point, and a moving speed of the capillary 15. Based on the first parameter and the second parameter, the calculation part calculates, among trajectories of the capillary 15 from where the wire w is crimped to the bond point to where the wire w is cut, at least a trajectory in a delivery step of delivering the wire w. Based on the trajectory of the capillary 15 calculated by the calculation part, the output part outputs a control signal controlling the XY table 12 and the bonding head 13. Based on various parameters stored in the storage part, the output part outputs various control signals controlling each part of the bump-forming device 1.

[0037] Next, a bump-forming method according to one embodiment of the present invention is described with reference to FIG. 2 to FIG. 5. The bump-forming device 1 described above is used in the bump-forming method. FIG. 2 is a flowchart schematically illustrating a bump-forming method according to one embodiment. FIG. 3 illustrates an example of a parameter input screen. FIG. 4 is a sectional view schematically illustrating a state immediately before a wire is bonded to a bond point. FIG. 5 is a sectional view schematically illustrating a state immediately after a wire is bonded to a bond point.

[0038] First, the first parameter and the second parameter input in the bump-forming method according to the present embodiment are described with reference to FIG. 4 and FIG. 5. ~~Provided is a~~FIG. 4 and FIG. 5 are sectional views illustrating a step of crimping the wire w to an electrode 52 corresponding to a bond point of a semiconductor device 50. A hole 15h and a chamfer 15c are formed in the capillary 15. The hole 15h and the chamfer 15c are through holes penetrating the capillary 15 in the Z direction, and the chamfer 15c is formed on the tip side of the hole 15h. The hole 15h and the chamfer 15c are connected, and the chamfer 15c opens at the tip of the capillary 15. The wire w is inserted through the hole 15h and the chamfer 15c. A diameter (hereinafter referred to as “hole diameter Dh”) of the hole 15h is substantially constant at the tip of the capillary 15 and is greater than a diameter (hereinafter referred to as “wire diameter Dw”) of the wire w. An angle formed by mutually facing inner peripheral surfaces of the chamfer 15c corresponds to the chamfer angle Ac. A diameter of an opening formed by the chamfer 15c at the tip of the capillary 15 corresponds

electrode 52 of the semiconductor device 50 corresponds to an example of a “first bond point” according to the present invention, and an electrode 72 of a substrate 70 corresponds to an example of a “second bond point” according to the present invention. The bump 54A is formed on the electrode 52 of the semiconductor device 50. Since the bump 54A is formed on the electrode 52 of the semiconductor device 50, bonding strength between the electrode 52 of the semiconductor device 50 and a bonding wire bw is improved. Accordingly, since sufficient bonding strength can be obtained without increasing a force for pressing the bonding wire bw against the electrode 52 of the semiconductor device 50, damage to the semiconductor device 50 caused by a wire bonding apparatus can be reduced.

[0062] The bump 54A is formed so as to have a smaller thickness on a side far from the electrode 72 of the substrate 70 than on a side close to the electrode 72 of the substrate 70. In other words, a surface of the bump 54A formed on the electrode 52 (one bond point of a pair of bond points) of the semiconductor device 50 is inclined away from the semiconductor device 50 as approaching the electrode 72 (the other bond point of the pair of bond points) of the substrate 70. In a mode of wire bonding illustrated in FIG. 8, first, the bonding wire bw is bonded to the electrode 72 of the substrate 70. Next, the capillary 15 is moved while the bonding wire bw is delivered. Finally, the bonding wire bw is bonded to the bump 54A and then cut. That is, the wire bonding illustrated in FIG. 8 is so-called forward bonding in which the electrode 72 of the substrate 70 is a primary bond point and the electrode 52 of the semiconductor device 50 is a secondary bond point. At this time, the bonding wire bw bonded to the bump 54A is away from an outer edge of the semiconductor device 50 due to the inclination of the surface of the bump 54A. Accordingly, even if the bonding wire bw extends substantially parallel to a surface of the semiconductor device 50 or the substrate 70, the inclination of the surface of the bump 54A prevents the bonding wire bw from falling down. According to this, contact between the semiconductor device 50 and the bonding wire bw can be suppressed.

[0063] In the second use example illustrated in FIG. 9, a bump 54B is used for wire bonding

of forward bonding as in the first use example. In FIG. 9, the bump 54B formed on the electrode 52 of the semiconductor device 50 is formed so as to have a greater thickness on the side far from the electrode 72 of the substrate 70 than on the side close to the electrode 72 of the substrate 70. According to this, tail cut of the bonding wire bw is facilitated, and bending of the bonding wire bw can be reduced.

[0064] In the third use example illustrated in FIG. 10, a bump 54C is used for wire bonding of so-called reverse bonding in which the electrode 52 of the semiconductor device 50 is the primary bond point and the electrode 72 of the substrate 70 electrode 72 is the secondary bond point. In FIG. 10, the bump 54C formed on the electrode 72 of the semiconductor device 70 is formed so as to have a smaller thickness on a side far from the electrode 52 of the semiconductor device 50 than on a side close to the electrode 52 of the substrate 50. According to this, like the first use example, the bonding wire bw can be prevented from falling down, and contact between the semiconductor device 50 and the bonding wire bw can be suppressed.

[0065] In the fourth use example illustrated in FIG. 11, a bump 54D is used for wire bonding of reverse bonding as in the third use example. In FIG. ~~10~~11, the bump ~~54C~~ 54D formed on the electrode 72 of the semiconductor device 70 is formed so as to have a greater thickness on the side far from the electrode 52 of the semiconductor device 50 than on the side close to the electrode 52 of the substrate 50. According to this, like the second use example, tail cut of the bonding wire bw is facilitated, and bending of the bonding wire bw can be reduced.

[0066] In the first to fourth use examples, the bump according to the first embodiment is formed on the secondary bond point. However, the bump may also be formed on the primary bond point. The bump may be formed at only one bond point or at both bond points of the pair of bond points electrically connected by wire bonding.

[0067] In the fifth use example illustrated in FIG. 12, a bump 54E is formed on the electrode 52 of the semiconductor device 50. The bump 54E is formed so as to have a smaller thickness on a side far from the outer edge of the semiconductor device 50 than on a side close to the outer edge

of the semiconductor device 50 when the electrode 52 is viewed in a plan view. In the sixth use example illustrated in FIG. 13, a bump 54F is formed on the electrode 52 of the semiconductor device 50. The bump 54F is formed so as to have a greater thickness on the side far from the outer edge of the semiconductor device 50 than on the side close to the outer edge of the semiconductor device 50 when the electrode 52 is viewed in a plan view. The bumps ~~54F~~54E and 54F are used for, for example, flip-chip mounting. Which of the bump ~~54F~~54E and the bump 54F is to be formed is appropriately selected according to the position, shape or the like of an object to be bonded. The bump ~~54F~~54E and the bump 54F may be used in applications other than flip-chip mounting.

[0068] The shape of the bump used for flip-chip mounting is not limited to that of the bump ~~54F~~54E or the bump 54F. For example, in the case of forming the bump on each of two adjacent electrodes, the two bumps may be formed so as to have a smaller thickness on a side close to each other than on a side away from each other, or may be formed so as to have a greater thickness on the side close to each other than on the side away from each other. Similarly, in the applications other than flip-chip mounting, the shape of the bump used for flip-chip mounting is not limited to that of the bump ~~54F~~54E or the bump 54F.

[0069] Next, a bump-forming method according to a second embodiment is described with reference to FIG. 14 and FIG. 15. FIG. 14 illustrates an example of a trajectory of a capillary according to the second embodiment. FIG. 15 is a photograph illustrating a bump formed according to the second embodiment.

[0070] The second embodiment is a bump-forming method for forming a bump of a second shape. As illustrated in FIG. ~~8~~14, the trajectory of the capillary 15 calculated by the calculation part of the bonding controller 10 in the present embodiment includes a first ascending path, a first slide path, a first descending path, a second ascending path, a second slide path, and a second descending path. The movement direction of the capillary 15 in the first ascending path and the second ascending path is set as the +Z direction, and the movement direction of the capillary 15 in the first descending path and the second descending path is set as the −Z direction. The movement

CLAIMS

[Claim 1] ~~(amended)~~

A bump-forming device comprising:

a bonding tool, bonding a wire to a bond point as a bonding target; and

a bonding controller, controlling the bonding tool to form a bump on the bond point,

wherein

the bonding controller is configured to execute:

a crimping step in which a ball part formed at a tip of ~~a~~the wire extending from a tip of the bonding tool is crimped to the bond point by the tip of the bonding tool;

a delivery step in which the bonding tool is moved while ~~a~~the wire is delivered from the ball part crimped to the bond point;

a pressing step in which a portion of the ball part crimped to the bond point is pressed by the tip of the bonding tool, and the ball part crimped to the bond point is deformed; and

a cutting step in which the wire is cut and the bump is formed on the bond point;

based on a first parameter relating to the wire and a second parameter relating to shape of the bonding tool, at least a trajectory in the delivery step in the trajectory of the bonding tool is determined;

the first parameter comprises a diameter of the ball part before being crimped and a diameter and a thickness of a crimp lower portion of the ball part crimped to the bond point, the crimp lower portion being formed between the bonding tool and the bond point; and

the second parameter comprises a hole diameter of a hole of the bonding tool through which the wire is inserted, and a chamfer diameter and a chamfer angle of a chamfer provided on a tip side of the hole of the bonding tool.

[Claim 2]

The bump-forming device according to claim 1, wherein

the bonding controller acquires the first parameter and the second parameter input by an input

device, and calculates the trajectory of the bonding tool.

[Claim 3] ~~(amended)~~

The bump-forming device according to claim 2, wherein

the bonding controller calculates a volume of a crimp upper portion of the ball part crimped to the bond point, the crimp upper portion being formed inside the bonding tool.

[Claim 4]

The bump-forming device according to claim 3, wherein

the trajectory of the bonding tool comprises an ascending path away from the bond point; and

the bonding controller calculates a distance of the ascending path based on the volume of the crimp upper portion.

[Claim 5]

The bump-forming device according to claim 4, wherein

the trajectory of the bonding tool further comprises a slide path moving in a direction intersecting the ascending path;

the first parameter comprises a diameter and a material of the wire; and

the bonding controller calculates a distance of the slide path based on the chamfer diameter and the diameter and the material of the wire.

[Claim 6]

The bump-forming device according to claim 5, wherein

the trajectory of the bonding tool further comprises a descending path approaching the bond point; and

the bonding controller calculates a distance of the descending path based on the distance of the ascending path and the material of the wire.

[Claim 7] ~~(amended)~~

A bump-forming method comprising:

a crimping step in which a ball part formed at a tip of a wire extending from a tip of a bonding

tool is crimped to a bond point by the tip of the bonding tool;

a delivery step in which the bonding tool is moved while the wire is delivered from the ball part crimped to the bond point;

a pressing step in which a portion of the ball part crimped to the bond point is pressed by the tip of the bonding tool, and the ball part crimped to the bond point is deformed; and

a cutting step in which the wire is cut and a bump is formed on the bond point,

wherein

based on a first parameter relating to the wire and a second parameter relating to shape of the bonding tool, at least a trajectory in the delivery step in the trajectory of the bonding tool is determined;

the first parameter comprises a diameter of the ball part before being crimped and a diameter and a thickness of a crimp lower portion of the ball part crimped to the bond point, the crimp lower portion being formed between the bonding tool and the bond point; and

the second parameter comprises a hole diameter of a hole of the bonding tool through which the wire is inserted, and a chamfer diameter and a chamfer angle of a chamfer provided on a tip side of the hole of the bonding tool.

[Claim 8]

The bump-forming method according to claim 7, wherein,

between a first bond point and a second bond point electrically connected by wire bonding, the bump is formed at the first bond point; and

the bump has a greater thickness on a side close to the second bond point than on a side far from the second bond point.

[Claim 9] ~~(amended)~~

A bump-forming program, causing a computer to execute:

crimping processing in which a ball part formed at a tip of a wire extending from a tip of a bonding tool is crimped to a bond point by the tip of the bonding tool;

delivery processing in which the bonding tool is moved while ~~a~~the wire is delivered from the ball part crimped to the bond point;

pressing processing in which a portion of the ball part crimped to the bond point is pressed by the tip of the bonding tool, and the ball part crimped to the bond point is deformed; and

cutting processing in which the wire is cut and a bump is formed on the bond point,

wherein

based on a first parameter relating to the wire and a second parameter relating to shape of the bonding tool, at least a trajectory in the delivery processing in the trajectory of the bonding tool is determined;

the first parameter comprises a diameter of the ball part before being crimped and a diameter and a thickness of a crimp lower portion of the ball part crimped to the bond point, the crimp lower portion being formed between the bonding tool and the bond point; and

the second parameter comprises a hole diameter of a hole of the bonding tool through which the wire is inserted, and a chamfer diameter and a chamfer angle of a chamfer provided on a tip side of the hole of the bonding tool.