Claims

1. A method of measuring a free air ball size during a wire bonding process of a wire bonder, the wire bonder having a position sensor and a bonding tool for forming an electrical connection between a semiconductor device and a substrate using a bonding wire, the method comprising the steps of:

forming a free air ball from a wire tail of the bonding wire;

using the position sensor to determine a positional difference between a free air ball contact position and a non-free air ball contact position of the bonding tool with respect to a reference position representing a decrease in a length of the wire tail before and after formation of the free air ball on the wire tail, wherein the free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when the free air ball contacts a conductive surface and the non-free air ball contact position is a position of the bonding tool when the wire tail contacts the conductive surface before the formation of the free air ball; and

measuring a volume of the wire tail that has been formed into the free air ball based on the positional difference; and

calculating a volume of the free air ball based on the volume of the wire tail that has been determined from measuring the positional difference.

2. The method of claim 1, wherein the non-free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when the wire tail contacts a bonding surface of the semiconductor device.

3. The method of any one of the preceding claims, wherein the step of measuring the free air ball size is based on the conservation of mass between the wire tail and the free air ball.

4. The method of any one of the preceding claims, wherein the non-free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when a base of the bonding tool contacts a bonding surface of the substrate.

5. A method of measuring a free air ball size during a wire bonding process of a wire bonder, the wire bonder having a position sensor and a bonding tool for forming an electrical connection between a semiconductor device and a substrate using a bonding wire, the method comprising the steps of:

forming a free air ball from a wire tail of the bonding wire;

using the position sensor to determine a positional difference between a free air ball contact position and a non-free air ball contact position of the bonding tool with respect to a reference position, wherein the free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when the free air ball contacts a conductive surface and the non-free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when a base of the bonding tool contacts the conductive surface; and

measuring the free air ball size based on the positional difference of the bonding tool as determined by the position sensor, wherein the step of measuring the free air ball size further comprises the step of deriving a radius of the free air ball based on a chamfered diameter of the bonding tool and a chamfered angle between the free air ball and the bonding tool.

6. The method of any one of the preceding claims, wherein the step of using the position sensor to determine the positional difference of the bonding tool comprises using an encoder to measure respective heights of the bonding tool with respect to a reference height.

7. The method of any one of the preceding claims, wherein the free air ball size is measured in relation to a radius of the free air ball.

8. The method of any one of the preceding claims, wherein the free air ball contact and non-free air ball contact positions of the bonding tool with respect to the reference position are the respective positions of a base of the bonding tool.

9. A wire bonder, comprising:

a bonding tool operative to form an electrical connection between a semiconductor device and a substrate using a bonding wire;

a position sensor operative to determine a positional difference between a free air ball contact position and a non-free air ball contact position of the bonding tool representing a decrease in a length of the wire tail before and after formation of the free air ball on the wire tail, wherein the free air ball contact position of the bonding tool is a position of the bonding tool when a free air ball contacts a conductive surface, the free air ball being formed from a wire tail of the bonding wire and the non-free air ball contact position is a position of the bonding tool when the wire tail contacts the conductive surface before the formation of the free air ball; and

a processor configured to measure a volume of the wire tail that has been formed into the free air ball based on the positional difference, and to calculate a volume of the free air ball based on the volume of the wire tail that has been determined from measuring the positional difference.

10. The wire bonder of claim 9, wherein the non-free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when the wire tail contacts a bonding surface of the semiconductor device.

11. The wire bonder of claim 9 or claim 10, wherein the processor is configured to measure the free air ball size based on the conservation of mass between the wire tail and the free air ball.

12. The wire bonder of any one of claims 9 to 11, wherein the non-free air ball contact position of the bonding tool with respect to the reference position when a base of the bonding tool contacts a bonding surface of the substrate.

13. A wire bonder, comprising:

a bonding tool operative to form an electrical connection between a semiconductor device and a substrate using a bonding wire;

a position sensor operative to determine a positional difference between a free air ball contact position and a non-free air ball contact position of the bonding tool, wherein the free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when a free air ball contacts a conductive surface and the non-free air ball contact position of the bonding tool is a position of the bonding tool with respect to the reference position when a base of the bonding tool contacts the conductive surface, the free air ball being formed from a wire tail of the bonding wire; and

a processor configured to measure a size of the free air ball based on the positional difference of the bonding tool as determined by the position sensor, wherein the processor is configured to measure the free air ball size by deriving a radius of the free air ball based on a chamfered diameter of the bonding tool and a chamfered angle between the free air ball and the bonding tool.

14. The wire bonder of any one of claims 9 to 13, wherein the position sensor is an encoder configured to measure respective heights of the bonding tool with respect to a reference height.

15. The wire bonder of any one of claims 9 to 14, wherein the free air ball size is measured in relation to a radius of the free air ball.

16. The wire bonder of any one of claims 9 to 15, wherein the first and second positions of the bonding tool with respect to the reference position are the respective positions of a base of the bonding tool.