**Claims**

1. A method of detecting a bonding failure of a wire bonder, the wire bonder comprising a bonding tool operative to form an electrical connection between a semiconductor die and a substrate using a bonding wire, the method comprising the steps of:

forming a first wire bond on a first surface located on the semiconductor die using the bonding tool and the bonding wire;

forming a second wire bond on a second surface located on the substrate using the bonding tool and the bonding wire such that a wire loop connects the first and second wire bonds, wherein the first surface is not electrically-conductive;

moving the bonding tool in a direction away from the second wire bond to break the bonding wire from the second wire bond;

detecting whether the second wire bond remains bonded to the substrate; and

determining an occurrence of the bonding failure if the second wire bond is no longer bonded to the substrate.

2. The method of claim 1, wherein the step of moving the bonding tool in the direction away from the second wire bond comprises the step of moving the bonding tool in upward and sideways directions.

3. The method of claim 1, wherein the step of moving the bonding tool in the direction away from the second wire bond to break the bonding wire from the second wire bond comprises the step of positioning the bonding tool at a predetermined position before the bonding wire is clamped to pull the bonding wire from the second wire bond.

4. The method of claim 3, wherein the predetermined position of the bonding tool is spaced from the second wire bond.

5. The method of claim 3, wherein the step of detecting whether the second wire bond remains bonded to the substrate further comprises the steps of:

moving the bonding tool in a direction towards the substrate whilst detecting a position of the bonding tool at which an electrical connection occurs between the bonding wire and the substrate;

comparing the detected position of the bonding tool with the predetermined position of the bonding tool; and

determining that the second wire bond is no longer bonded to the substrate if the detected position of the tip of the bonding tool does not substantially correspond to the predetermined position of the bonding tool.

6. The method of claim 5, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 20% from the predetermined position.

7. The method of claim 5, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 10% from the predetermined position.

8. The method of claim 5, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 5% from the predetermined position.

9. The method of claim 1, wherein the step of detecting whether the second wire bond remains bonded to the substrate comprises the steps of:

measuring a force acting on the bonding tool from the second wire bond using a force sensor configured to measure one or more external forces acting on the bonding tool; and

comparing the measured force acting on the bonding tool with a predetermined force that is expected to act on the bonding tool when the second wire bond remains bonded to the substrate.

10. The method of claim 9, wherein it is determined that the second wire bond is no longer bonded to the substrate if the measured force does not substantially correspond to the predetermined force.

11. The method of claim 10, wherein the measured force does not substantially correspond to the predetermined force if the measured force is outside a tolerance range of 20% from the predetermined force.

12. The method of claim 10, wherein the measured force does not substantially correspond to the predetermined force if the measured force is outside a tolerance range of 10% from the predetermined force.

13. The method of claim 10, wherein the measured force does not substantially correspond to the predetermined force if the measured force is outside a tolerance range of 5% of the predetermined force.

14. The method of claim 9, wherein the predetermined force is an average of typical forces as measured by the force sensor when the bonding wire is being tensioned to break from the second wire bond and when the bonding wire has successfully broken from the second wire bond.

15. The method of claim 14, wherein it is determined that the second wire bond is no longer bonded to the substrate if the measured force is substantially less than the predetermined force.

16. A method of detecting a bonding failure of a wire bonder, the wire bonder comprising a bonding tool operative to form an electrical connection between a semiconductor die and a substrate using a bonding wire, and the wire bonder further comprising a force sensor for measuring a force based on one or more external forces acting on the bonding tool, the method comprising the steps of:

forming a first wire bond on a first surface located on the semiconductor die using the bonding tool;

forming a second wire bond on a second surface located on the substrate using the bonding tool such that a wire loop connects the first and second wire bonds;

moving the bonding tool in a direction away from the second wire bond to break the bonding wire from the second wire bond;

detecting whether the second wire bond remains bonded to the substrate by measuring the force acting on the bonding tool using the force sensor; and

determining an occurrence of the bonding failure if the second wire bond is no longer bonded to the substrate.

17. The method of claim 16, wherein the step of detecting whether the second wire bond remains bonded to the substrate comprises the step of comparing the measured force acting on the bonding tool with a predetermined force that is expected to act on the bonding tool when the second wire bond remains bonded to the substrate.

18. The method of claim 17, wherein the measured force does not substantially correspond to the predetermined force if the measured force is outside a tolerance range of 20% from the predetermined force.

19. The method of claim 17, wherein the predetermined force is an average of typical forces as measured by the force sensor when the bonding wire is being tensioned to break from the second wire bond and when the bonding wire has successfully broken from the second wire bond.

20. The method of claim 19, wherein it is determined that the second wire bond is no longer bonded to the substrate if the measured force is substantially less than the predetermined force.

Claims

1. A method of detecting a bonding failure of a wire bonder, the wire bonder comprising a bonding tool operative to form an electrical connection between a semiconductor die and a substrate using a bonding wire, the method comprising the steps of:

forming a first wire bond on a first surface located on the semiconductor die using the bonding tool and the bonding wire;

forming a second wire bond on a second surface located on the substrate using the bonding tool and the bonding wire such that a wire loop connects the first and second wire bonds;

moving the bonding tool in a direction away from the second wire bond to break the bonding wire from the second wire bond;

detecting that the second wire bond does not remain bonded to the substrate; and

determining an occurrence of the bonding failure, wherein the step of detecting that the second wire bond does not remain bonded to the substrate comprises the steps of:

moving the bonding tool in a direction towards the substrate while detecting a position of the bonding tool at which an electrical connection occurs between the bonding wire and the substrate;

comparing the detected position of the bonding tool with a predetermined position of the bonding tool, the predetermined position of the bonding tool indicating an absence of a bonding failure;

detecting that the detected position of the tip of the bonding tool does not substantially correspond to the predetermined position of the bonding tool; and

determining that the second wire bond is no longer bonded to the substrate.

2. The method of claim 1, wherein the step of moving the bonding tool in the direction away from the second wire bond comprises the step of moving the bonding tool in upward and sideways directions.

3. The method of claim 1 or claim 2, wherein the step of moving the bonding tool in the direction away from the second wire bond to break the bonding wire from the second wire bond comprises the step of positioning the bonding tool at a predetermined position before the bonding wire is clamped to pull the bonding wire from the second wire bond.

4. The method of claim 3, wherein the predetermined position of the bonding tool is spaced from the second wire bond.

5. The method of any one of the preceding claims, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 20% from the predetermined position.

6. The method of any one of the preceding claims, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 10% from the predetermined position.

7. The method of any one of the preceding claims, wherein the detected position of the bonding tool does not substantially correspond to the predetermined position of the bonding tool if it is outside a tolerance range of 5% from the predetermined position.