

DESCRIPTION

TITLE OF THE INVENTION

BONDING APPARATUS

5

TECHNICAL FIELD

[0001] The present disclosure relates to a bonding apparatus.

BACKGROUND ART

10

[0002] Patent Document 1 describes a chip-on-wafer bonding method for mounting chips on a wafer. In this chip-on-wafer bonding method, a plurality of chips are bonded to a substrate after surface activation treatment and hydrophilization treatment are performed on the chips and surface activation treatment and hydrophilization treatment are performed on the substrate.

15

RELATED-ART DOCUMENTS

PATENT DOCUMENTS

[0003]

Patent Document 1: Japanese Patent No. 6337400

20

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] The technology according to the present disclosure can suppress charging of a bond head when a die held by the bond head is bonded to a target substrate in a die-on-process manufacturing process.

25

MEANS TO SOLVE THE PROBLEM

[0005] According to one aspect of the present disclosure, a bonding apparatus for bonding a plurality of dies to a target substrate includes: a substrate holder configured to hold the target substrate; and a head configured to bond the plurality of dies to the target substrate held by the substrate holder, wherein the head includes: a bond head configured to hold each of the plurality of dies and having electrical conductivity; an insulator configured to hold the bond head; and a ground connector configured to connect the bond head to a ground potential.

30
35

EFFECTS OF THE INVENTION

[0006] According to the present disclosure, when a die held by a bond head is bonded to a target substrate in a die-on-process manufacturing process,
5 charging of the bond head can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

[FIG. 1] FIG. 1 is a plan view illustrating an outline of a configuration of a wafer
10 on which a plurality of dies are mounted.

[FIG. 2] FIG. 2 is a cross-sectional view illustrating an outline of a configuration of a first carrier holding first dies.

[FIG. 3] FIG. 3 is a plan view illustrating an outline of a configuration of the first carrier holding the first dies.

15 [FIG. 4] FIG. 4 is a cross-sectional view illustrating an outline of a configuration of a second carrier holding second dies.

[FIG. 5] FIG. 5 is a plan view illustrating an outline of a configuration of the second carrier holding the second dies.

20 [FIG. 6] FIG. 6 is a plan view illustrating an outline of a configuration of a processing system.

[FIG. 7] FIG. 7 is a flowchart illustrating main steps of a die-on-wafer manufacturing process.

[FIG. 8] FIG. 8 is an explanatory diagram schematically illustrating some steps of the die-on-wafer manufacturing process.

25 [FIG. 9] FIG. 9 is a perspective view illustrating an outline of a configuration of a first bonding apparatus according to an embodiment.

[FIG. 10] FIG. 10 is a side view and a plan view illustrating an outline of a configuration of a head according to the embodiment.

30 [FIG. 11] FIG. 11 is a side view illustrating an outline of a configuration of a head according to another embodiment.

[FIG. 12] FIG. 12 is a perspective view illustrating an outline of a configuration of a first bonding apparatus according to another embodiment.

MODE FOR CARRYING OUT THE INVENTION

35 **[0008]** In recent years, in a semiconductor device manufacturing process, a

chip-on-wafer (CoW) manufacturing process has been studied as one of the three-dimensional mounting technologies in response to a demand for further higher performance and higher density of a semiconductor device. The chip-on-wafer manufacturing is performed by, for example, the method disclosed in

5 Patent Document 1.

[0009] In a chip-on-wafer manufacturing process (hereinafter referred to as a "die-on-wafer manufacturing process"), as disclosed in Patent Document 1, a plurality of semiconductor chips (hereinafter referred to as "dies") are bonded to a semiconductor substrate (hereinafter referred to as a "wafer") after
10 surface activation treatment and hydrophilization treatment are performed on the dies and surface activation treatment and hydrophilization treatment are performed on the wafer.

[0010] The plurality of dies are bonded to the wafer by a bonding apparatus. For example, in the bonding apparatus, first, a pickup is used to pick up a die
15 from a carrier holding a plurality of dies. Next, a head receives the die from the pickup. The die held by the head and the wafer held by a wafer holder are arranged to face each other. Thereafter, the head is lowered to place and bond the die onto the wafer.

[0011] For example, the head includes an electrically conductive bond head configured to hold a die, and an insulating plate configured to hold the upper surface of the bond head. That is, the bond head is electrically floating. In such a case, when the bond head repeatedly receives a die from the pickup and transfers the die to the wafer, the bond head becomes charged. If the bond head is charged in this manner, when a die is received from the pickup, the bond
20 head discharges upon contacting the die, thereby causing a current to flow from the bond head to the die. In such a case, a circuit (device) included in the die would be damaged. Therefore, there is room for improvement in mounting a plurality of dies on a wafer.

[0012] The technology according to the present disclosure suppresses
30 charging of a bond head when dies held by the bond head are bonded to a target substrate in a die-on-process manufacturing process. Hereinafter, a processing system including a bonding apparatus according to an embodiment and a processing method will be described with reference to the drawings. In the present specification and the drawings, components having substantially
35 the same functional configurations are denoted by the same reference

numerals, and redundant description will be omitted.

[0013] In the present embodiment, as illustrated in FIG. 1, a plurality of types of dies D1 and D2 are mounted on a wafer W serving as a target substrate.

Specifically, as illustrated in FIGS. 2 and 3, a plurality of first dies D1 held by a first carrier C1 and, as illustrated in FIGS. 4 and 5, a plurality of second dies D2 held by a second carrier C2 are bonded to the target wafer W.

[0014] As illustrated in FIG. 1, the wafer W on which the first dies D1 and the second dies D2 are to be mounted is a semiconductor wafer, such as a silicon substrate, or a glass substrate used in a semiconductor device manufacturing process. For example, the diameter of the wafer W is 300 mm, and the thickness of the wafer W is about 800 μm . Note that, in the wafer W, a surface on which the first dies D1 and the second dies D2 are mounted is referred to as a front surface Wa, and a surface opposite to the front surface Wa is referred to as a back surface Wb.

[0015] Note that the number and the arrangement of the first dies D1 and the second dies D2 to be mounted on the front surface Wa of the wafer W are set to a desired pattern. Further, a device layer (not illustrated) may be formed on the front surface Wa. The device layer is formed so as to correspond to device layers E of the first dies D1, which will be described below.

[0016] As illustrated in FIGS. 2 and 3, the first carrier C1 holds the plurality of first dies D1. Each of the first dies D1 has a configuration in which, for example, a silicon layer S1 and a device layer E are stacked. A circuit is formed in the device layer E. When the first dies D1 are bonded to the wafer W as will be described later, the bonding accuracy required for the first dies D1 is high. That is, the first dies D1 are high-accuracy dies. Note that, in each of the first dies D1, a surface on which the device layer E is formed is referred to as a front surface D1a, and a surface opposite to the front surface D1a is referred to as a back surface D1b.

[0017] As illustrated in FIGS. 4 and 5, the second carrier C2 holds the plurality of second dies D2. Each of the second dies D2 has a configuration in which, for example, a silicon layer S2 and an oxide film F are stacked. A device such as a circuit is not formed in the oxide film F. When the second dies D2 are bonded to the wafer W as will be described later, the bonding accuracy required for the second dies D2 is low. That is, the second dies D2 are low-accuracy dies. Note that, in each of the second dies D2, a surface on which the

oxide film F is formed is referred to as a front surface D2a, and a surface opposite to the front surface D2a is referred to as a back surface D2b.

[0018] As described above, the first dies D1 and the second dies D2 are different types of dies. A circuit is formed in each of the first dies D1, whereas a circuit is not formed in each of the second dies D2. Therefore, the bonding accuracy required for the first dies D1 is relatively high, and the bonding accuracy required for the second dies D2 is relatively low. Further, the shape (size and thickness) of the first dies D1 is different from the shape (size and thickness) of the second die D2. Therefore, the number of the first dies D1 held by the first carrier C1 is also different from the number of the second dies held by the second carrier C2.

[0019] The first carrier C1 and the second carrier C2 have the same configuration. First, the configuration of the first carrier C1 will be described.

[0020] As illustrated in FIGS. 2 and 3, the first carrier C1 has, on its upper surface, a chucking surface for holding the plurality of first dies D1 by electrostatic chucking and vacuum suction. The first carrier C1 chucks and holds the silicon layer S1 on the back surface D1b of each of the first dies D1. The first carrier C1 has a configuration in which a main body M1 and an insulating layer N1 are stacked.

[0021] The main body M1 has substantially the same diameter and substantially the same thickness as the wafer W on which the first dies D1 are to be mounted. For example, the diameter of the main body M1 is 300 mm and the thickness of the main body M1 is about 800 μm . Further, the main body M1 is formed of a material having electrical conductivity, such as silicon, aluminum, an aluminum alloy, stainless steel, alumina, zirconia, SiC, or titanium. In other words, a silicon substrate may be used as the main body M1. Note that the main body M1 may be configured to have substantially the same diameter as the wafer on which the first dies D1 are to be mounted, and configured to have a thickness (for example, 500 μm to 1,000 μm) different from the wafer.

[0022] A plurality of through-holes H1 penetrating in the thickness direction of the main body M1 are formed in the main body M1. The plurality of through-holes H1 can be formed at any positions on the chucking surface of the first carrier C1. For example, one through-hole H1 may be formed so as to be associated with a corresponding one of the plurality of first dies D1 held by the

first carrier C1. In other words, the number of through-holes H1 formed may be the same as the number of the plurality of first dies D1 held by the first carrier C1. Alternatively, for example, a plurality of through-holes H1 may be formed so as to be associated with a corresponding one of the plurality of first dies D1 held by the first carrier C1. In other words, the number of through-holes H1 formed may be larger than the number of the plurality of first dies D1 held by the first carrier C1.

[0023] Further, the number, the size, the pitch, and the arrangement of the through-holes H1 are not particularly limited, and are desirably set to a number, a size, and a pitch that can ensure strength (rigidity) of the first carrier C1 such that deformation such as bending does not occur in the first carrier C1. For example, the diameter of each of the through-holes H1 is 0.5 mm to 5.0 mm, and the pitch of the through-holes H1 (the distance between the centers of adjacent through-holes H1) is 0.5 mm to 5.0 mm.

[0024] The insulating layer N1 is a layer formed on the surface of the main body M1, and forms the chucking surface of the first carrier C1 for holding the first dies D1. No through-holes are formed in the insulating layer N1, and the insulating layer N1 covers the surface of the main body M1. The thickness of the insulating layer N1 is such a thickness that the first dies D1 can be held on the first carrier C1 by electrostatic chucking. The thickness of the insulating layer N1 is, for example, several tens of μm .

[0025] The insulating layer N1 is formed of a material having flexibility and an insulating property, such as polyimide or ethylene-vinyl acetate copolymer (EVA). In the present embodiment, "the insulating layer N1 has flexibility" means that the elastic modulus of the insulating layer N1 on the main body M1 is 2 GPa or less, and is preferably 0.5 GPa or less. Further, in the present embodiment, "the insulating layer N1 has an insulating property" means that the dielectric breakdown voltage of the insulating layer N1 on the main body M1 is 30 kV or more, and is preferably 40 kV or more.

[0026] As illustrated in FIGS. 4 and 5, the second carrier C2 has the same configuration as the first carrier C1 as described above, and has a configuration in which a main body M2 and an insulating layer N2 are stacked. The configurations of the main body M2 and the insulating layer N2 are the same as the configurations of the main body M1 and the insulating layer N1, respectively. A plurality of through-holes H2 penetrating in the thickness

direction of the main body M2 are formed in the main body M2. Because the second dies D2 held by the second carrier C2 are of a different type from the first dies D1, the number, the size, the pitch, and the arrangement of the through-holes H2 may be different from those of the through-holes H1 of the first carrier C1.

[0027] The first carrier C1 according to the present embodiment is configured as described above, and chucks and holds the first dies D1 on the chucking surface by generating an electrostatic (Coulomb) force between the first carrier C1 and the first dies D1. Similarly, the second carrier C2 chucks and holds the second die D2 on the chucking surface by generating an electrostatic (Coulomb) force between the second carrier C2 and the second dies D2.

[0028] Further, in the first carrier C1 according to the present embodiment, the insulating layer N1 is formed of a flexible material having a low elastic modulus. After the first dies D1 are arranged on the first carrier C1 and before the first dies D1 are chucked and held by an electrostatic force, a gap is formed between each of the first dies D1 and the insulating layer N1. By virtue of the flexibility of the insulating layer N1, when the first dies D1 are chucked to the first carrier C1 by the electrostatic force, the force attracting the first dies D1 to the insulating layer N1 causes air to escape from between each of the first dies D1 and the insulating layer N1, thereby forming a pseudo-vacuum state between each of the first dies D1 and the insulating layer N1. Accordingly, a vacuum suction force generated by the pseudo-vacuum state is exerted between the first carrier C1 and each of the first dies D1, in addition to the electrostatic chucking due to the electrostatic force, thereby forming a firm holding state using both the electrostatic chucking force and the vacuum suction force. Similarly, the second carrier C2 chucks and holds the second dies D2 by using both the electrostatic chucking force and the vacuum suction force.

[0029] The method of holding the dies D1 and D2 by the carriers C1 and C2 is not limited to that of the present embodiment. For example, the dies D1 and D2 may be pressed against and pressure-bonded to the carriers C1 and C2. In such a case, by pressing the dies D1 and D2 against the carriers C1 and C2, air escapes from between the dies D1 and the insulating layer N1 and between the dies D2 and the insulating layer N2, a vacuum suction force is generated between the dies D1 and the insulating layer N1 and between the dies D2 and the insulating layer N2, and the dies D1 and D2 are chucked and held by the

carriers C1 and C2. In such a case, the material of the main bodies M1 and M2 of the carriers C1 and C2 does not need to have electrical conductivity and may be selected as desired. Further, the material of the insulating layers N1 and N2 does not need to have an insulating property and may be selected as desired.

- 5 **[0030]** Further, for example, an adhesive sheet may be used for the insulating layers N1 and N2 of the carriers C1 and C2. In this case, an adhesive force is generated between the dies D1 and the insulating layer N1 and between the dies D2 and the insulating layer N2, and thus the dies D1 and D2 are held by the carriers C1 and C2. Note that a thermal release sheet may be used for the
- 10 insulating layers N1 and N2. A thermal release sheet is a sheet that has adhesive strength at room temperature but is released when heated. As will be described later, when the dies D1 and D2 are bonded to the wafer W, the dies D1 and D2 are detached from the carriers C1 and C2. At this time, by heating the insulating layers N1 and N2, it becomes easier to detach the dies D1 and D2.
- 15 **[0031]** Next, a processing system 1 according to the present embodiment will be described. In the processing system 1, a plurality of first dies D1 held by a first carrier C1 and a plurality of second dies D2 held by a second carrier C2 are mounted on a wafer W. FIG. 6 is a plan view illustrating an outline of the configuration of the processing system 1.
- 20 **[0032]** As illustrated in FIG. 6, the processing system 1 has a configuration in which a loading and unloading station 10 and a processing station 20 are integrally connected. In the loading and unloading station 10, front opening unified pods (FOUPs) Fw, Fc1, and Fc2 capable of accommodating a
- 25 corresponding one of a plurality of wafers W, a corresponding one of a plurality of first carriers C1, and a corresponding one of a plurality of second carriers C2, respectively, are loaded from and unloaded to the outside, for example. The processing station 20 is provided with, for example, three processing blocks 21 to 23, and includes various processing apparatuses for implementing a series of processes described later.
- 30 **[0033]** The loading and unloading station 10 includes a FOUP mounting stage 30. In the illustrated example, a plurality of, for example, two FOUPs Fw, one Fc1, and one Fc2 are mounted on the FOUP mounting stage 30 and are arranged in a line in the Y-axis direction. The number and the arrangement of the FOUPs Fw, Fc1, and Fc2 mounted on the FOUP mounting stage 30 are not limited to
- 35 those of the present embodiment, and may be determined as desired.

[0034] On the positive X-axis side of the FOUP mounting stage 30, a transfer apparatus 40 is provided adjacent to the FOUP mounting stage 30. The transfer apparatus 40 is configured to be movable on a transfer path 41 extending in the Y-axis direction. Further, the transfer apparatus 40 includes, for example, two transfer arms 42, 42 configured to hold and transfer a wafer W, a first carrier C1, and a second carrier C2. Each of the transfer arms 42 is configured to be movable in the horizontal direction, in the vertical direction, about the horizontal axis, and about the vertical axis. The configuration of the transfer arms 42 is not limited to that of the present embodiment, and the transfer arms 42 may have any configuration. The transfer apparatus 40 is configured to transfer the wafer W, the first carrier C1, and the second carrier C2 to the FOUPs Fw, Fc1, and Fc2 on the FOUP mounting stage 30, a transition apparatus 60 described later, and a buffer apparatus 61 described later.

[0035] The processing station 20 is provided with, for example, the three processing blocks 21 to 23. The first processing block 21, the second processing block 22, and the third processing block 23 are arranged side by side in this order from the negative X-axis side to the positive X-axis side.

[0036] The first processing block 21 is provided with a transfer apparatus 50, a transition apparatus 60, a buffer apparatus 61, an inspection apparatus 70, a wafer modification apparatus 71, a die modification apparatus 72, a wafer cleaning apparatus 73, a die cleaning apparatus 74, a wafer hydrophilization apparatus 75, and a die hydrophilization apparatus 76. The number and the arrangement of these various processing apparatuses are not limited to those of the present embodiment, and may be determined as desired.

[0037] The transfer apparatus 50 is configured to be movable on a transfer path 51 extending in the X-axis direction. Further, the transfer apparatus 50 includes, for example, two transfer arms 52, 52 configured to hold and transfer the wafer W, the first carrier C1, and the second carrier C2. Each of the transfer arms 52 is configured to be movable in the horizontal direction, in the vertical direction, about the horizontal axis, and about the vertical axis. Each of the transfer arms 52 is configured to transfer the wafer W, the first carrier C1, and the second carrier C2 to the apparatuses 60, 61, and 70 to 76 of the first processing block 21, a transition apparatus 90 described later, and a buffer apparatus 91 described later.

[0038] The transition apparatus 60 and the buffer apparatus 61 are arranged

on the negative X-axis side of the transfer apparatus 50. The transition apparatus 60 and the buffer apparatus 61 are provided so as to be stacked vertically in this order from the top. A plurality of buffer apparatuses 61 may be stacked and provided.

5 **[0039]** The transition apparatus 60 transfers the wafer W, the first carrier C1, and the second carrier C2 between the transfer apparatus 40 and the transfer apparatus 50. The buffer apparatus 61 temporarily stores the wafer W, the first carrier C1, and the second carrier C2.

10 **[0040]** The inspection apparatus 70, the wafer modification apparatus 71, and the die modification apparatus 72 are arranged on the positive Y-axis side of the transfer apparatus 50. The inspection apparatus 70, as well as the wafer modification apparatus 71 and the die modification apparatus 72, are provided so as to be stacked vertically in this order from the top. The wafer modification apparatus 71 and the die modification apparatus 72 are arranged side by side
15 in this order from the negative X-axis side to the positive X-axis side.

20 **[0041]** The inspection apparatus 70 inspects the wafer W on which first dies D1 and second dies D2 are mounted. The inspection apparatus 70 images the wafer W by using, for example, an IR camera, and inspects the presence or absence of voids between the front surface Wa of the wafer W and the dies D1 and D2. Note that the inspection apparatus 70 may inspect the positions of the dies D1 and D2 bonded to the front surface Wa of the wafer W.

25 **[0042]** The wafer modification apparatus 71 uses plasma to modify the front surface Wa of the wafer W. In the wafer modification apparatus 71, oxygen gas, nitrogen gas, hydrogen gas, or a mixed gas thereof, each of which is a processing gas, is excited into a plasma and ionized in a reduced-pressure atmosphere, for example. The oxygen ions, nitrogen ions, or hydrogen ions are directed onto the front surface Wa of the wafer W, and the front surface Wa is plasma-processed and modified.

30 **[0043]** Similar to the wafer modification apparatus 71, the die modification apparatus 72 uses plasma to modify front surfaces D1a and D2a of the dies D1 and D2. In the die modification apparatus 72, oxygen gas, nitrogen gas, hydrogen gas, or a mixed gas thereof, each of which is a processing gas, is excited into a plasma and ionized in a reduced-pressure atmosphere, for example. The oxygen ions, nitrogen ions, or hydrogen ions are directed onto the
35 surfaces D1a and D2a of the dies D1 and D2 held by the carriers C1 and C2, and

the surfaces D1a and D2a are plasma-processed and modified.

[0044] The wafer cleaning apparatus 73, the die cleaning apparatus 74, the wafer hydrophilization apparatus 75, and the die hydrophilization apparatus 76 are arranged on the negative Y-axis side of the transfer apparatus 50. The wafer cleaning apparatus 73 and the wafer hydrophilization apparatus 75 are stacked vertically in this order from the top, and the die cleaning apparatus 74 and the die hydrophilization apparatus 76 are stacked vertically in this order from the top. The wafer cleaning apparatus 73 and the die cleaning apparatus 74 are arranged side by side in this order from the negative X-axis side to the positive X-axis side. The wafer hydrophilization apparatus 75 and the die hydrophilization apparatus 76 are arranged side by side in this order from the negative X-axis side to the positive X-axis side.

[0045] The wafer cleaning apparatus 73 cleans the front surface Wa of the wafer W. In the wafer cleaning apparatus 73, while rotating the wafer W held by a spin chuck, for example, a cleaning liquid, such as pure water, DI water, DHF, or IPA, is supplied onto the wafer W. Then, the supplied cleaning liquid diffuses on the front surface Wa of the wafer W, and the front surface Wa is cleaned.

[0046] Similar to the wafer cleaning apparatus 73, the die cleaning apparatus 74 cleans the front surfaces D1a and D2a of the dies D1 and D2. In the die cleaning apparatus 74, while rotating the carriers C1 and C2 held by a chuck, a cleaning liquid is supplied onto the dies D1 and D2 held by the carriers C1 and C2. Then, the supplied cleaning liquid diffuses on the front surfaces D1a and D2a of the dies D1 and D2, and the front surfaces D1a and D2a are cleaned.

[0047] The wafer hydrophilization apparatus 75 hydrophilizes and rinses the front surface Wa of the wafer W. In the wafer hydrophilization apparatus 75, while rotating the wafer W held by a spin chuck, for example, pure water is supplied onto the wafer W. Then, the supplied pure water diffuses on the front surface Wa of the wafer W, and the front surface Wa is hydrophilized. Further, the front surface Wa is rinsed by the pure water.

[0048] Similar to the wafer hydrophilization apparatus 75, the die hydrophilization apparatus 76 hydrophilizes and rinses the front surfaces D1a and D2a of the dies D1 and D2. In the die hydrophilization apparatus 76, while rotating the carriers C1 and C2 held by a spin chuck, for example, pure water is supplied onto the dies D1 and D2 held by the carriers C1 and C2. Then, the

supplied pure water diffuses on the front surfaces D1a and D2a of the dies D1 and D2, and the front surfaces D1a and D2a are hydrophilized. Further, the front surfaces D1a and D2a are rinsed by the pure water.

[0049] The second processing block 22 is provided with a transfer apparatus 80, the transition apparatus 90, the buffer apparatus 91, and a first bonding apparatus 100. The number and the arrangement of these various processing apparatuses are not limited to those of the present embodiment, and may be determined as desired.

[0050] The transfer apparatus 80 is configured to be movable on a transfer path 81 extending in the X-axis direction. Further, the transfer apparatus 80 includes, for example, two transfer arms 82, 82 configured to hold and transfer the wafer W, the first carrier C1, and the second carrier C2. Each of the transfer arms 82 is configured to be movable in the horizontal direction, in the vertical direction, about the horizontal axis, and about the vertical axis. Each of the transfer arms 82 is configured to transfer the wafer W, the first carrier C1, and the second carrier C2 to the apparatuses 90, 91, and 100 of the second processing block 22, a transition apparatus 120 described later, and a buffer apparatus 121 described later.

[0051] The transition apparatus 90 and the buffer apparatus 91 are arranged on the negative X-axis side of the transfer apparatus 80. The transition apparatus 90 and the buffer apparatus 91 are stacked vertically in this order from the top. A plurality of buffer apparatuses 91 may be stacked and provided.

[0052] The transition apparatus 90 transfers the wafer W, the first carrier C1, and the second carrier C2 between the transfer apparatus 50 and the transfer apparatus 80. The buffer apparatus 91 temporarily stores the wafer W, the first carrier C1, and the second carrier C2.

[0053] For example, two first bonding apparatuses 100 are arranged on the positive Y-axis side of the transfer apparatus 80, and two first bonding apparatuses 100 are arranged on the negative Y-axis side of the transfer apparatus 80. Each first bonding apparatus 100 bonds the first dies D1 (high-accuracy dies) held by the first carrier C1 to the wafer W. That is, the bonding accuracy required for the first bonding apparatus 100 is high (such a bonding apparatus may be hereinafter referred to as a "high-accuracy bonding apparatus"). Details of a configuration of the first bonding apparatus 100 will be described later.

[0054] The third processing block 23 is provided with a transfer apparatus 110, the transition apparatus 120, the buffer apparatus 121, and a second bonding apparatus 130. The number and the arrangement of these various processing apparatuses are not limited to those of the present embodiment, and may be determined as desired.

[0055] The transfer apparatus 110 is configured to be movable on a transfer path 111 extending in the X-axis direction. Further, the transfer apparatus 110 includes, for example, two transfer arms 112, 112 configured to hold and transfer the wafer W and the second carrier C2. Each of the transfer arms 112 is configured to be movable in the horizontal direction, in the vertical direction, about the horizontal axis, and about the vertical axis. Each of the transfer arms 112 is configured to transfer the wafer W and the second carrier C2 to the apparatuses 120, 121, and 130 of the third processing block 23.

[0056] The transition apparatus 120 and the buffer apparatus 121 are arranged on the negative X-axis side of the transfer apparatus 110. The transition apparatus 120 and the buffer apparatus 121 are stacked vertically in this order from the top. A plurality of the buffer apparatuses 121 may be stacked and provided.

[0057] The transition apparatus 120 transfers the wafer W and the second carrier C2 between the transfer apparatus 80 and the transfer apparatus 110. The buffer apparatus 121 temporarily stores the wafer W, the first carrier C1, and the second carrier C2.

[0058] For example, two second bonding apparatuses 130 are arranged on the positive Y-axis side of the transfer apparatus 110, and two second bonding apparatuses 130 are arranged on the negative Y-axis side of the transfer apparatus 110. Each second bonding apparatus 130 bonds the second dies D2 (low-accuracy dies) held by the second carrier C2 to the wafer W. That is, the bonding accuracy required for the second bonding apparatus 130 is low (such a bonding apparatus may be hereinafter referred to as a "low-accuracy bonding apparatus"). Details of a configuration of the second bonding apparatus 130 will be described later.

[0059] The processing system 1 described above includes at least one control apparatus 140. The control apparatus 140 processes computer-executable instructions that cause the processing system 1 to execute various processes described in the present disclosure. The control apparatus 140 may be

configured to control each component of the processing system 1 to execute various processes described herein. In one embodiment, a part or the entirety of the control apparatus 140 may be included in the processing system 1. The control apparatus 140 may include a processor, a storage, and a communication interface. The control apparatus 140 is implemented by, for example, a computer. The processor may be configured to read, from the storage, a program providing logic or routines that enable various control operations, and to execute the read program to perform the various control operations. This program may be stored in the storage in advance, or may be acquired through a medium when necessary. The acquired program is stored in the storage, and is read from the storage and executed by the processor. The medium may be any of various computer-readable storage media, or may be a communication line connected to the communication interface. The storage medium may be transitory or non-transitory. The processor may be a central processing unit (CPU) or may be one or more circuits. The storage may include a random access memory (RAM), a read only memory (ROM), a hard disk drive (HDD), a solid state drive (SSD), or a combination thereof. The communication interface may communicate with the processing system 1 via a communication line such as a local area network (LAN).

[0060] Note that the processing system 1 according to the present embodiment is configured as described above, but another processing apparatus may be further included in the processing system 1 according to the purpose, or a part of the processing apparatus may be provided outside the processing system 1 according to the purpose.

[0061] Next, a die-on-wafer manufacturing process performed in the processing system 1 configured as described above will be described. FIG. 7 is a flowchart illustrating main steps of the die-on-wafer manufacturing process. FIG. 8 is an explanatory diagram schematically illustrating some steps of the die-on-wafer manufacturing process.

[0062] First, the FOUPs Fw, Fc1, and Fc2 accommodating a corresponding one of a plurality of wafers W, a corresponding one of a plurality of first carriers C1, and a corresponding one of a plurality of second carriers C2, respectively, are mounted on the FOUP mounting stage 30 of the loading and unloading station 10. At this time, as illustrated in FIG. 8 (a), a plurality of first dies D1 are held by a first carrier C1, and as illustrated in FIG. 8 (b), a plurality

of second dies D2 are held by a second carrier C2. Further, the first carrier C1 is accommodated with the first dies D1 facing upward, and the second carrier C2 is accommodated with the second dies D2 facing upward.

[0063] Next, a wafer W in the FOUP Fw is taken out by the transfer apparatus 40 and transferred to the transition apparatus 60. The wafer W transferred to the transition apparatus 60 is transferred to the wafer cleaning apparatus 73 by the transfer apparatus 50. In the wafer cleaning apparatus 73, a front surface Wa of the wafer W is cleaned with, for example, a cleaning liquid (St1 in FIG. 7).

[0064] Next, the wafer W is transferred to the wafer modification apparatus 71 by the transfer apparatus 50. In the wafer modification apparatus 71, plasma processing is performed in, for example, a reduced-pressure atmosphere, and the front surface Wa of the wafer W is modified (St2 in FIG. 7).

[0065] Next, the wafer W is transferred to the wafer hydrophilization apparatus 75 by the transfer apparatus 50. In the wafer hydrophilization apparatus 75, for example, by using pure water, hydroxyl groups (silanol groups) adhere to the front surface Wa of the wafer W modified in St2, and the front surface Wa is hydrophilized. Further, the front surface Wa is rinsed with the pure water (St3 in FIG. 7).

[0066] Next, the wafer W is transferred to the transition apparatus 90 by the transfer apparatus 50, and is further transferred to a first bonding apparatus 100 by the transfer apparatus 80. Note that if bonding processing is already being performed in the four first bonding apparatuses 100, the wafer W is transferred to the buffer apparatus 91 and temporarily stored in the buffer apparatus 91.

[0067] While the above-described steps St1 to St3 are being performed on the wafer W, processing is performed on the first dies D1 held by the first carrier C1. First, the first carrier C1 in the FOUP Fc1 is taken out by the transfer apparatus 40 and transferred to the transition apparatus 60. The first carrier C1 transferred to the transition apparatus 60 is transferred to the die cleaning apparatus 74 by the transfer apparatus 50. In the die cleaning apparatus 74, front surfaces D1a of the first dies D1 are cleaned with, for example, a cleaning liquid (St4 in FIG. 7).

[0068] Next, the first carrier C1 is transferred to the die modification apparatus 72 by the transfer apparatus 50. In the die modification apparatus

72, plasma processing is performed in, for example, a reduced-pressure atmosphere, and the front surfaces D1a of the first dies D1 are modified (St5 in FIG. 7).

[0069] Next, the first carrier C1 is transferred to the die hydrophilization apparatus 76 by the transfer apparatus 50. In the die hydrophilization apparatus 76, for example, by using pure water, hydroxyl groups (silanol groups) adhere to the front surfaces D1a of the first dies D1 modified in St5, and the front surfaces D1a are hydrophilized. Further, the front surfaces D1a are rinsed with the pure water (St6 in FIG. 7).

[0070] Next, the first carrier C1 is transferred to the transition apparatus 90 by the transfer apparatus 50, and is further transferred to the first bonding apparatus 100 by the transfer apparatus 80. Note that if bonding processing is already being performed in the four first bonding apparatuses 100, the first carrier C1 is transferred to the buffer apparatus 91 and temporarily stored in the buffer apparatus 91.

[0071] While the above-described steps St1 to St3 are being performed on the wafer W and the above-described steps St4 to St6 are performed on the first dies D1, processing is performed on the second dies D2 held by the second carrier C2. First, the second carrier C2 in the FOUP Fc2 is taken out by the transfer apparatus 40 and transferred to the transition apparatus 60. The second carrier C2 transferred to the transition apparatus 60 is transferred to the die cleaning apparatus 74 by the transfer apparatus 50. In the die cleaning apparatus 74, front surfaces D2a of the second dies D2 are cleaned with, for example, a cleaning liquid (St7 in FIG. 7).

[0072] Next, the second carrier C2 is transferred to the die modification apparatus 72 by the transfer apparatus 50. In the die modification apparatus 72, plasma processing is performed in, for example, a reduced-pressure atmosphere, and the front surfaces D2a of the second dies D2 are modified (St8 in FIG. 7).

[0073] Next, the second carrier C2 is transferred to the die hydrophilization apparatus 76 by the transfer apparatus 50. In the die hydrophilization apparatus 76, for example, by using pure water, hydroxyl groups (silanol groups) adhere to the front surfaces D2a of the second dies D2 modified in St8, and the front surfaces D2a are hydrophilized. Further, the front surfaces D2a are rinsed with the pure water (St9 in FIG. 7).

[0074] Next, the second carrier C2 is transferred to the transition apparatus 90 by the transfer apparatus 50, transferred to the transition apparatus 120 by the transfer apparatus 80, and further transferred to a second bonding apparatus 130 by the transfer apparatus 110. Note that if bonding processing is already being performed in the four second bonding apparatuses 130, the second carrier C2 is transferred to the buffer apparatus 121 and temporarily stored in the buffer apparatus 121.

[0075] As described above, the wafer W subjected to steps St1 to St3 is transferred to the first bonding apparatus 100, and the first carrier C1 subjected to steps St4 to St6 is transferred to the first bonding apparatus 100. In the first bonding apparatus 100, each of the first dies D1 held by the first carrier C1 is detached from the first carrier C1 and is picked up. Further, as illustrated in FIG. 8 (c), the front surface D1a of each of the picked-up first dies D1 and the front surface Wa of the wafer W are superimposed, and each of the first dies D1 is pressed, thereby bonding each of the first dies D1 to the wafer W (St10 in FIG. 7).

[0076] In St10, because the front surface Wa of the wafer W and the front surfaces D1a of the first dies D1 have been modified in St2 and St5, respectively, first, Van der Waals forces (intermolecular forces) are generated between the front surface Wa and each of the front surfaces D1a, and each of the front surfaces Wa is bonded to the front surface Wa. Further, because the front surface Wa of the wafer W and the front surfaces D1a of the first dies D1 have been hydrophilized in St3 and St6, respectively, hydrophilic groups between the front surface Wa and each of the front surfaces D1a are hydrogen-bonded (intermolecular forces), and each of the front surfaces D1a is strongly bonded to the front surface Wa.

[0077] Further, as described above, the first bonding apparatus 100 is a high-accuracy bonding apparatus. The first dies D1 include device layers E in which circuits or the like are formed, and require high bonding accuracy. In this regard, in St10, the first dies D1 can be bonded to desired positions on the wafer W with high accuracy.

[0078] In St10, in a case where all the first dies D1 held by the first carrier C1 are bonded to the wafer W, the first carrier C1 is transferred to the transition apparatus 90 by the transfer apparatus 80, transferred to the transition apparatus 60 by the transfer apparatus 50, and further transferred to the FOUNDRY

Fc1 by the transfer apparatus 40. Conversely, in a case where first dies D1 remain on the first carrier C1 after St10 is performed, the first carrier C1 may remain in the first bonding apparatus 100, and the first dies D1 may be bonded to a subsequent wafer W. Alternatively, in a case where first dies D1 remain on the first carrier C1 after St10 is performed, the first carrier C1 may be transferred to the buffer apparatus 91 by the transfer apparatus 80 and temporarily stored in the buffer apparatus 91.

[0079] Conversely, in St10, in a case where the first dies D1 are bonded to all desired positions on the wafer W, the wafer W is transferred to the transition apparatus 120 by the transfer apparatus 80, and is further transferred to the second bonding apparatus 130 by the transfer apparatus 110. Note that if bonding processing is already being performed in the four second bonding apparatuses 130, the wafer W is transferred to the buffer apparatus 121 and temporarily stored in the buffer apparatus 121.

[0080] Further, the second carrier C2 subjected to the above-described steps St7 to St9 has been transferred to the second bonding apparatus 130. In the second bonding apparatus 130, each of the second dies D2 held by the second carrier C2 is detached from the second carrier C2 and is picked up. Further, as illustrated in FIG. 8 (d), the front surface D2a of each of the picked-up second dies D2 and the front surface Wa of the wafer W are superimposed, and each of the second dies D2 is pressed, thereby bonding each of the second dies D2 to the wafer W (St11 in FIG. 7).

[0081] In St11, because the front surface Wa of the wafer W and the front surfaces D2a of the second dies D2 have been modified in St2 and St8, respectively, first, Van der Waals forces (intermolecular forces) are generated between the front surface Wa and each of the front surfaces D2a, and each of the front surfaces D2a is bonded to the front surface Wa. Further, because the front surface Wa of the wafer W and the front surfaces D2a of the second dies D2 have been hydrophilized in St3 and St9, respectively, hydrophilic groups between the front surface Wa and each of the front surfaces D2a are hydrogen-bonded (intermolecular forces), and each of the front surfaces D2a is strongly bonded to the front surface Wa.

[0082] Further, as described above, the second bonding apparatus 130 is a low-accuracy bonding apparatus. The second dies D2 do not include circuits or the like therein and require low bonding accuracy. In this regard, in St11, the

second dies D2 are bonded to desired positions on the wafer W with low accuracy. In this case, because low bonding accuracy is sufficient, the time required for St11 can be shortened.

[0083] In St11, in a case where all the second dies D2 held by the second

5 carrier C2 are bonded to the wafer W, the second carrier C2 is transferred to the transition apparatus 120 by the transfer apparatus 110, transferred to the transition apparatus 90 by the transfer apparatus 80, transferred to the transition apparatus 60 by the transfer apparatus 50, and further transferred to the FOUP Fc2 by the transfer apparatus 40. Conversely, in a case where

10 second dies D2 remain on the second carrier C2 after St11 is performed, the second carrier C2 may remain in the second bonding apparatus 130, and the second dies D2 may be bonded to a subsequent wafer W. Alternatively, in a case where second dies D2 remain on the second carrier C2 after St11 is performed, the second carrier C2 may be transferred to the buffer apparatus 121 by the

15 transfer apparatus 110 and temporarily stored in the buffer apparatus 121.
[0084] Conversely, in St11, in a case where the second dies D2 are bonded to all desired positions on the wafer W as illustrated in FIG. 1, the wafer W is transferred to the transition apparatus 120 by the transfer apparatus 110, transferred to the transition apparatus 90 by the transfer apparatus 80, and
20 transferred to the inspection apparatus 70 by the transfer apparatus 50. In the inspection apparatus 70, for example, the wafer W is imaged, and the presence or absence of voids between the front surface Wa of the wafer W and the dies D1 and D2 is inspected (St12 in FIG. 7). The inspection apparatus 70 may inspect the positions of the dies D1 and D2 bonded to the front surface Wa of
25 the wafer W.

[0085] Next, the wafer W is transferred to the transition apparatus 60 by the transfer apparatus 50, and is further transferred to the FOUP Fw by the transfer apparatus 40. In this manner, the entire die-on-wafer manufacturing process is completed.

30 **[0086]** Note that FOUPs in which the wafer W, the first carrier C1, and the second carrier C2 are collected do not necessarily have to be the same FOUPs as the FOUPs that respectively accommodated the wafer W, the first carrier C1, and the second carrier C2 at the time of loading. That is, for example, the FOUPs that respectively accommodated the wafer W, the first carrier C1, and the
35 second carrier C2 may respectively unload members different from those

accommodated at the time of loading. Alternatively, new FOUPs or the like for unloading the wafer W, the first carrier C1, and the second carrier C2 may be brought into the processing system 1.

[0087] According to the above-described embodiment, the processing system

5 1 includes the first bonding apparatus 100, which is a high-accuracy bonding apparatus, and the second bonding apparatus 130, which is a low-accuracy bonding apparatus. The first dies D1 include the device layers E in which circuits or the like are formed and require high bonding accuracy. In this regard, in the first bonding apparatus 100, the first dies D1 can be bonded to
10 desired positions on the wafer W with high accuracy. Further, the second dies D2 do not include circuits or the like formed therein and require low bonding accuracy. In this regard, in the second bonding apparatus 130, the second dies D2 are bonded to desired positions on the wafer W with low accuracy. Because low bonding accuracy is sufficient, the time required for bonding processing of
15 the second dies D2 to the wafer W can be shortened. Therefore, it is possible to improve the throughput of the die-on-wafer manufacturing process while appropriately mounting the first dies D1 and the second dies D2 of the respective types on the wafer W with bonding accuracies required for the respective types.

20 **[0088]** Further, in the present embodiment, the second bonding apparatus 130 is a low-accuracy bonding apparatus, and as will be described later, its apparatus configuration can be simplified to low-accuracy specifications as compared to a high-accuracy bonding apparatus. As a result, the cost of the second bonding apparatus 130 can be suppressed, and the cost of the
25 processing system 1 can be reduced.

[0089] Next, the configurations of the above-described first bonding apparatus 100 and second bonding apparatus 130 will be described. Required bonding accuracies are different between the first bonding apparatus 100 and the second bonding apparatus 130. Therefore, first, the configuration of the
30 first bonding apparatus 100 will be described, and then the configuration of the second bonding apparatus 130 will be described focusing on differences from the first bonding apparatus 100. FIG. 9 is a perspective view illustrating an outline of the configuration of the first bonding apparatus 100.

[0090] As illustrated in FIG. 9, the first bonding apparatus 100 includes a
35 stage 200. The stage 200 is divided into a detachment region 201 and a bonding

region 202. The detachment region 201 and the bonding region 202 are arranged side by side in the horizontal direction (X-axis direction). In the detachment region 201, a first die D1 held by the first carrier C1 is detached from the first carrier C1 and picked up. In the bonding region 202, the first die D1 picked up in the detachment region 201 is bonded to the wafer W.

[0091] A carrier holder 210 is provided in the detachment region 201. The carrier holder 210 has, as its upper surface, a holding surface for holding the first carrier C1, and holds the first carrier C1 holding the first die D1 in a state in which a front surface D1a of the first die D1 faces upward.

[0092] A moving mechanism 211 is provided below the carrier holder 210. The carrier holder 210 is configured to be movable in the horizontal direction (the X-axis direction and the Y-axis direction) by the moving mechanism 211. Further, the carrier holder 210 is configured to be rotatable about the vertical axis by the moving mechanism 211. A driver of the moving mechanism 211 is not particularly limited, and for example, a linear motor is used.

[0093] An air cap 220 serving as an air supply is provided inside the carrier holder 210. An air supply source (not illustrated) that supplies air to the air cap 220 is connected to the air cap 220. The air cap 220 supplies air to through-holes H1 of the first carrier C1 held by the carrier holder 210, and further supplies air to a back surface D1b of the first die D1 on the first carrier C1 through the through-holes H1. Then, air pressure is applied to the first die D1, and as a result, adhesion between the first die D1 and the insulating layer N1 on the chucking surface of the first carrier C1 is reduced. Thus, the first die D1 can be detached from the chucking surface of the first carrier C1.

[0094] A pickup 230 is provided above the carrier holder 210. The pickup 230 picks up and transfers the first die D1 from the first carrier C1. Specifically, the pickup 230 holds the first die D1 that has been lifted up as a result of a reduction in adhesion with the insulating layer N1 by the supply of air from the air cap 220 to detach the first die D1 from the first carrier C1, and further transfers the first die D1 from the detachment region 201 to the bonding region 202 while holding it.

[0095] A method of holding the first die D1 by the pickup 230 is not particularly limited. However, because the front surface D1a of the first die D1 held by the pickup 230 is a device surface of a device layer E, the pickup 230 needs to hold the first die D1 so as not to damage the device surface. For

example, a collet chuck may be used as the pickup 230. Alternatively, a non-contact chuck capable of holding the first die D1 from above in a non-contact manner by utilizing the Bernoulli effect or the ultrasonic squeeze effect may be used as the pickup 230. Alternatively, instead of holding the front surface D1a of the first die D1, the pickup 230 may be configured to clamp and hold side surfaces of the first die D1 that has been lifted up by the supply of air, for example.

[0096] The pickup 230 is supported by a moving mechanism 231. The moving mechanism 231 supports and moves the pickup 230. The moving mechanism 231 includes an arm 232, a rail 233, a support member 234, and a driver 235. A distal end of the arm 232 supports the pickup 230, and a proximal end of the arm 232 is attached to the rail 233. The rail 233 extends in the X-axis direction and is supported by the support member 234. The driver 235 moves the pickup 230 in the X-axis direction (direction along the rail 233), the Y-axis direction, and the vertical direction. Further, the driver 235 rotates the pickup 230 about the horizontal axis (about the X-axis), and the pickup 230 can invert the front and back surfaces of the first die D1 while holding it. In addition, the driver 235 rotates the pickup 230 about the vertical axis, and can adjust the position of the held first die D1 in a rotational direction (θ -axis direction). Note that a drive source of the driver 235 is not particularly limited, and for example, a linear motor is used.

[0097] A first imaging device 240 is provided above the carrier holder 210. For example, a camera is used for the first imaging device 240. The first imaging device 240 images at least two points of the first die D1 on the first carrier C1 held by the carrier holder 210 from above. The first imaging device 240 is fixed. The carrier holder 210 is moved such that the first imaging device 240 images the two points of the first die D1. The captured image is output to the control apparatus 140, and the position of the first die D1 on the first carrier C1 is measured in the control apparatus 140. The control apparatus 140 controls the moving mechanism 231 based on the measured position of the first die D1, and adjusts the position of the pickup 230 so that the pickup 230 appropriately picks up the first die D1.

[0098] A second imaging device 241 is provided on the positive X-axis side of the carrier holder 210 and below the pickup 230. For example, a camera is used for the second imaging device 241. The second imaging device 241 images at

least two points of the first die D1 held by the pickup 230 from below. The second imaging device 241 is fixed. The pickup 230 is moved such that the second imaging device 241 images the two points of the first die D1. The captured image is output to the control apparatus 140, and the position of the first die D1 held by the pickup 230 is measured in the control apparatus 140. The control apparatus 140 controls the moving mechanism 231 based on the measured position of the first die D1, and adjusts the position of the pickup 230 so that the pickup 230 can transfer the first die D1 to an appropriate position of a bond head 261 described later.

[0099] A wafer holder 250 serving as a substrate holder is provided in the bonding region 202. The wafer holder 250 has, as its upper surface, a holding surface for holding the wafer W, and holds the wafer W in a state in which the front surface Wa, which is a surface on which the first die D1 is to be mounted, faces upward. The wafer holder 250 is supported by a support plate 251.

[0100] A moving mechanism 252 is provided below the support plate 251. The wafer holder 250 and the support plate 251 are configured to be movable in the horizontal direction (the X-axis direction and the Y-axis direction) by the moving mechanism 252. Further, the wafer holder 250 and the support plate 251 are configured to be rotatable about the vertical axis by the moving mechanism 252. A driver of the moving mechanism 252 is not particularly limited, and for example, a linear motor is used.

[0101] A head 260 is provided above the wafer holder 250. The head 260 receives and holds the first die D1 from the pickup 230, transfers the first die D1 to the wafer W while holding it, and bonds the first die D1 to the wafer W.

As illustrated in FIG. 10, the head 260 includes the bond head 261, an insulating plate 262 serving as an insulator, and a base 263.

[0102] The bond head 261 receives and holds the first die D1 held by the pickup 230 from above. A holding surface (lower surface) of the bond head 261 for holding the first die D1 has a projecting shape whose central portion protrudes downward.

[0103] A method of holding the first die D1 by the bond head 261 is not particularly limited. The back surface D1b of the first die D1 held by the bond head 261 is a silicon layer S1. Thus, unlike the pickup 230, the bond head 261 is not necessarily required to be configured by a collet chuck, a non-contact chuck, or the like. For example, a vacuum chuck may be used for the bond head

261, and the bond head 261 may chuck and hold the first die D1 by drawing a vacuum with a vacuum mechanism (not illustrated).

[0104] The bond head 261 is formed of an electrically conductive material, and can be formed of, for example, a metal. The bond head 261 is supported by the insulating plate 262 as will be described later, and is electrically floating.

[0105] The insulating plate 262 is larger than the bond head 261, and holds the entire upper surface of the bond head 261. A method of holding the bond head 261 by the insulating plate 262 is not particularly limited. For example, the insulating plate 262 may chuck and hold the bond head 261 by drawing a vacuum with a vacuum mechanism (not illustrated). In such a case, the bond head 261 is configured to be detachable from the insulating plate 262, and the bond head 261 is configured to be replaceable.

[0106] The insulating plate 262 is formed of a light-transmitting and insulating material, and can be formed of, for example, glass. As will be described later, imaging devices 280, 281, and 282 are configured to image four alignment marks 265, and the imaging devices 281 and 282 are configured to image the wafer W. Thus, the insulating plate 262 is configured to be transparent so as to transmit light.

[0107] The base 263 supports an outer peripheral portion of the upper surface of the insulating plate 262. The base 263 has a loop shape, and an opening 263a is formed in a central portion of the base 263. The opening 263a is formed to be at least larger than the bond head 261. That is, the bond head 261 held by the insulating plate 262 is disposed inward of the opening 263a in a plan view.

[0108] The base 263 is formed of an electrically conductive material, and can be formed of, for example, a metal. The base 263 is connected to a grind potential.

[0109] An electrically conductive film 264 serving as a ground connector is formed on a surface of the insulating plate 262. The electrically conductive film 264 extends on the lower surface and a side surface of the insulating plate 262, and is formed so as to connect the upper surface of the bond head 261 and the lower surface of the base 263. Specifically, the electrically conductive film 264 is formed between the upper surface of the bond head 261 and the lower surface of the insulating plate 262 so as to cover the entire upper surface of the bond head 261. Further, the electrically conductive film 264 is formed so as to

be in contact with a portion of the lower surface of the base 263.

[0110] The electrically conductive film 264 is formed of an electrically conductive material, and can be formed of, for example, a metal. Further, the electrically conductive film 264 is preferably a transparent electrically conductive film that transmits light, and may be, for example, an indium tin oxide (ITO) thin film in which tin oxide is added to indium oxide. The ITO thin film is formed by electron-beam evaporation or sputtering evaporation. Further, the ITO thin film may be formed by coating. In such a case, the bond head 261 is connected to the ground potential via the electrically conductive film 264 and the base 263.

[0111] A plurality of, for example, four alignment marks 265 are provided on the lower surface of the insulating plate 262. The four alignment marks 265 are arranged outward of the bond head 261 held by the insulating plate 262 and inward of the opening 263a in a plan view.

[0112] As illustrated in FIG. 9, a third imaging device 280, which will be described later, is provided below the head 260, and a fourth imaging device 281 and a fifth imaging device 282, which will be described later, are provided above the head 260. As these imaging devices 280, 281, and 282 minutely move over time, alignment is required at a desired timing. This alignment is performed by the imaging devices 280, 281, and 282 imaging the four alignment marks 265. For this reason, the insulating plate 262 is configured to be transparent.

[0113] Further, each of the fourth imaging device 281 and the fifth imaging device 282, which will be described later, images the wafer W held by the wafer holder 250 below the head 260. Each of the fourth imaging device 281 and the fifth imaging device 282 images the wafer W through the insulating plate 262 located outward of the bond head 261 and inward of the opening 263a in a plan view. For this reason, the insulating plate 262 is configured to be transparent.

[0114] The head 260 is supported by a moving mechanism 270. The moving mechanism 270 supports and moves the head 260. The moving mechanism 270 includes an arm 271, a rail 272, a support member 273, and a driver 274. A distal end of the arm 271 supports the base 263 of the head 260, and a proximal end of the arm 271 is attached to the rail 272. The rail 272 extends in the X-axis direction and is supported by the support member 273. The driver 274 moves the head 260 in the X-axis direction (direction along the rail 272),

the Y-axis direction, and the vertical direction. Further, the driver 274 can rotate the head 260 about the vertical axis to adjust the position in the rotation direction (θ -axis direction) of the held first die D1. Note that a drive source of the driver 274 is not particularly limited, and for example, a linear motor is used.

[0115] The third imaging device 280 is provided below the head 260. For example, a camera is used for the third imaging device 280. The third imaging device 280 images at least two points of the first die D1 held by the bond head 261 from below in a state in which the wafer holder 250 is retracted to a position not overlapping the third imaging device 280 in a plan view. The third imaging device 280 is fixed. The bond head 261 is moved such that the third imaging device 280 images the two points of the first die D1. The captured image is output to the control apparatus 140, and the position of the first die D1 held by the bond head 261 is measured in the control apparatus 140.

[0116] The fourth imaging device 281 is provided above the head 260, specifically above the opening 263a of the base 263. For example, a camera is used for the fourth imaging device 281. The fourth imaging device 281 images at least two points of the wafer W held by the wafer holder 250 from above. At least one of the fourth imaging device 281 or the wafer holding part 250 is moved such that the fourth imaging device 281 images the two points of the wafer W. The captured image is output to the control apparatus 140, and the position of the wafer W held by the wafer W is measured in the control apparatus 140.

[0117] The control apparatus 140 adjusts the position of the first die D1 with respect to the wafer W based on the position of the first die D1 measured using the third imaging device 280 and the position of the wafer W measured using the fourth imaging device 281. Specifically, the control apparatus 140 controls at least one of the moving mechanism 252 or the moving mechanism 270 to move at least one of the first die D1 or the wafer W, and adjusts the position of the first die D1 with respect to the wafer W such that the first die D1 is bonded at an appropriate position on the wafer W.

[0118] The fifth imaging device 282 is provided above the head 260, specifically above the opening 263a of the base 263. For example, an IR camera is used for the fifth imaging device 282. The fifth imaging device 282 images the first die D1 mounted on the wafer W from above. The captured image is output

to the control apparatus 140, and the position of the first die D1 with respect to the wafer W is measured in the control apparatus 140. That is, the control apparatus 140 inspects the bonding accuracy of the first die D1 with respect to the wafer W.

5 **[0119]** Note that each of the fourth imaging device 281 and the fifth imaging device 282 may be supported by the arm 271 of the moving mechanism 270 via a support member (not illustrated), and configured to be movable in the horizontal direction (X-axis direction and Y-axis direction) by the moving mechanism 270. Alternatively, each of the fourth imaging device 281 and the
10 fifth imaging device 282 may be supported by a moving mechanism (not illustrated) different from the moving mechanism 270, and configured to be movable in the horizontal direction (X-axis direction and Y-axis direction) by the moving mechanism.

15 **[0120]** Next, a method of bonding first dies D1 to the wafer W, which is performed using the first bonding apparatus 100 configured as described above, will be described.

20 **[0121]** First, the wafer W and the first carrier C1 holding a plurality of first dies D1 are transferred to the first bonding apparatus 100. The wafer W is held by the wafer holder 250 in a state in which the front surface Wa of the wafer W faces upward. At this time, the wafer holder 250 is disposed at a position not overlapping the third imaging device 280 in a plan view, for example, at a position on the positive X-axis side of the third imaging device 280. The first carrier C1 is held by the carrier holder 210 in a state in which front surfaces D1a of the first dies D1 face upward.

25 **[0122]** Next, the first imaging device 240 images at least two points of one first die D1 to be bonded among the plurality of first dies D1 on the first carrier C1 held by the carrier holder 210. The captured image is output to the control apparatus 140, and the position of the first die D1 on the first carrier C1 is measured in the control apparatus 140. The control apparatus 140 controls the
30 moving mechanism 231 based on the measured position of the first die D1 to move the carrier holder 210, thereby adjusting the position of the pickup 230 with respect to the first die D1 to be picked up by the pickup 230.

35 **[0123]** Next, the air cap 220 selectively supplies air to through-holes H1 corresponding to the one first die D1 to be bonded so as to expand the insulating layer N1, thereby pushing up the one first die D1 from below to lift

the one first die D1.

[0124] Next, the pickup 230 is lowered, and a front surface D1a of the lifted one first die D1 is held by the pickup 230. The first die D1 may be held by the pickup 230 before the first die D1 is lifted by the air, or the first die D1 may be held by the pickup 230 simultaneously when the first die D1 is lifted by the air. Subsequently, the pickup 230 is raised to pick up the first die D1 from the first carrier C1.

[0125] Next, the pickup 230 is moved in the positive X-axis direction to a position above the second imaging device 241. The second imaging device 241 images at least two points of the first die D1 held by the pickup 230 from below. The captured image is output to the control apparatus 140, and the position of the first die D1 held by the pickup 230 is measured in the control apparatus 140. The control apparatus 140 controls the moving mechanism 231 based on the measured position of the first die D1 to adjust the position of the pickup 230 so as to transfer the first die D1 to a central portion of the bond head 261.

[0126] Next, the pickup 230 is rotated about the horizontal axis (about the X-axis), thereby inverting the front and back surfaces of the first die D1. Then, the back surface D1b of the first die D1 held by the pickup 230 is set to face upward.

[0127] Next, the pickup 230 is further moved in the positive X-axis direction to a position below the bond head 261. Subsequently, the first die D1 is transferred from the pickup 230 to the bond head 261. The first die D1 is disposed at the central portion of the bond head 261.

[0128] Next, the third imaging device 280 images at least two points of the first die D1 held by the bond head 261 from below. The captured image is output to the control apparatus 140, and the position of the first die D1 held by the bond head 261 is measured in the control apparatus 140.

[0129] Next, the wafer holder 250 is moved below the bond head 261 (the fourth imaging device 281). Subsequently, the fourth imaging device 281 images at least two points of the wafer W held by the wafer holder 250 from above. The captured image is output to the control apparatus 140, and the position of the wafer W held by the wafer is measured in the control apparatus 140. The control apparatus 140 adjusts the position of the first die D1 with respect to the wafer W based on the position of the first die D1 measured using

the third imaging device 280 and the position of the wafer W measured using the fourth imaging device 281, such that the first die D1 is bonded at an appropriate position on the wafer W.

[0130] Next, the bond head 261 is lowered to superimpose the front surface D1a of the first die D1 held by the bond head 261 on the front surface Wa of the wafer W, and presses the first die D1, thereby bonding the first die D1 to the wafer W. Subsequently, the bond head 261 is raised.

[0131] Here, as described above, the holding surface (lower surface) of the bond head 261 for holding the first die D1 has a projecting shape whose central portion protrudes downward. For example, if the first die D1 is held while being shifted from the central portion of the bond head 261, and the first die D1 is pressed against the wafer W, the surface pressure uniformity of the first die D1 with respect to the wafer W would become poor, and as a result, voids would be generated between the wafer W and the first die D1. In this regard, in the present embodiment, because the position of the pickup 230 is adjusted based on the captured image of the first die D1 by the second imaging device 241, the first die D1 is appropriately held at the central portion of the bond head 261. Therefore, when the first die D1 is bonded to the wafer W, the surface pressure uniformity of the first die D1 with respect to the wafer W can be improved, and generation of voids can be suppressed.

[0132] As described above, the bonding operation of the first die D1 to the wafer W is performed. Such a bonding operation is continuously performed independently for each of the plurality of first dies D1 chucked and held on the first carrier C1.

[0133] When the first dies D1 are bonded to all desired positions on the wafer W, next, the fifth imaging device 282 images the first dies D1 mounted on the wafer W from above. The captured image is output to the control apparatus 140, the positions of the first dies D1 with respect to the wafer W are measured in the control apparatus 140, and the bonding accuracy of the first dies D1 with respect to the wafer W is inspected. In this manner, the entire bonding processing in the first bonding apparatus 100 is completed.

[0134] According to the above-described embodiment, in the first bonding apparatus 100, the bonding of a first die D1 to the wafer W is repeatedly performed using the bond head 261 of the head 260. That is, the bond head 261 repeatedly performs the receiving of a first die D1 from the pickup 230 and the

transferring of the first die D1 to the wafer W.

[0135] Conventionally, because a bond head is held by an insulating plate and is electrically floating, when the bond head repeatedly receives and transfers a die, the bond head becomes charged. If the bond head becomes charged in this manner, when receiving a die from a pickup, the bond head discharges upon contacting the die, thereby causing a current to flow from the bond head to the die. In such a case, there is a risk that a circuit (device) included in the die may be damaged.

[0136] In this regard, in the present embodiment, the bond head 261 is connected to the ground potential via the electrically conductive film 264 and the base 263. Therefore, even if the receiving and transferring of a first die D1 are repeatedly performed using the bond head 261, charging of the bond head 261 can be suppressed. As a result, damage to a circuit of the first die D1 can be suppressed. Further, adhesion of particles to the first die D1 can also be suppressed. Therefore, the first die D1 can be appropriately mounted on the wafer W, and the quality of a product can be improved.

[0137] Further, various position adjustments (alignments) are performed in the first bonding apparatus 100. That is, the first imaging device 240 is used to adjust the position of the pickup 230 and the position of a first die D1 to be picked up by the pickup 230. The second imaging device 241 is used to adjust the position of the pickup 230 such that the first die D1 is transferred to the central portion of the bond head 261. The third imaging device 280 and the fourth imaging device 281 are used to adjust the position of the first die D1 with respect to the wafer W. Therefore, the first die D1 can be bonded at an appropriate position on the wafer W. Further, it is also possible to suppress voids when bonding the first die D1 to the wafer W. Therefore, in the first bonding apparatus 100, it becomes possible to bond the first die D1 to the wafer W with high bonding accuracy.

[0138] Further, in the first bonding apparatus 100, by increasing the rigidity of the moving mechanism 211, the rigidity of the arm 232 of the moving mechanism 231, the rigidity of the moving mechanism 252, and the rigidity of the arm 271 of the moving mechanism 270, respectively, the movement of the carrier holder 210, the movement of the pickup 230, the movement of the wafer holder 250, and the movement of the head 260 can be made highly accurate. In this case, the bonding accuracy of the first die D1 to the wafer W in the first

bonding apparatus 100 can be increased.

[0139] Further, in the first bonding apparatus 100, by increasing the performance of each of the driver of the moving mechanism 211, the driver 235 of the moving mechanism 231, the driver of the moving mechanism 252, and the driver 274 of the moving mechanism 231, the movement of the carrier holder 210, the movement of the pickup 230, the movement of the wafer holder 250, and the movement of the head 260 can be accelerated. Therefore, the time required for bonding processing in the first bonding apparatus 100 can be shortened.

[0140] Next, the configuration of the second bonding apparatus 130 will be described focusing on differences from the first bonding apparatus 100. The second bonding apparatus 130 is a low-accuracy bonding apparatus, and its apparatus configuration can be simplified to low-accuracy specifications as compared to the first bonding apparatus 100.

[0141] For example, in the second bonding apparatus 130, because the positional accuracy of a second die D2 with respect to the wafer W does not need to be high, at least one of the first imaging device 240, the third imaging device 280, or the fourth imaging device 281 can be omitted. Further, in a case where it is not necessary to suppress voids when bonding the second die D2 to the wafer W, the second imaging device 241 can be omitted. Further, in a case where the bonding accuracy of the second die D2 with respect to the wafer W does not need to be high and inspection is unnecessary, the fifth imaging device 282 can be omitted.

[0142] Further, in the second bonding apparatus 130, by increasing the performance of each of the driver of the moving mechanism 211, the driver 235 of the moving mechanism 231, the driver of the moving mechanism 252, and the driver 274 of the moving mechanism 270, the movement of the carrier holder 210, the movement of the pickup 230, the movement of the wafer holder 250, and the movement of the head 260 can be accelerated. On the other hand, if the performance of each driver is increased in this manner, the driver becomes large, and thus, for example, it is preferable to decrease the rigidity of the moving mechanism 211, the rigidity of the arm 232 of the moving mechanism 231, the rigidity of the moving mechanism 252, and the rigidity of the arm 271 of the moving mechanism 270, respectively. In this regard, because the required bonding accuracy for the second bonding apparatus 130 is low, it

becomes possible to decrease these rigidities.

[0143] As described above, as compared to the first bonding apparatus 100, in the second bonding apparatus 130, its apparatus configuration can be simplified to low-accuracy specifications, and further, the bonding conditions can be set to low-accuracy specifications. Therefore, the time required for bonding processing in the second bonding apparatus 130 can be shortened. It is also possible for the second bonding apparatus 130 to have the same apparatus configuration as the first bonding apparatus 100 and have only the bonding conditions set to low-accuracy specifications.

[0144] The bonding conditions are conditions when the first die D1 and the second die D2 are bonded to the wafer W, and are apparatus parameters. The apparatus parameters are, for example, the acceleration/deceleration and speed of the movement of the carrier holder 210, the movement of the pickup 230, the movement of the wafer holder 250, and the movement of the head 260 by the moving mechanisms 211, 231, 252, and 270, or a waiting time until driving of the drivers of these moving mechanisms 211, 231, 252, and 270 becomes stable. Further, the apparatus parameters are the presence or absence of imaging and an imaging time by the imaging devices 240, 241, 280, 281, and 282.

[0145] In the above-described second bonding apparatus 130 as well, the bond head 261 is connected to the ground potential via the electrically conductive film 264 and the base 263. Thus, even if the receiving of a second die D2 and the transferring of the second die D2 are repeatedly performed using the bond head 261, charging of the bond head 261 can be suppressed. As a result, adhesion of particles to the second die D2 can be suppressed, and the second die D2 can be appropriately mounted on the wafer W.

[0146] Note that the detachment region 201 and the bonding region 202 are arranged side by side in the horizontal direction (X-axis direction) in each of the first bonding apparatus 100 and the second bonding apparatus 130 in the above-described embodiment, but, for example, the detachment region 201 and the bonding region 202 may be stacked in the vertical direction. In such a case, the footprint (occupied area) of each of the first bonding apparatus 100 and the second bonding apparatus 130 can be kept small.

[0147] In the above-described embodiment, the electrically conductive film 264 is used as the ground connector for connecting the bond head 261 to the

ground potential in each of the first bonding apparatus 100 and the second bonding apparatus 130, but the configuration of the ground connector is not limited thereto.

[0148] For example, as illustrated in FIG. 11, a ground connector 300 may include a conductor 301 and electrically conductive films 302 and 303. The conductor 301 is provided so as to pass through a through-hole 262a provided in the insulating plate 262 in the thickness direction of the insulating plate 262, and connect the electrically conductive film 302 to the electrically conductive film 303. The lower-side electrically conductive film 302 is formed between the upper surface of the bond head 261 and the lower surface of the insulating plate 262 so as to cover the entire upper surface of the bond head 261. The upper-side electrically conductive film 303 is formed so as to extend on the upper surface of the insulating plate 262 and contact a portion of a side surface of the base 263.

[0149] Each of the conductor 301 and the electrically conductive films 302 and 303 is formed of an electrically conductive material, and can be formed of, for example, a metal. Further, each of the conductor 301 and the electrically conductive films 302 and 303 is preferably formed of a transparent electrically conductive material that transmits light, and may be formed of, for example, indium tin oxide (ITO) in which tin oxide is added to indium oxide. In such a case, the bond head 261 is connected to the ground potential via the lower-side electrically conductive film 302, the conductor 301, the upper-side electrically conductive film 303, and the base 263. In such a case, even if the receiving and transferring of dies D1 and D2 are repeatedly performed using the bond head 261, charging of the bond head 261 can be suppressed.

[0150] In the above-described embodiment, the bond head 261 is connected to the ground potential to suppress charging of the bond head 261, but static electricity may be further removed from the bond head 261. For example, as illustrated in FIG. 12, in the first bonding apparatus 100 (the second bonding apparatus 130), a static eliminator 310 is provided below the head 260. For the static eliminator 310, an ionizer may be used, for example. Then, ions are supplied from the static eliminator 310 to the bond head 261, and static electricity is removed from the bond head 261. Further, for the static eliminator 310, for example, a light irradiator may be used. Then, light is emitted from the static eliminator 310 to the bond head 261, and static

electricity is removed from the bond head 261.

[0151] In such a case, the bond head 261 is connected to the ground potential and static electricity is removed by the static eliminator 310. Thus, even if the receiving and transferring of dies D1 and D2 are repeatedly performed using the bond head 261, charging of the bond head 261 can be further suppressed. No that it is conceivable to remove static electricity from the bond head 261 only by the static eliminator 310; however, in such a case, removing static electricity would take time and charging of the bond head 261 would not be completely suppressed. Therefore, as in the present embodiment, it is preferable to connect the bond head 261 to the ground potential.

[0152] In the above-described embodiment, the first carrier C1 holds a plurality of first dies D1 and the second carrier C2 holds a plurality of second dies D2, but one carrier may hold a plurality of first dies D1 and a plurality of second dies D2. Alternatively, one carrier may hold three or more types of dies, and a pattern of dies held by one carrier is not particularly limited.

[0153] Further, in the above-described embodiment, an example in which the first dies D1 and the second dies D2 are mounted on the wafer W has been described, but three or more types of dies may be mounted on the wafer W. For example, third dies D3 can be mounted on the wafer W in addition to the first dies D1 and the second dies D2. In such a case, the processing system 1 may include a dedicated bonding apparatus (not illustrated) configured to bond the third dies D3 to the wafer W. Alternatively, for example, in a case where the third dies D3 are low-accuracy dies, the second dies D2 and the third dies D3 may be bonded to the wafer W by replacing the bond head 261 in the second bonding apparatus 130.

[0154] In the above-described embodiment, the dies D1 and D2 held by the carriers C1 and C2 are mounted on the wafer W, but carriers holding the dies D1 and D2 before being mounted are not limited to the carriers C1 and C2 of the above-described embodiment. For example, the dies D1 and D2 may be attached to dicing tapes fixed to dicing frames. Silicon layers S1 and S2 on the back surfaces D1b and D2b of the dies D1 and D2 are attached to the dicing tapes.

[0155] Embodiments disclosed herein should be considered in all respects as illustrative and not restrictive. Various omissions, substitutions, and changes may be made to the above-described embodiments without departing from the

scope and spirit of the appended claims. For example, the components of the above-described embodiments can be combined as desired. From such a combination, functions and effects of the respective components involved in the combination can be naturally obtained, and other functions and effects obvious to those skilled in the art from the description of the present specification can be obtained.

[0156] Further, the effects described in the present specification are merely explanatory or illustrative and are not restrictive. That is, the technology according to the present disclosure can achieve other effects obvious to those skilled in the art from the description of the present specification, in addition to or instead of the effects described in the present specification.

DESCRIPTION OF THE REFERENCE NUMERALS

[0157]

100 first bonding apparatus
130 second bonding apparatus
250 wafer holder
260 head
261 bond head
262 insulating plate
264 electrically conductive film
D1 first die
D2 second die
W wafer

-36-
CLAIMS

[Claim 1] A bonding apparatus for bonding a plurality of dies to a target

5 substrate, the bonding apparatus comprising:

a substrate holder configured to hold the target substrate; and

a head configured to bond the plurality of dies to the target substrate
held by the substrate holder, wherein

the head includes:

10 a bond head configured to hold each of the plurality of dies and
having electrical conductivity;

an insulator configured to hold the bond head; and

a ground connector configured to connect the bond head to a
ground potential.

15

[Claim 2] The bonding apparatus according to claim 1, wherein the ground

connector includes an electrically conductive film provided on a surface of the
insulator.

20

[Claim 3] The bonding apparatus according to claim 2, wherein the ground
connector includes a conductor configured to pass through a through-hole
provided in the insulator in a thickness direction of the insulator.

25

[Claim 4] The bonding apparatus according to claim 1, wherein the ground
connector is configured to transmit light.

30

[Claim 5] The bonding apparatus according to claim 4, wherein the ground
connector includes indium tin oxide.

35 [Claim 6] The bonding apparatus according to claim 1, wherein the insulator is

configured to transmit light.

[Claim 7] The bonding apparatus according to claim 1, wherein

5 the head includes a base configured to support the insulator, and
 the ground connector is connected to the base.

[Claim 8] The bonding apparatus according to claim 7, wherein

10 the base is configured to support an outer peripheral portion of an
 upper surface of the insulator, and has an opening in a center portion of the
 base,

 the insulator is configured to hold an upper surface of the bond head,
 the bond head is disposed inward of the opening in a plan view, and
15 the ground connector includes an electrically conductive film between
 the upper surface of the bond head and a lower surface of the insulator.

[Claim 9] The bonding apparatus according to claim 1, further comprising:

20 a static eliminator configured to remove static electricity from the bond
 head.

[Claim 10] The bonding apparatus according to claim 1, further comprising:

25 a pickup configured to pick up each of the plurality of dies from a carrier
 holding the plurality of dies, wherein

 the bond head is configured to receive each of the plurality of dies from
 the pickup and to bond each of the plurality of dies to the target substrate.