PROBE CARD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 USC § 119 to Korean Patent Application No. 2006-118032, filed on November 28, 2006 in the Korean Intellectual Property Office (KIPO), the contents of which are herein incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Example embodiments of the present invention relate to a probe card for testing for normal operation of semiconductor devices. More particularly, example embodiments of the present invention relate to a probe card having improved probe bonding strength.

2. Description of the Related Art

Recently, as information media such as computers have become widespread, semiconductor device development has made rapid progress. In view of functions of semiconductor devices, the semiconductor devices may require high operational speeds and large storage capacities. To meet the above-mentioned requirements, semiconductor fabrication processes for the semiconductor devices have been developed toward high integration degrees, improved reliability, high responsive speeds, etc.

Generally, the semiconductor devices are manufactured by a fab process

for forming electrical circuits including electrical elements on a semiconductor substrate such as a silicon substrate, an electrical die sorting (EDS) process for testing electrical characteristics of semiconductor chips on the silicon substrate formed by the fab process, and a packaging process for encapsulating the semiconductor chips using an epoxy resin, and cutting the encapsulated semiconductor chips to singulate the encapsulated semiconductor chips into semiconductor chips.

Here, the EDS process is an essential process for checking whether the semiconductor chip is operating normally or not before performing the packaging process. The EDS process may include the use of a probe card having a plurality of probes that make contact with the semiconductor chips, respectively.

The probe card may be used for testing normal operation of the semiconductor chips by applying electrical signals to the semiconductor chips that make contact with the probes, by detecting responsive signals from the semiconductor chips.

A conventional needle-type probe card may be manufactured by bending needles, each needle having a tip formed at one end, arranging the needles at predetermined positions, and fixing the needles to a substrate by a soldering process. Here, to ensure contact between the probe and a pad of the semiconductor chip, it may be required to provide the probe with elasticity.

However, the probe may be deformed, the horizontal level of the probe may not be maintained and/or the position of the probe may be misaligned because the conventional needle-type probe card is repeatedly used.

Further, since the conventional needle-type probe card may be manually manufactured, the conventional needle-type probe card may have low productivity. Furthermore, as the semiconductor devices have become highly integrated, the semiconductor devices may have a fine pitch. However, it may be difficult to arrange needles of the conventional needle-type probe card so as to correspond to the fine pitch of the semiconductor devices. Moreover, interferences between the needles of the conventional needle-type probe card may be generated so that the conventional needle-type probe card may have very low test accuracy.

To overcome the problems of the conventional needle-type probe card, a cantilever-type probe card has been proposed.

The cantilever-type probe card may be manufactured by vertically forming a bump on a substrate, forming a tip portion and a support beam for supporting the tip portion on a sacrificial substrate, bonding the bump to one end of the support beam, and removing the sacrificial substrate.

A microelectromechanical system (MEMS) probe card, which is a type of cantilever-type probe card, may be manufactured MEMS technology. Particularly, the MEMS technology may allow the probe card to be manufactured at a semiconductor substrate level. Thus, time and costs for testing the semiconductor devices may be significantly reduced.

According to a conventional method of manufacturing the MEMS probe card, a bump is bonded to one end of a support beam by a soldering process. Particularly, a solder paste is interposed between the bump and the support

beam. The solder paste is heated to a temperature of about 200°C to about 350°C to melt the solder paste, thereby combining the bump and the support beam with each other.

However, in the conventional MEMS probe card, a position error between the bump and the support beam may be generated while heating and cooling the bump and the support beam in the bonding process. Further, when the conventional MEMS probe card is repeatedly used, the support beam may be deformed and misaligned due to weak bonding strength between the bump and the support beam. As a result, the conventional MEMS probe card may have low durability.

SUMMARY OF THE INVENTION

Example embodiments of the present invention provide a probe card that includes a firmly fixed probe.

A probe card in accordance with one aspect of the present invention includes a substrate, a bump, a probe and a combining member. The bump is formed on the substrate. The probe includes a support beam and a tip protruded from a first end of the support beam. The combining member electrically connects the bump to the probe. The combining member includes a first combining portion and a second combining portion surrounding an outer face of the first combining portion.

According to one example embodiment, the first combining portion and the second combining portion may be tightly fitted to each other. Further, a

solder paste may be interposed between the first combining portion and the second combining portion.

According to another example embodiment, the first combining portion may be formed on the bump. The second combining portion may be formed at a second end of the tip opposite to the first end. Alternatively, the first combining portion may be formed at the second end of the tip. The second combining formed on the bump.

According to still another example embodiment, the second combining portion may have a cylindrical shape having a hollow portion that has a size corresponding to an outer circumference of the first combining portion.

A probe card in accordance with another aspect of the present invention includes a substrate, a probe and a combining member. The probe includes a support beam and a tip protruded from a first end of the support beam. The combining member includes a first combining portion formed on the substrate and a second combining portion tightly fitted to the first combining portion. Further, the second combining portion has a shape configured to surround an outer face of the first combining portion.

According to one example embodiment, the first combining portion may be protruded from an inner face of a recess formed at the substrate. The second combining portion may have a cylindrical shape having a hollow portion that has a size corresponding to an outer circumference of the first combining portion. Further, a solder paste may be interposed between the first combining portion and the second combining portion.

According to the present invention, a probe card may be firmly and accurately fixed to a substrate or a bump. Further, the probe card may have improved reliability so that test failures of semiconductor devices, which are tested using the probe card, may be reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features and advantages of the invention will become readily apparent by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a cross-sectional view illustrating a probe card in accordance with a first example embodiment of the present invention;

FIG. 2 is a perspective view illustrating the probe card in FIG. 1;

FIG. 3 is a cross-sectional view illustrating a probe card in accordance with a second example embodiment of the present invention;

FIG. 4 is a perspective view illustrating the probe card in FIG. 3;

FIG. 5 is a cross-sectional view illustrating a probe card in accordance with a third example embodiment of the present invention; and

FIG. 6 is a perspective view illustrating the probe card in FIG. 5.

DESCRIPTION OF THE EMBODIMENTS

The present invention is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should

not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

It will be understood that when an element or layer is referred to as being "on," "connected to" or "coupled to" another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

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. It will be understood that 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. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries,

should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Embodiment 1

FIG. 1 is a cross-sectional view illustrating a probe card in accordance with a first example embodiment of the present invention, and FIG. 2 is a perspective view illustrating the probe card in FIG. 1.

Referring to FIGS. 1 and 2, a probe card of this example embodiment includes a substrate 101 having a circuit pattern 102, a bump 110 formed on the pattern 102, and a plurality of probes 120 having a first end at which a tip 122 making contact with a semiconductor device is formed and a second end, which is opposite to the first end, combined with the bump 110.

Additionally, the probe card further includes a combining member 130 for fixing the bump 110 and the probes 120 to each other to electrically couple the bump 110 and the probes 120 to each other.

Here, the probe card may serve as a space expansion device for electrically coupling the semiconductor device, which has pads arranged by a first pitch, to a printed circuit board (PCB), which has pads arranged by a second pitch wider than the first pitch.

In this example embodiment, the substrate 101 may include a single-layer ceramic structure or a multilayer ceramic structure. Further, the circuit pattern 102 on the substrate 101 may correspond to the first pitch of the

semiconductor device.

The bump 110 is protruded from the circuit pattern 102 of the substrate 101. The bump 110 electrically connects the circuit pattern 102 to the probes 120.

Each of the probes 120 includes a support beam 121 and the tip 122. A fixed end of the support beam 121 is fixed to the bump 110. The support beam 121 horizontally extends from the bump 110. In this example embodiment, the support beam 121 may have a bar shape that has a thin thickness, a width, and a length longer than the width.

Here, to sufficiently provide the tip 122 and the pad of the semiconductor device with stable contact reliability by pressing the tip 122 toward the pad of the semiconductor device, the support beam 121 may have elasticity. Further, for allowing the probes 120 to simultaneously make contact with the pads, a space may be formed between an upper face of the substrate 101 and the support beam 121.

The tip 122 is protruded from a free end of the support beam 121 along an upward vertical direction opposite to a downward vertical direction toward the substrate 101.

The tip 122 directly makes contact with the pad of the semiconductor device. Thus, the tip 122 may advantageously have a pointed end for piercing into an oxide layer on the pad to make contact with the pad. Further, the tip 122 may have wear resistance for allowing the tip 122 to repeatedly make contact with the pad. In this example embodiment, the tip 122 may have a conical

shape or a pyramid shape having the pointed end. Alternatively, the tip 122 may have one of various shapes different from the above-mentioned shapes.

The combining member 130 combines the bump 110 with the probes 120. The combining member 130 has a first combining portion 131 protruded from the bump 110, and a second combining portion 132 tightly fitted to the first combining portion 131.

The first combining portion 131 protruded from the bump 110 is inserted into the second combining portion 132.

In this example embodiment, a clearance may not be formed between the first combining portion 131 and the second combining portion 132. Thus, the second combining portion 132 may have a hollow portion corresponding to an outer circumference of the first combining portion 131. For example, an inner circumference of the second combining portion 132 may be substantially the same as the outer circumference of the first combining portion 131. Alternatively, to increase the bonding strength between the first combining portion 131 and the second combining portion 132, the outer circumference of the first combining portion 131 may be slightly larger than the inner circumference of the second combining portion 132.

As shown in FIG. 2, in this example embodiment, the combining member 130 include the first combining portion 131 having a solid rectangular columnar shape protruded from the bump 110, and the second combining portion 132 having a hollow rectangular columnar shape that has the hollow portion having a size corresponding to the outer circumference of the first combining portion 131.

Here, the shape of the combining member 130 may not be restricted to the above-mentioned configuration. For example, the first combining portion 131 may have a solid cylindrical shape. The second combining portion 132 may have a hollow cylindrical shape having a hollow portion that has a diameter substantially the same as that of the first combining portion 131.

Here, as mentioned above, the first combining portion 131 and the second combining portion 132 of the combining member 130 are tightly fitted to each other. Thus, to assemble the first combining portion 131 and the second combining portion 132 with each other, heat or pressure may be applied to the first combining portion and/or the second combining portion 132 to insert the first combining portion 131 into the hollow portion of the second combining portion 132, thereby tightly fitting the first combining portion 131 and the second combining portion 132 to each other.

Further, to tightly fit the first combining portion 131 and the second combining portion 132 to each other, the second combining portion 132 may have a shape for surrounding no less than about 1/2 of the outer circumference of the first combining portion 131.

In this example embodiment, the first combining portion 131 is separately formed on the bump 110. Alternatively, the first combining portion 131 and the bump 110 may be formed simultaneously with each other. Further, in this example embodiment, the second combining portion 132 is formed on the support beam 121. Alternatively, the second combining portion 132 and the support beam 121 may be formed simultaneously with each other.

Additionally, an adhesive member may be formed on the first combining portion 131. In this example embodiment, the adhesive member may include a solder paste 140. When the solder paste 140 is heated to a temperature of about 200°C to about 350°C, the solder paste 140 is melted to firmly combine the first combining portion 131 and the second combining portion 132 with each other.

Alternatively, the first combining portion 131 and the second combining portion 132 of the combining member 130 may be combined with each other by a brazing process at a temperature of no less than about 450°C, a conductive adhesive, etc., as well as the solder paste 140.

According to this example embodiment, physical bonding strength generated by the tight fit as well as the bonding strength generated by the solder paste 140 may be applied between the probe 120 and the bump 110 so that the probe 120 and the bump 110 may be firmly secured to each other. Further, since position errors and deformations of the probes 120 may be prevented, the probe card may have improved structural stability.

Embodiment 2

FIG. 3 is a cross-sectional view illustrating a probe card in accordance with a second example embodiment of the present invention, and FIG. 4 is a perspective view illustrating the probe card in FIG. 3.

In Example Embodiment 1, the first combining portion 131 is inserted into the second combining portion 132. In contrast, in this example embodiment, a

second combining portion 232 is inserted into the first combining portion 231.

Hereinafter, a probe card of this example embodiment is illustrated in detail with reference to FIGS. 3 and 4. Here, substantially identical elements in Example Embodiments 1 and 2 are referred to by identical names and any further illustrations with respect to the same elements are omitted herein for brevity.

Referring to FIGS. 3 and 4, a probe card of this example embodiment includes a substrate 201 having a circuit pattern 202, a bump 210 formed on the pattern 202, a plurality of probes 220 having a first end at which a tip 222 making contact with a semiconductor device is formed and a second end, which is opposite to the first end, combined with the bump 210, and a combining member 230 for combining the bump 210 and the probe 220 with each other.

In this example embodiment, the substrate 201 may include a single-layer ceramic structure or a multilayer ceramic structure. Further, the circuit pattern 202 on the substrate 201 may correspond to the first pitch of the semiconductor device.

The bump 210 is protruded from the circuit pattern 202 of the substrate 201.

Each of the probes 220 includes a support beam 221 and the tip 222. A fixed end of the support beam 221 is fixed to the bump 210. The support beam 221 horizontally extends from the bump 210. The tip 222 is protruded from a free end of the support beam 221 along an upward vertical direction opposite to a downward vertical direction toward the substrate 201.

In this example embodiment, the support beam 221 may have a bar shape that has a width and a length longer than the width.

Here, to sufficiently provide the tip 222 and the pad of the semiconductor device with stable contact reliability, the tip 222 may have a conical shape or a pyramid shape having a pointed end.

The combining member 230 has a first combining portion 231 protruded from the bump 210, and a second combining portion 232 tightly fitted to the first combining portion 231. The second combining portion 232 is formed at the fixed end of the support beam 221.

In this example embodiment, the first combining portion 231 is separately formed on the bump 210. Alternatively, the first combining portion 231 and the bump 210 may be formed simultaneously with each other. Further, in this example embodiment, the second combining portion 232 is formed on the support beam 221. Alternatively, the second combining portion 232 and the support beam 221 may be formed simultaneously with each other.

The second combining portion 232 is inserted into the first combining portion 231. To tightly fit the second combining portion 232 to the first combining portion 231, the second combining portion 232 may have an outer circumference substantially the same as an inner circumference of a hollow portion in the first combining portion 231. Alternatively, the outer circumference of the second combining portion 232 may be slightly larger than the inner circumference of the first combining portion 231.

As shown in FIG. 4, in this example embodiment, the second combining

portion 232 has a solid rectangular columnar shape protruded from the support beam 221. The first combining portion 231 has a hollow rectangular columnar shape that has the hollow portion having a size corresponding to a diameter of the second combining portion 232.

Additionally, a solder paste 240 may be formed on the first combining portion 231. In this example embodiment, the solder paste 240 is interposed between the first combining portion 231 and the second combining portion 232. When the solder paste 240 is heated, the solder paste 240 is melted to firmly solder the first combining portion 231 and the second combining portion 232 with each other.

Embodiment 3

FIG. 5 is a cross-sectional view illustrating a probe card in accordance with a second example embodiment of the present invention, and FIG. 6 is a perspective view illustrating the probe card in FIG. 5.

In this example embodiment, a first combining portion 331 for fixing a probe 320 is formed at a substrate 301 differently from the structures in Example Embodiments 1 and 2.

Hereinafter, a probe card of this example embodiment is illustrated in detail with reference to FIGS. 5 and 6. Here, substantially identical elements in Example Embodiments 1 to 3 are referred to by identical names and any further illustrations with respect to the same elements are omitted herein for brevity.

Referring to FIGS. 5 and 6, a probe card of this example embodiment

includes a substrate 301 having a circuit pattern 302, a plurality of probes 320 having a tip 322 that makes contact with a semiconductor device, and a combining member 330 for combining the substrate 301 and the probe 320 with each other.

Each of the probes 320 includes a bar-shaped support beam 321 and the tip 322 is protruded from a free end of the support beam 321 along an upward vertical direction opposite to a downward vertical direction toward the substrate 301.

Here, to sufficiently provide the tip 322 and the pad of the semiconductor device with stable contact reliability, the tip 322 may have a conical shape or a pyramid shape having a pointed end.

In this example embodiment, the substrate 301 may include a single-layer ceramic structure or a multilayer ceramic structure. Further, the circuit pattern 302 on the substrate 301 may correspond to the first pitch of the semiconductor device.

The combining member 330 has a first combining portion 331 formed at the substrate 301, and a second combining portion 332 formed at a fixed end of the support beam 321.

The first combining portion 331 may be arranged correspond to the circuit pattern 302. Further, the first combining portion 331 is formed in a recess 303 formed at a surface portion of the substrate 301.

In this example embodiment, the recess 303 may be formed by partially removing the circuit pattern 302 and a portion of the substrate 301 adjacent to

the circuit pattern 302. The first combining portion 331 extends from a bottom face of the recess 303. The circuit pattern 302 is partially arranged on the first combining portion 331. That is, the first combining portion 331 may be formed by partially removing the substrate 301, not removing the first combining portion 331, during the formation of the recess 303.

In this example embodiment, the recess 303 and the first combining portion 331 may be simultaneously obtained by forming a recessed face at a surface portion of the substrate 301 by a sandblasting process.

The recess 303 may have an inner space for sufficiently receiving the second combining portion 332. Further, the recess 303 may have a shape corresponding to that of the second combining portion 332. For example, when the second combining portion 332 has a rectangular columnar shape or a cylindrical columnar shape, the recess 303 may have a rectangular columnar hollow portion or a cylindrical columnar hollow portion corresponding to the shapes of the second combining portion 332.

The second combining portion 332 has a hollow portion for receiving the first combining portion 331. For example, when the first combining portion 331 has a rectangular columnar shape or a cylindrical columnar shape, the second combining portion 332 may have a hollow rectangular columnar shape or a hollow cylindrical columnar hollow portion having a hollow portion that corresponds to the shapes of the first combining portion 331.

Further, a clearance may not be formed between the hollow portion of the second combining portion 332 and the outer circumference of the first

combining portion 331.

Additionally, a solder paste 340 may be formed on the first combining portion 331. In this example embodiment, the circuit pattern 302 is positioned on the first combining portion 331. The solder paste 340 is formed on the circuit pattern 302.

Therefore, when the first combining portion 331 is inserted into the second combining portion 332, pressure may be applied to combine the first combining portion 331 and the second combining portion 332 with each other. When the combining member 340 is heated to the melting temperature of the solder paste 340, the solder paste 340 may be melted to firmly combine the first combining portion 331 and the second combining portion 332 with each other.

According to the present invention, a probe in a probe card may have improved bonding strength. Further, since position errors and deformations of the probes may be prevented, the probe card may have improved structural stability. As a result, test failures of semiconductor devices, which are tested using the probe card, may be reduced.

Having described the preferred embodiments of the present invention, it is noted that modifications and variations can be made by persons skilled in the art in light of the above teachings. It is therefore to be understood that changes may be made in the particular embodiment of the present invention disclosed which is within the scope and the spirit of the invention outlined by the appended claims.

WHAT IS CLAIMED IS:

1. A probe card comprising:

a substrate;

a bump formed on the substrate;

a probe including a support beam and a tip protruded from a free end of the support beam; and

a combining member for electrically coupling the bump and the probe to each other, the combining member including a first combining portion and a second combining portion surrounding an outer face of the first combining portion.

2. The probe card of claim 1, wherein the first combining portion and the second combining portion are tightly fitted to each other.

3. The probe card of claim 1, further comprising a solder paste interposed between the first combining portion and the second combining portion.

4. The probe card of claim 1, wherein the first combining portion is formed on the bump, and the second combining portion is formed at a fixed end of the support beam opposite to the free end.

5. The probe card of claim 1, wherein the first combining portion is

formed at a fixed end of the support beam opposite to the free end, and the second combining portion is formed on the bump.

6. The probe card of claim 1, wherein the second combining portion has a columnar shape including a hollow portion that has a size corresponding to an outer circumference of the first combining portion.

7. A probe card comprising:

a substrate;

a probe including a support beam and a tip protruded from a free end of the support beam; and

a combining member including a first combining portion formed on the substrate, and a second combining portion having a shape for surrounding an outer face of the first combining portion to be combined with the first combining portion.

8. The probe card of claim 7, wherein the first combining portion and the second combining portion are tightly fitted to each other.

9. The probe card of claim 7, wherein the first combining portion is protruded from a recess that formed on at a surface portion of the substrate.

10. The probe card of claim 7, wherein the second combining portion

has a columnar shape including a hollow portion that has a size corresponding to an outer circumference of the first combining portion.

11. The probe card of claim 7, further comprising a solder paste interposed between the first combining portion and the second combining portion.