APPARATUS AND METHODS FOR TOOL MARK FREE STITCH BONDING

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Application No. 63/130,376 filed December 23, 2020, entitled APPARATUS AND METHODS FOR TOOL MARK FREE STITCH BONDING, the disclosure of which is hereby expressly incorporated by reference herein in its respective entirety.

BACKGROUND

Field

[0002] The present disclosure relates to wire bonding on semiconductor devices.

Description of the Related Art

[0003] Wire bonding is an electrical interconnection technique that uses thin wire and a combination of heat, pressure and/or ultrasonic energy. Wire bonding is a solid phase welding process, where two metallic materials (e.g., wire and pad surface, or wire and PCB lead surface) are brought into intimate contact. Once the materials are in intimate contact, electron sharing or inter diffusion of atoms takes place, resulting in the formation of a wire bond.

SUMMARY

[0004] In an aspect, the present disclosure relates to a method for wire bonding. The method includes feeding a wire through a capillary tip and attaching a first end of the wire to a first location, thereby forming a ball bond. The method further includes moving the capillary tip towards a second location while the wire feeds out of the capillary tip. The method further includes attaching a second end of the wire to the second location while preventing contact between the capillary tip and the second location, thereby forming a stitch bond without a tool mark at the second location, wherein the first location is a bond pad on a semiconductor die, and the second location is a thin-plated lead finger on a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

[0005] In some examples, the method can further include, after forming the stitch bond, contacting the second end of the wire with the capillary tip.

[0006] In some examples, the method can further include, before forming the stitch bond, determining effective bonding parameters, with the bonding parameters

including one or more of: impact force, bonding force, ultrasonic energy levels, pressure, and temperature.

[0007] ~~In some examples, the first location can be a bond pad on a semiconductor die, and the second location can be a lead finger on a printed circuit board. The lead finger on the printed circuit board can be a thin-plated lead finger. The thin-plated lead finger can be formed of nickel, gold, and palladium.~~

[0008] In accordance with another aspect, the present disclosure relates to a wire bonding system that includes a handling apparatus configured to position a semiconductor die on a circuit board. The wire bonding system further includes a wire bonding apparatus configured to feed a wire through a capillary tip and attach a first end of the wire to a first location thereby forming a ball bond. The wire bonding apparatus is further configured to move the capillary tip towards a second location while the wire feeds out of the capillary tip. The wire bonding apparatus is further configured to attach a second end of the wire to the second location while preventing contact between the capillary tip and the second location, thereby forming a stitch bond without a tool mark at the second location, wherein the first location is a bond pad on a semiconductor die, and the second location is a thin-plated lead finger on a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

[0009] In some examples, the wire bonding apparatus can be further configured to contact the second end of the wire with the capillary tip after forming the stitch bond.

[0010] In some examples, the wire bonding apparatus can be further configured to determine effective bonding parameters, with the bonding parameters including one or more of: impact force, bonding force, ultrasonic energy levels, pressure, and temperature, before forming the stitch bond.

[0011] ~~In some examples, the first location can be a bond pad on a semiconductor die, and the second location can be a lead finger on a printed circuit board. The lead finger on the printed circuit board can be a thin-plated lead finger. The thin-plated lead finger can be formed of nickel, gold, and palladium.~~

[0012] In another aspect, the present disclosure relates to a method for wire bonding. The method includes using a capillary tool to form a ball bond on a surface of a first location and a stitch bond on a surface of a second location by feeding a wire out of a distal end of the capillary tool, wherein using the capillary tool to form the stitch bond includes moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and attaching a second end of the wire to the second location while preventing a tool mark at the second

location by preventing contact between the distal end of the capillary tool and the second location, the second location is a thin-plated lead finger of a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium. The method further includes preventing contact between the distal end of the capillary tool and the surface of the second location during formation of the stitch bond.

[0013] In some examples, the method can further include strengthening the stitch bond by contacting the stitch bond with the distal end of the capillary tool.

[0014] In some examples, using the capillary tool to form the ball bond can include exposing a first end of the wire out of the distal end of the capillary tool, and attaching the first end of the wire to the surface of the first location. The first location can be a bond pad on a semiconductor die.

[0015] ~~In some examples, using the capillary tool to form the stitch bond can include moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and attaching a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location. The second location can be a lead finger of a printed circuit board.~~

[0016] ~~According to~~In another aspect, the present disclosure relates to a wire bonding system that includes a handling apparatus configured to position a semiconductor die on a circuit board. The wire bonding system further includes a wire bonding apparatus that includes a capillary tool configured to form a ball bond on a surface of a first location and a stitch bond on a surface of a second location by feeding a wire out of a distal end of the capillary tool. The wire bonding apparatus is configured prevent contact between the distal end of the capillary tool and the surface of the second location during formation of the stitch bond, wherein the wire bonding apparatus is configured to form the stitch bond by moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and to attach a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location, the second location is a thin-plated lead finger of the printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

[0017] In some examples, the wire bonding apparatus can be further configured to strengthen the stitch bond by contacting the stitch bond with the distal end of the capillary tool.

[0018] In some examples, the wire bonding apparatus can be configured to form the ball bond by exposing a first end of the wire out of the distal end of the capillary tool, and to attach the first end of the wire to the surface of the first location. The first location can be a bond pad on the semiconductor die.

[0019] ~~In some examples, the wire bonding apparatus can be configured to form the stitch bond by moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and to attach a second~~

~~end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location. The second location can be a lead finger of the printed circuit board.~~

[0020] For purposes of summarizing the disclosure, certain examples~~aspects~~, advantages and novel features of the inventions have been described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any

WHAT IS CLAIMED IS:

1. A method for wire bonding, the method comprising:

feeding a wire through a capillary tip;

attaching a first end of the wire to a first location, thereby forming a ball bond;

moving the capillary tip towards a second location while the wire feeds out of the capillary tip; and

attaching a second end of the wire to the second location while preventing contact between the capillary tip and the second location, thereby forming a stitch bond without a tool mark at the second location,

wherein the first location is a bond pad on a semiconductor die, and the second location is a thin-plated lead finger on a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

2. The method of claim 1 further comprising, after forming the stitch bond, contacting the second end of the wire with the capillary tip.

3. The method of claim 1 further comprising, before forming the stitch bond, determining effective bonding parameters, the bonding parameters including one or more of: impact force, bonding force, ultrasonic energy levels, pressure, and temperature.

~~4. The method of claim 1 wherein the first location is a bond pad on a semiconductor die, and the second location is a lead finger on a printed circuit board.~~

~~5. The method of claim 4 wherein the lead finger on the printed circuit board is a thin-plated lead finger.~~

~~6. The method of claim 5 wherein the thin-plated lead finger is formed of nickel, gold, and palladium.~~

~~7.~~4. A wire bonding system comprising:

a handling apparatus configured to position a semiconductor die on a circuit board; and

a wire bonding apparatus configured to feed a wire through a capillary tip and attach a first end of the wire to a first location thereby forming a ball bond, the wire bonding apparatus further configured to move the capillary tip towards a second location while the wire feeds out of the capillary tip, the wire bonding apparatus further configured to attach a second end of the wire to the second location while preventing contact between the capillary tip and the second location, thereby forming a stitch bond without a tool mark at the second location,

wherein the first location is a bond pad on a semiconductor die, and the second location is a thin-plated lead finger on a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

~~8.~~5. The system of claim ~~4~~7 wherein the wire bonding apparatus is further configured to contact the second end of the wire with the capillary tip after forming the stitch bond.

~~9.~~6. The system of claim ~~4~~7 wherein the wire bonding apparatus is further configured to determine effective bonding parameters, the bonding parameters including one or more of: impact force, bonding force, ultrasonic energy levels, pressure, and temperature, before forming the stitch bond.

~~10. The system of claim 7 wherein the first location is a bond pad on a semiconductor die, and the second location is a lead finger on a printed circuit board.~~

~~11. The system of claim 10 wherein the lead finger on the printed circuit board is a thin-plated lead finger.~~

~~12. The system of claim 11 wherein the thin-plated lead finger is formed of nickel, gold, and palladium.~~

~~13.~~7. A method for wire bonding, the method comprising:

using a capillary tool to form a ball bond on a surface of a first location and a stitch bond on a surface of a second location by feeding a wire out of a distal end of the capillary tool,

wherein using the capillary tool to form the stitch bond includes moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and attaching a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location, the second location is a thin-plated lead finger of a printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium; and

preventing contact between the distal end of the capillary tool and the surface of the second location during formation of the stitch bond.

~~14.~~8. The method of claim 7~~13~~ further comprising strengthening the stitch bond by contacting the stitch bond with the distal end of the capillary tool.

~~15.~~9. The method of claim 7~~13~~ wherein using the capillary tool to form the ball bond includes exposing a first end of the wire out of the distal end of the capillary tool, and attaching the first end of the wire to the surface of the first location.

~~16.~~10. The method of claim 9~~15~~ wherein the first location is a bond pad on a semiconductor die.

~~17. The method of claim 13 wherein using the capillary tool to form the stitch bond includes moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and attaching a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location.~~

~~18. The method of claim 17 wherein the second location is a lead finger of a printed circuit board.~~

~~19.~~11. A wire bonding system comprising:

a handling apparatus configured to position a semiconductor die on a circuit board; and

a wire bonding apparatus including a capillary tool configured to form a ball bond on a surface of a first location and a stitch bond on a surface of a second location by feeding a wire out of a distal end of the capillary tool, the wire bonding apparatus configured prevent contact between the distal end of the capillary tool and the surface of the second location during formation of the stitch bond;

wherein the wire bonding apparatus is configured to form the stitch bond by moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and to attach a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location, the second location is a thin-plated lead finger of the printed circuit board, the thin-plated lead finger is formed of nickel, gold, and palladium.

~~20.~~12. The system of claim 11~~19~~ wherein the wire bonding apparatus is further configured to strengthen the stitch bond by contacting the stitch bond with the distal end of the capillary tool.

~~21.~~13. The system of claim 11~~19~~ wherein the wire bonding apparatus is configured to form the ball bond by exposing a first end of the wire out of the distal end of the capillary tool, and to attach the first end of the wire to the surface of the first location.

~~22.~~14. The system of claim 13~~21~~ wherein the first location is a bond pad on the semiconductor die.

~~23. The system of claim 19 wherein the wire bonding apparatus is configured to form the stitch bond by moving the distal end of the capillary tool towards the second location while the wire feeds out of the distal end of the capillary tool, and to attach a second end of the wire to the second location while preventing a tool mark at the second location by preventing contact between the distal end of the capillary tool and the second location.~~

~~24. The method of claim 23 wherein the second location is a lead finger of the printed circuit board.~~