bond) condition may occur. For example, such non-stick conditions include: (a) a free air ball that does not sufficiently bond to a bond pad (i.e., non-stick-on-pad (NSOP)); and (b) the wire fails to sufficiently bond to a lead (i.e., non-stick-on-lead (NSOL)). Any of these conditions during formation of a wire loop (or a conductive bump) may result in a delay of subsequent operations and costly operator intervention. Such conditions may be caused, for example, by: contamination of a bonding location; variation of the material used to form a bonding location; etc.

[0007] Thus, it would be desirable to provide improved methods of performing wire bonding operations including improved methods of forming wire loops and conductive bumps.

SUMMARY OF THE INVENTION

[0008] According to an exemplary embodiment of the present invention, a method of performing a wire bonding operation is provided. The method includes the steps of: ~~(a) performing a wire bonding operation between a portion of wire and a bonding location using a bonding tool; (b) raising the bonding tool to a desired height; (c) performing a test to determine if the portion of wire is sufficiently bonded to the bonding location; and (d) automatically performing another wire bonding operation between the portion of wire and the bonding location using the bonding tool if, during step (c), it is determined that the portion of wire was not sufficiently bonded to the bonding location in step (a).~~ (a) performing a wire bonding operation between a portion of wire and a bonding location using a bonding tool; (b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location; (c) determining that the portion of wire in contact with the bonding location is not sufficiently bonded to the bonding location; and (d) automatically performing another wire bonding operation between the portion of wire and the bonding location using the bonding tool after step (c).

[0009] According to another exemplary embodiment of the present invention, a method of forming a wire loop is provided. The method includes the steps of: ~~(a) performing a bonding operation between a free air ball formed from a wire and a first bonding location using a bonding tool; (b) raising the bonding tool to a desired height; (c) performing a test to determine if the free air ball is sufficiently bonded to the first bonding location; and (d) automatically performing another bonding operation between the free air ball and the first bonding location if, during step (c), it is determined that the free air ball was not sufficiently bonded to the first bonding location in step (a).~~

(a) performing a bonding operation between a free air ball formed from a wire and a first bonding location using a bonding tool; (b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location; (c) determining that the wire with the free air ball in contact with the bonding location is not sufficiently bonded to the first bonding location; and (d) automatically performing another bonding operation between the free air ball and the first bonding location after step (c).

[0010] According to yet another exemplary embodiment of the present invention, a method of forming a wire loop is provided. The method includes the steps of: ~~(a) forming a first bond of wire at a first bonding location using a bonding tool; (b) extending a length of wire, continuous with the first bond, to a second bond location; (c) performing a bonding operation between a portion of the length of wire and the second bonding location using the bonding tool; (d) raising the bonding tool to a~~

~~desired height; (e) performing a test to determine if the portion of the length of wire is sufficiently bonded to the second bonding location; (f) automatically performing another bonding operation between the portion of the length of wire and the second bonding location if, during step (e), it is determined that the portion of the length of wire was not sufficiently bonded to the second bonding location.~~ (a) forming a first bond of wire at a first bonding location using a bonding tool; (b) extending a length of wire, continuous with the first bond, to a second bond location; (c) performing a bonding operation between a portion of the length of wire and the second bonding locating using the bonding tool; (d) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location; (e) determining that the portion of the length of wire in contact with the bonding location is not sufficiently bonded to the second bonding location; and (f) automatically performing another bonding operation between the portion of the length of wire and the second bonding location after step (c).

[0011] According to another exemplary embodiment of the present invention, a method of forming a conductive bump is provided. The method includes the steps of: ~~(a) performing a bonding operation between a free air ball formed from a wire to a bonding location using a bonding tool; (b) raising the bonding tool to a desired height; (c) performing a test to determine if the free air ball is sufficiently bonded to the bonding location; and (d) automatically performing another bonding operation between the free air ball and the bonding location if, during step (c), it is determined that the free air ball was not sufficiently bonded to the bonding location.~~ (a) performing a bonding operation between a free air ball formed from a wire to a bonding location using a bonding tool; (b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location; (c) determining that the wire with the free air ball in contact with the bonding location is not sufficiently bonded to the bonding location; and (d) automatically performing another bonding operation between the free air ball and the bonding location after step (c).

[0012] The methods of the present invention may also be embodied as an apparatus (e.g., as part of the intelligence of a wire bonding machine), or as computer program instructions on a computer readable carrier (e.g., a computer readable carrier including a wire bonding program used in connection with a wire bonding machine).

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention is best understood from the following detailed description when read in connection with the accompanying drawings. It is emphasized that, according to common practice, the various features of the drawings are not to scale. On the contrary, the dimensions of the various features are arbitrarily expanded or reduced for clarity. For example, the relative position of the wire clamps and the bonding tool as shown herein are not shown to scale. Included in the drawings are the following figures:

FIGS. 1A-1J are a series of block diagrams illustrating a conventional process of forming a wire loop;

FIGS. 2A-2O are a series of block diagrams illustrating a method of forming a wire loop in accordance with an exemplary embodiment of the present invention;

What is Claimed:

1. A method of performing a wire bonding operation, the method comprising the steps of:

(a) performing a wire bonding operation between a portion of wire and a bonding location using a bonding tool;

(b) raising the bonding tool to a desired height;

(c) performing a test to determine if the portion of wire is sufficiently bonded to the bonding location; and

(d) automatically performing another wire bonding operation between the portion of wire and the bonding location using the bonding tool if, during step (c), it is determined that the portion of wire was not sufficiently bonded to the bonding location in step (a).

2. The method of claim 1 wherein the portion of wire is included in a first bond of a wire loop.

3. The method of claim 1 wherein the portion of wire is included in a second bond of a wire loop.

4. The method of claim 1 wherein the portion of wire is a free air ball configured to be formed into a conductive bump.

5. The method of claim 1 wherein step (c) includes performing an electrical continuity test between the portion of wire and the bonding location.

6. The method of claim 5 wherein wire clamps of a wire bonding machine are closed during the electrical continuity test, the wire clamps being a portion of a conductive path used to perform the electrical continuity test.

7. The method of claim 1 wherein step (d) is performed automatically using computer program instructions accessible from a wire bonding machine.

8. The method of claim 1 wherein step (d) is performed automatically using computer program instructions installed on a computer of a wire bonding machine.

9. The method of claim 1 where step (d) is performed without operator intervention.

10. The method of claim 1 wherein the wire bonding operation is configured to be performed on a wire bonding machine, and the wire bonding machine is configured to execute a wire bonding program controlled by a computer, and steps (a)-(d) are included in the wire bonding program such that the re-bonding in step (d) is performed without interrupting the wire bonding program.

11. The method of claim 1 wherein the portion of wire is bonded to a different area of the bonding location in step (d) as compared to an area of the bonding location to which the portion of wire was attempted to be bonded in step (a).

12. The method of claim 1 wherein step (d) is performed using identical bonding parameters used during the bonding operation of step (a).

13. The method of claim 1 wherein step (d) is performed using at least one different bonding parameter from bonding parameters used during the bonding operation of step (a).

14. The method of claim 1 further comprising the step of (e) performing another test to determine if the portion of wire is sufficiently re-bonded to the bonding location after step (d).

15. The method of claim 14 further comprising the step of (f) alerting an operator if, during step (e), it is determined that the portion of wire was not sufficiently re-bonded to the bonding location.

16. The method of claim 1 wherein step (c) is performed such that the portion of wire is continuous with a wire supply of a wire bonding machine.

17. The method of claim 1 wherein the method is performed on a ball bonding machine.

18. The method of claim 1 wherein the method is performed on a wedge bonding machine.

19. A method of forming a wire loop, the method comprising the steps of:

(a) performing a bonding operation between a free air ball formed from a wire and a first bonding location using a bonding tool;

(b) raising the bonding tool to a desired height;

(c) performing a test to determine if the free air ball is sufficiently bonded to the first bonding location; and

(d) automatically performing another bonding operation between the free air ball and the first bonding location if, during step (c), it is determined that the free air ball was not sufficiently bonded to the first bonding location in step (a).

20. A method of forming a wire loop, the method comprising the steps of:

(a) forming a first bond of wire at a first bonding location using a bonding tool;

(b) extending a length of wire, continuous with the first bond, to a second bond location;

(c) performing a bonding operation between a portion of the length of wire and the second bonding location using the bonding tool;

(d) raising the bonding tool to a desired height;

(e) performing a test to determine if the portion of the length of wire is sufficiently bonded to the second bonding location; and

(f) automatically performing another bonding operation between the portion of the length of wire and the second bonding location if, during step (e), it is determined that the portion of the length of wire was not sufficiently bonded to the second bonding location.

21. A method of forming a conductive bump, the method comprising the steps of:

(a) performing a bonding operation between a free air ball formed from a wire to a bonding location using a bonding tool;

(b) raising the bonding tool to a desired height;

(c) performing a test to determine if the free air ball is sufficiently bonded to the bonding location; and

(d) automatically performing another bonding operation between the free air ball and the bonding location if, during step (c), it is determined that the free air ball was not sufficiently bonded to the bonding location.

What is claimed:

1. A method of performing a wire bonding operation, the method comprising the steps of:

(a) performing a wire bonding operation between a portion of wire and a bonding location using a bonding tool;

(b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location;

(c) determining that the portion of wire in contact with the bonding location is not sufficiently bonded to the bonding location; and

(d) automatically performing another wire bonding operation between the portion of wire and the bonding location using the bonding tool after step (c).

2. The method of claim 1 wherein the portion of wire is included in a first bond of a wire loop.

3. The method of claim 1 wherein the portion of wire is included in a second bond of a wire loop.

4. The method of claim 1 wherein the portion of wire is a free air ball configured to be formed into a conductive bump.

5. The method of claim 1 wherein step (c) includes performing an electrical continuity test between the portion of wire and the bonding location.

6. The method of claim 5 wherein wire clamps of a wire bonding machine are closed during the electrical continuity test, the wire clamps being a portion of a conductive path used to perform the electrical continuity test.

7. The method of claim 1 wherein step (d) is performed automatically using computer program instructions accessible from a wire bonding machine.

8. The method of claim 1 wherein step (d) is performed automatically using computer program instructions installed on a computer of a wire bonding machine.

9. The method of claim 1 where step (d) is performed without operator intervention.

10. The method of claim 1 wherein the wire bonding operation is configured to be performed on a wire bonding machine, and the wire bonding machine is configured to execute a wire bonding program controlled by a computer, and steps (a)-(d) are included in the wire bonding program such that the re-bonding in step (d) is performed without interrupting the wire bonding program.

11. The method of claim 1 wherein step (d) is performed using identical bonding parameters used during the bonding operation of step (a).

12. The method of claim 1 wherein step (d) is performed using at least one different bonding parameter from bonding parameters used during the bonding operation of step (a).

13. The method of claim 1 further comprising the step of (e) performing another test to determine if the portion of wire is sufficiently re-bonded to the bonding location after step (d).

14. The method of claim 13 further comprising the step of (f) alerting an operator if, during step (e), it is determined that the portion of wire was not sufficiently re-bonded to the bonding location.

15. The method of claim 1 wherein step (c) is performed such that the portion of wire is continuous with a wire supply of a wire bonding machine.

16. The method of claim 1 wherein the method is performed on a ball bonding machine.

17. The method of claim 1 wherein the method is performed on a wedge bonding machine.

18. A method of forming a wire loop, the method comprising the steps of:

(a) performing a bonding operation between a free air ball formed from a wire and a first bonding location using a bonding tool;

(b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location;

(c) determining that the wire with the free air ball in contact with the bonding location is not sufficiently bonded to the first bonding location; and

(d) automatically performing another bonding operation between the free air ball and the first bonding location after step (c).

19. A method of forming a wire loop, the method comprising the steps of:

(a) forming a first bond of wire at a first bonding location using a bonding tool;

(b) extending a length of wire, continuous with the first bond, to a second bond location;

(c) performing a bonding operation between a portion of the length of wire and the second bonding location using the bonding tool;

(d) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location;

(e) determining that the portion of the length of wire in contact with the bonding location is not sufficiently bonded to the second bonding location; and

(f) automatically performing another bonding operation between the portion of the length of wire and the second bonding location after step (c).

20. A method of forming a conductive bump, the method comprising the steps of:

(a) performing a bonding operation between a free air ball formed from a wire to a bonding location using a bonding tool;

(b) raising the bonding tool to a desired height with the portion of wire being in contact with the bonding location;

(c) determining that the wire with the free air ball in contact with the bonding location is not sufficiently bonded to the bonding location; and

(d) automatically performing another bonding operation between the free air ball and the bonding location after step (c).