact;

the dielectric material of the top bonding layer of the first layer is bonded to the dielectric material of the bottom bonding layer of the first layer;

the second layer comprises a top bonding layer and a bottom bonding layer each comprising a dielectric material and excluding a conductive bonding contact; and

the dielectric material of the top bonding layer of the second layer is bonded to the dielectric material of the bottom bonding layer of the second layer.

11. The semiconductor device of claim 10, wherein:

the base die comprises an interconnect layer extending along a second direction perpendicular to the first direction; and

each of the first contact structure, the second contact structure, and the third contact structure is coupled to the interconnect layer.

12. The semiconductor device of claim 11, further comprising:

a computing die and an interposer, wherein:

the base die and the computing die are integrated on different positions of the interposer along the second direction; and

the base die and the computing die are coupled through the interconnect layer and the interposer.

13. The semiconductor device of claim 12, wherein:

the interconnect layer is coupled to first conductive terminals on a surface of the interposer;

the computing die is coupled to second conductive terminals on the surface of the interposer; and

the first conductive terminals and the second conductive terminals are coupled through conductive lines in the interposer.

14. A method, comprising:

providing a first die and a second die, wherein the first die comprises a first conductive layer and at least a first bonding layer, and the second die comprises a second conductive layer and at least a second bonding layer;

stacking the second die on the first die along a first direction;

bonding the second bonding layer to the first bonding layer, wherein the first bonding layer and the second bonding layer each include a dielectric material and exclude a conductive bonding contact;

forming a first contact structure and a second contact structure that extend along the first direction, wherein:

the first contact structure contacts the first conductive layer without extending through the first bonding layer; and

the second contact structure extends through the first conductive layer, the first bonding layer, and the second bonding layer and contacts the second conductive layer without extending through the second die;

forming a third bonding layer on a surface of the first die opposite to the first bonding layer, wherein the third bonding layer comprises conductive bonding contacts and a dielectric material isolating the conductive bonding contacts;

providing a base die, wherein the base die comprises vias extending along the first direction and a fourth bonding layer comprising conductive bonding contacts coupled to the vias and a dielectric material isolating the conductive bonding contacts; and

bonding the fourth bonding layer of the base die to the third bonding layer on the surface of the first die, wherein bonding the fourth bonding layer to the third bonding layer comprises bonding the dielectric material of the fourth bonding layer to the dielectric material of the third bonding layer and bonding the conductive bonding contacts of the fourth bonding layer to the conductive bonding contacts of the third bonding layer.

15. The method of claim 14, wherein stacking the second die on the first die along the first direction comprises:

aligning the second die with the first die to place the first conductive layer and the second conductive layer at a same position along a second direction perpendicular to the first direction, wherein the first conductive layer and the second conductive layer are of a same size.

16. The method of claim 14, wherein forming the first contact structure and the second contact structure comprises:

forming a mask layer on top of the first die;

etching the mask layer to form a first opening and a second opening;

forming a first contact hole and a second contact hole extending along the first direction, wherein the first contact hole extends from the first opening to the first conductive layer, and the second contact hole extends from the second opening to the first conductive layer;

filling the first contact hole with a filler material;

deepening the second contact hole until the second contact hole extends through the first conductive layer and extends to the second conductive layer;

removing the filler material in the first contact hole;

forming insulating layers in each of the first contact hole and the second contact hole; and

forming the first contact structure in the first contact hole and the second contact structure in the second contact hole by depositing a conductive material into the first contact hole and the second contact hole.

17. The method of claim 14, further comprising:

stacking a base die on the first die, wherein the base die comprises a third conductive layer; and

forming a third contact structure coupled to the base die, and wherein forming the first contact structure, the second contact structure, and the third contact structure comprises:

forming a mask layer on top of the base die;

etching the mask layer to form a first opening, a second opening, and a third opening;

forming a first contact hole, a second contact hole, and a third contact hole extending along the first direction, wherein the first contact hole extends from the first opening to the first conductive layer, the second contact hole extends from the second opening to the first conductive layer, and the third contact hole extends from the third opening to the third conductive layer;

filling the first contact hole and the third contact hole with a filler material;

deepening the second contact hole until the second contact hole extends through the first conductive layer and extends to the second conductive layer;

removing the filler material in the first contact hole and the third contact hole;

forming insulating layers in each of the first contact hole, the second contact hole, and the third contact hole; and

forming the first contact structure in the first contact hole, the second contact structure in the second contact hole, and the third contact structure in the third contact hole by depositing a conductive material into the first contact hole, the second contact hole, and the third contact hole.