~~SEMICONDUCTOR DEVICE AND~~ METHOD OF FORMING PROTECTIVE MATERIAL BETWEEN SEMICONDUCTOR DIE STACKED ON SEMICONDUCTOR WAFER TO REDUCE DEFECTS DURING SINGULATION

Field of the Invention

The present invention relates in general to semiconductor devices and, more particularly, to a semiconductor device and method of forming protective material between semiconductor die stacked on a semiconductor wafer to reduce defects during singulation.

Background of the Invention

Semiconductor devices are commonly found in modern electronic products. Semiconductor devices vary in the number and density of electrical components. Discrete semiconductor devices generally contain one type of electrical component, e.g., light emitting diode (LED), small signal transistor, resistor, capacitor, inductor, and power metal oxide semiconductor field effect transistor (MOSFET). Integrated semiconductor devices typically contain hundreds to millions of electrical components. Examples of integrated semiconductor devices include microcontrollers, microprocessors, charged-coupled devices (CCDs), solar cells, and digital micro-mirror devices (DMDs).

Semiconductor devices perform a wide range of functions such as high-speed calculations, transmitting and receiving electromagnetic signals, controlling electronic devices, transforming sunlight to electricity, and creating visual projections for television displays. Semiconductor

Claims

What is claimed:

1. A method of making a semiconductor device, comprising:

providing a semiconductor wafer containing a plurality of first semiconductor die;

mounting a plurality of second semiconductor die to a first surface of the semiconductor wafer;

placing a ~~first~~ tape on a second surface of the semiconductor wafer opposite the first surface of the semiconductor wafer;

forming a protective material over the second semiconductor die and first surface of the semiconductor wafer;

~~removing the first tape;~~

singulating the semiconductor wafer between the second semiconductor die into individual die-to-wafer packages each containing the second semiconductor die stacked on the first semiconductor die, the protective material protecting the semiconductor wafer during singulation;

removing the tape;

mounting the die-to-wafer package to a substrate;

removing the protective material to expose the second semiconductor die and first surface of the semiconductor wafer; and

depositing an encapsulant over the die-to-wafer package and substrate.

2. The method of claim 1, further including forming a plurality of conductive vias through the semiconductor wafer.

3. The method of claim 1, wherein the protective material includes polyvinyl alcohol and water.

4. The method of claim 1, further including depositing underfill material beneath the first semiconductor die.

5. The method of claim 1, further including depositing underfill material beneath the second semiconductor die.

6. The method of claim 1, wherein the substrate includes a build-up interconnect structure.

7. A method of making a semiconductor device, comprising:

providing a semiconductor wafer containing a plurality of first semiconductor die;

mounting a plurality of second semiconductor die to a ~~first~~ surface of the semiconductor wafer;

forming a protective material over the second semiconductor die and ~~first~~ surface of the semiconductor wafer; ~~and~~

singulating the semiconductor wafer between the second semiconductor die into individual die-to-wafer packages each containing the second semiconductor die stacked on the first semiconductor die, the protective material protecting the semiconductor wafer during singulation; and

removing the protective material to expose the second semiconductor die and surface of the semiconductor wafer.

8. The method of claim 7, wherein the protective material includes polyvinyl alcohol and water.

~~9. The method of claim 7, further including removing the protective material after singulation.~~

~~10~~9. The method of claim 7, wherein the protective material includes encapsulant.

1~~1~~0. The method of claim 7, further including:

forming a build-up interconnect structure over the first semiconductor die; and

depositing an encapsulant over the first semiconductor die, second semiconductor die, and build-up interconnect structure.

1~~2~~1. The method of claim 7, further including mounting the die-to-wafer package to a substrate.

1~~3~~2. The method of claim 7, further including forming a plurality of conductive vias through the semiconductor wafer.

1~~4~~3. The method of claim 7, further including:

depositing first underfill material beneath the first semiconductor die; and

depositing second underfill material beneath the second semiconductor die.

1~~5~~4. A method of making a semiconductor device, comprising:

providing a semiconductor wafer;

forming a plurality of channels in a first surface of the semiconductor wafer;

depositing a protective layer over and between the channels in the first surface of the semiconductor wafer; ~~and~~

grinding a second surface of the semiconductor wafer opposite the first surface of the semiconductor wafer to reduce a thickness of the semiconductor wafer, the protective ~~material~~layer protecting the channels during grinding; and

removing the protective layer to expose the channels in the first surface of the semiconductor wafer.

~~16. The method of claim 15, further including removing the protective layer.~~

175. The method of claim 154, further including removing the protective layer with deionized water.

186. The method of claim 164, further including singulating the semiconductor wafer.

197. The method of claim 154, wherein the protective material includes polyvinyl alcohol and water.

~~20. A semiconductor device made by a process, comprising:~~

~~providing a semiconductor wafer containing a plurality of first semiconductor die;~~

~~mounting a plurality of second semiconductor die to a first surface of the semiconductor wafer;~~

~~forming protective material over the second semiconductor die and first surface of the semiconductor wafer; and~~

~~singulating the semiconductor wafer between the second semiconductor die into individual die-to-wafer packages each containing the second semiconductor die stacked on the second semiconductor die, the protective material protecting the semiconductor wafer during singulation.~~

~~21. The semiconductor device of claim 20, wherein the protective material includes polyvinyl alcohol and water.~~

~~22. The semiconductor device of claim 20, further including removing the protective material after singulation.~~

~~23. The semiconductor device of claim 20, wherein the protective material includes encapsulant.~~

~~24. The semiconductor device of claim 20, further including:~~

~~forming a build-up interconnect structure over the first semiconductor die; and~~

~~depositing an encapsulant over the first semiconductor die, second semiconductor die, and build-up interconnect structure.~~

~~25. The semiconductor device of claim 20, further including forming a plurality of conductive vias through the semiconductor wafer.~~

18. The method of claim 14, further including forming a plurality of conductive vias through the semiconductor wafer.

19. A method of making a semiconductor device, comprising:

providing a semiconductor wafer having a plurality of semiconductor die;

forming a plurality of channels in a first surface of the semiconductor wafer between the semiconductor die;

depositing a protective material over the first surface of the semiconductor wafer and the channels;

grinding a second surface of the semiconductor wafer to remove a portion of the semiconductor wafer; and

removing the protective material to expose the first surface of the semiconductor wafer and the channels.

20. The method of claim 19, wherein grinding the second surface of the semiconductor wafer further includes singulating the semiconductor wafer between the semiconductor die.

21. The method of claim 19, wherein forming the plurality of channels in the first surface of the semiconductor wafer

includes forming the channels at a depth of 30-50 percent of a reduced thickness of the semiconductor wafer.

22. The method of claim 19, wherein the protective material is a water-soluble material.

23. The method of claim 19, wherein the protective material includes polyvinyl alcohol and water.

24. The method of claim 19, further including forming a plurality of conductive vias through the semiconductor wafer.

25. The method of claim 7, wherein removing the protective material exposes the surface of the semiconductor wafer.