the copying mechanism causes a facing surface being the mounting surface or the holding surface and connected to the second spherical surface to swing with respect to a reference surface facing the facing surface and being the holding surface or the mounting surface, and is switchable between a free state in which swinging of the facing surface is enabled and a locked state in which swinging of the facing surface is restricted; and a controller, executing adjustment processing once or more times and adjusting the facing surface to be parallel to the reference surface, in which in the adjustment processing, the facing surface is caused to directly or indirectly abut against the reference surface after the copying mechanism is set to the locked state, then the copying mechanism is switched to the free state and the facing surface is directly or indirectly pressed against the reference surface, and then the copying mechanism is switched to the locked state.

[0009] In this case, the controller may repeat the adjustment processing until a pressing position being an axial position of the bonding head when the facing surface is pressed against the reference surface in the adjustment processing reaches a specified reference value.

[0010] The controller may store the axial position of the bonding head when the facing surface is pressed against the reference surface as the pressing position. The controller may repeat the adjustment processing until a change amount between the pressing position obtained by a previous pressing and the pressing position obtained by a current pressing reaches a specified reference value.

[0011] The copying mechanism may be mounted on the stage. In the adjustment processing, the controller may press the holding surface being the reference surface against an intersection of the mounting surface being the facing surface and a normal of the mounting surface passing through a swing center of the copying mechanism.

[0012] The controller may also execute initial processing prior to the adjustment processing. In the initial processing, the controller may cause the facing surface to directly or indirectly abut against the reference surface after setting the copying mechanism to the free state, then directly

or indirectly press the facing surface against the reference surface, and then switch the copying mechanism to the locked state.

[0013] A manufacturing method of a semiconductor device disclosed in the present specification is a manufacturing method of a semiconductor device as follows. By bonding a chip sucked and held by a holding surface of a bonding head having a copying mechanism to a substrate mounted on a stage, a semiconductor device is manufactured. The manufacturing method of a semiconductor device is characterized in the following. The stage or the bonding head is equipped with the copying mechanism. The copying mechanism has a first spherical surface and a second spherical surface provided swingably with respect to the first spherical surface. The copying mechanism causes a facing surface being the mounting surface or the holding surface to swing with respect to a reference surface facing the facing surface and being the holding surface or the mounting surface. The copying mechanism is switchable between a free state in which swinging of the facing surface is enabled and a locked state in which swinging of the facing surface is restricted. An adjustment step is included in which the following operations are performed. The facing surface is caused to directly or indirectly abut against the reference surface after the copying mechanism is set to the locked state, then the copying mechanism is switched to the free state and the facing surface is directly or indirectly pressed against the reference surface, and the copying mechanism is switched to the locked state. The adjustment step is performed once or more times and the facing surface is adjusted to be parallel to the reference surface.

Effects of the Invention

[0014] According to the technique disclosed in the present specification, a holding surface of a bonding head can be adjusted by a simple procedure to be parallel to a mounting surface of a stage with high accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is a diagram showing a configuration of a manufacturing apparatus of a

reference surface 110, as shown in FIG. 5B. This abutting may be detected based on reaction force from the reference surface 110, or may be detected based on a change in an axial position Pz of the bonding head 14. In any case, if the facing surface 50 abuts against the reference surface 110 in the locked state, the copying mechanism 22 is switched from the locked state to the free state, as shown in FIG. 6A. Then, in this state, the facing surface 50 is pressed against the reference surface 110 with a predetermined load. Accordingly, the movable member 42 swings in a direction of eliminating tilting of the facing surface 50. Then, after this pressing, the copying mechanism 22 is switched from the free state to the locked state.

[0038] In the copying processing of this example, the above adjustment processing is executed once or multiple times. Here, as is clear from the foregoing description, in the adjustment processing, the tilting of the facing surface 50 at the start of pressing of the facing surface 50 against the reference surface 110 is maintained to be the tilting of the facing surface 50 obtained by the initial processing or the previous adjustment processing. In other words, in the adjustment processing, when the facing surface 50 is pressed against the reference surface 110, the tilting of the facing surface 50 is already eliminated to some extent. Since the pressing of the facing surface 50 against the reference surface 110 is started in the state in which the tilting of the facing surface 50 is eliminated to some extent, the facing surface 50 is able to be closer to the completely parallel state than in the initial processing or the previous adjustment processing. That is, by executing once or more times the adjustment processing for pressing the facing surface 50 against the reference surface 110 while maintaining the tilting of the facing surface 50 obtained by the initial processing or the previous adjustment processing, the facing surface 50 is able to be relatively reliably parallel to the reference surface 110.

[0039] The number of times of execution of the adjustment processing may be specified in advance. Alternatively, the adjustment processing may be repeated until it can be determined that the facing surface 50 is sufficiently parallel to the reference surface 110. The determination that a sufficiently parallel state is achieved may be made based on, for example, a

pressing position Pp[i] being the axial position Pz of the bonding head 14 when the facing surface 50 is pressed against the reference surface 110. For example, the axial position Pz when the facing surface 50 is sufficiently parallel can be inferred to some extent from a past measurement or an arrangement of the stage 12 and the bonding head 14. Therefore, the axial position Pz when the facing surface 50 is sufficiently parallel is inferred as a reference position Pdef, and the adjustment processing may be repeated until the pressing position Pp[i] obtained by the actual adjustment processing reaches the reference position Pdef. In the case where the facing surface 50 is sufficiently parallel to the reference surface 110, even if the facing surface 50 is pressed against the reference surface 110, the axial position Pz of the bonding head 14 does not change. Therefore, the adjustment processing may be repeated until a change amount between a pressing position Pp[i-1] obtained by the initial processing or the previous adjustment processing and the pressing position Pp[i] obtained by the current adjustment processing becomes less than the specified reference value. In any case, by executing the adjustment processing once or more times, the facing surface 50 is able to be relatively reliably parallel to the reference surface 110.

[0040] Next, a flow of the copying processing will be described with reference to FIG. 7 to FIG. 9. FIG. 7 is a flowchart describing a flow of the entire copying processing. As described above and as shown in FIG. 7, the controller 34 first executes the initial processing as the copying processing (S10). FIG. 8 is a flowchart showing a flow of the initial processing. In the initial processing, the controller 34 first drives the copying mechanism drive part 32 to set the copying mechanism 22 to the free state (S12). In response to an instruction from the controller 34, the copying mechanism drive part 32 supplies compressed air to the spherical aerostatic bearing 44 to make the movable member 42 swingable. When the free state is achieved, the movable member 42 tilts largely in one direction as shown in FIG. 4A due to dead weight of a pipe or the like. Subsequently, the controller 34 drives the movement mechanism 26 to lower the bonding head 14 toward the stage 12 (S14). The controller 34 monitors

whether the facing surface 50 has abutted against the reference surface 110 during this lowering (S16).

[0041] When the facing surface 50 abuts against the reference surface 110 as a result of the lowering (Yes in S16), the controller 34 drives the movement mechanism 26 to press the facing surface 50 against the reference surface 110 with a predetermined load (S18). Accordingly, the movable member 42 receives the reaction force from the reference surface 110 and swings in the direction of eliminating tilting. However, as the pressing progresses, the frictional force between the facing surface 50 and the reference surface 110 increases, and is balanced with the force that causes the movable member 42 to swing. In this case, swinging of the movable member 42 is stopped while the tilting of the facing surface 50 with respect to the reference surface 110 remains. The controller 34 stores the axial position Pz of the bonding head 14 at the moment when the pressing operation is completed as the pressing position Pp[i].

[0042] If the facing surface 50 can be pressed with the predetermined load, the controller 34 subsequently drives the copying mechanism drive part 32 to switch the copying mechanism 22 to the locked state (S20). Then, if the bonding head 14 is lifted to a height away from the mounting surface 18 (S22), the initial processing is ended.

[0043] If the initial processing is ended, as shown in FIG. 7, the adjustment processing is subsequently executed (S30). FIG. 9 is a flowchart showing a flow of adjustment processing. At the start of the adjustment processing, the copying mechanism 22 is in the locked state. While maintaining this locked state, the controller 34 drives the movement mechanism 26 to lower the bonding head 14 toward the stage 12 (S32, S34). Since the locked state is maintained, at this moment, the tilting of the facing surface 50 obtained by the initial processing or the previous adjustment processing is maintained. The controller 34 monitors whether the facing surface 50 has abutted against the reference surface 110 during this lowering (S36).

[0044] When the facing surface 50 abuts against the reference surface 110 as a result of the lowering (Yes in S36), the controller 34 drives the copying mechanism drive part 32 to switch

WHAT IS CLAIMED IS:

1. A manufacturing apparatus of a semiconductor device, comprising:

a stage, having a mounting surface on which a substrate is mounted;

a bonding head, having a holding surface sucking and holding a chip, movable relative to the stage in a plane direction and a normal direction of the stage;

a copying mechanism, having a first spherical surface and a second spherical surface provided swingably with respect to the first spherical surface, mounted on the stage or the bonding head, wherein the copying mechanism causes a facing surface being the mounting surface or the holding surface and connected to the second spherical surface to swing with respect to a reference surface facing the facing surface and being the holding surface or the mounting surface, and is switchable between a free state in which swinging of the facing surface is enabled and a locked state in which swinging of the facing surface is restricted; and

a controller, executing adjustment processing once or more times and adjusting the facing surface to be parallel to the reference surface, wherein in the adjustment processing, the facing surface is caused to directly or indirectly abut against the reference surface after the copying mechanism is set to the locked state, then the copying mechanism is switched to the free state and the facing surface is directly or indirectly pressed against the reference surface, and then the copying mechanism is switched to the locked state.

2. The manufacturing apparatus of a semiconductor device according to claim 1, wherein

the controller repeats the adjustment processing until a pressing position being an axial position of the bonding head when the facing surface is pressed against the reference surface in the adjustment processing reaches a specified reference value.

3. The manufacturing apparatus of a semiconductor device according to claim 1, wherein

the controller stores an axial position of the bonding head when the facing surface is pressed against the reference surface as a pressing position;

the controller repeats the adjustment processing until a change amount between the

pressing position obtained by a previous pressing and the pressing position obtained by a current pressing reaches a specified reference value.

4. The manufacturing apparatus of a semiconductor device according to any one of claims 1 to 3, wherein

the copying mechanism is mounted on the stage;

the controller presses the holding surface being the reference surface against an intersection of the mounting surface being the facing surface and a normal of the mounting surface passing through a swing center of the copying mechanism in the adjustment processing.

5. The manufacturing apparatus of a semiconductor device according to any one of claims 1 to 4, wherein

the controller also executes initial processing prior to the adjustment processing;

the controller causes the facing surface to directly or indirectly abut against the reference surface after setting the copying mechanism to the free state, then directly or indirectly presses the facing surface against the reference surface, and then switches the copying mechanism to the locked state in the initial processing.

6. A manufacturing method of a semiconductor device, manufacturing a semiconductor device by bonding a chip sucked and held by a holding surface of a bonding head having a copying mechanism to a substrate mounted on a stage, wherein

the stage or the bonding head is equipped with the copying mechanism, the copying mechanism having a first spherical surface and a second spherical surface provided swingably with respect to the first spherical surface, the copying mechanism causing a facing surface being a mounting surface or the holding surface to swing with respect to a reference surface facing the facing surface and being the holding surface or the mounting surface, wherein the copying mechanism is switchable between a free state in which swinging of the facing surface is enabled and a locked state in which swinging of the facing surface is restricted;

an adjustment step is comprised to perform: causing the facing surface to directly or

indirectly abut against the reference surface after setting the copying mechanism to the locked state, then switching the copying mechanism to the free state and directly or indirectly pressing the facing surface against the reference surface, and switching the copying mechanism to the locked state;

the adjustment step is performed once or more times and the facing surface is adjusted to be parallel to the reference surface.