

Description

Title of Invention: PRESS DEVICE, PRESS METHOD, AND METHOD FOR MANUFACTURING ELECTRONIC COMPONENT

Technical Field

[0001] The present invention relates to a press apparatus, an electronic component, a press method, and a method of manufacturing an electronic component.

Background Art

[0002] When a semiconductor element such as an IC chip is to be mounted on a substrate, bumps (for example, solder bumps or gold bumps) may be provided on the substrate, and the semiconductor element may be mounted on the substrate via the bumps. In this case, the bumps each have a top with a spherical shape, and the bumps are provided as a plurality of bumps, resulting in that variation in the height of tops of the bumps may occur. When the variation in the height occurs as described above, there may be some bumps with which the semiconductor element cannot be brought into contact.

[0003] In view of the foregoing, hitherto, there has been proposed an apparatus in which tops of bumps are pressed with a flat surface of a pressing body (upper press head of a press apparatus) to flatten the tops of the bumps so that a uniform height of the bumps is achieved (Patent Literature 1 and Patent

Literature 2).

[0004] When the bumps are to be flattened as described above, typically, the upper press head is heated. Accordingly, solder or the like may adhere to a pressing surface (flat surface) of the head. In order to prevent such adhesion, a head made of a material such as ceramics, to which solder or the like is less liable to adhere, as described in Patent Literature 1 is used as the head.

[0005] Further, in Patent Literature 2, there is disclosed an apparatus in which a density of solder bumps in each of a plurality of regions is measured, and a pressing amount and a pressing load, with which the solder bumps are to be pressed with a head, are set in accordance with the measured density.

Citation List

[0006] Patent Literature 1: JP 2002-270630 A

Patent Literature 2: JP 2022-150593 A

Summary of Invention

Technical Problem

[0007] However, in flattening processing of bumps, at the start of first pressing, a difference in temperature between a substrate side and a head is large, and a temperature on the head side rapidly decreases. A speed at which heat is taken away from the head is higher than a speed at which heat supplied

from a heating mechanism such as a heater is transferred to the head so that a heat amount of the head is gradually removed, resulting in that press working (flattening) cannot be performed at an appropriate temperature in some cases. Accordingly, at the initial stage of press working, a defective product is produced, resulting in that a processed product at the initial stage is required to be discarded. Further, at the time of replacing a workpiece (substrate provided with bumps), the head is heated with the heating mechanism during the replacement so that the temperature of the head, which has been optimized for flattening, increases, resulting in that the bumps may not be able to be pressed at an appropriate temperature.

[0008] There may also be proposed a measure of suppressing a decrease in temperature on the head side by heating the substrate side in advance (before press working) to reduce the difference in temperature between the substrate side and the head side. However, in such a case, a heating mechanism and a temperature adjustment system on the substrate side are additionally required. Further, in a case of a large-sized substrate on which pressing is to be performed a plurality of times, it is difficult to heat the substrate with the temperature being kept uniform, and while pressing is being sequentially performed, the temperature of the substrate gradually decreases. Thus, a difference in temperature occurs on the substrate between the first press working and press working performed after a

plurality of times of press working, resulting in that the difference in temperature between the substrate and the head may also change.

[0009] Accordingly, in view of the above-mentioned problems, the present invention provides: a press apparatus configured to be capable of pressing bumps with a head (upper press head) at a temperature suitable for flattening the bumps, to stably flatten the bumps; an electronic component in which bumps are stably flattened so as to prevent a semiconductor element from having a connection failure portion; a press method that enables pressing bumps at a temperature suitable for flattening the bumps; and a method of manufacturing an electronic component, which allows bumps to be stably flattened so as to prevent a semiconductor element from having a connection failure portion.

Solution to Problem

[0010] According to the present invention, there is provided a press apparatus which is configured to flatten bumps on a substrate by pressing the bumps with an upper press head, the press apparatus comprising: a heating mechanism configured to heat the upper press head; and a temperature adjustment mechanism configured to be brought into contact with the upper press head under a state of being free of flattening processing by the pressing with the upper press head, to adjust a temperature of the upper press head to a temperature within a

predetermined proper range. Here, the term "predetermined proper range" refers to such a range as to prevent occurrence of a difference in deformation amount of the bumps. That is, when the temperature is excessively high, the deformation amount is larger, and when the temperature is excessively low, the deformation amount is smaller.

Advantageous Effects of Invention

[0011] According to the present invention, press working (flattening processing) can be performed with the temperature of the upper press head being set at a temperature within the predetermined proper range, thereby being capable of preventing occurrence of a product defect.

Brief Description of Drawings

[0012] FIG. 1 is a simplified block diagram for illustrating an overall configuration of a press apparatus according to the present invention.

FIG. 2 is a simplified sectional view of a main part of the press apparatus according to the present invention.

FIG. 3 is a simplified view for illustrating a state obtained immediately before a contact body configured to adjust a temperature of an upper press head of the press apparatus according to the present invention is brought into contact with the upper press head.

FIG. 4 is a flowchart for illustrating a press method using the press apparatus according to the present invention.

FIG. 5 is a graph for showing a relationship between a press working time and the temperature of the upper press head in the press method using the press apparatus according to the present invention.

Description of Embodiments

[0013] Now, description is made of embodiments of the present invention with reference to FIG. 1 to FIG. 5.

[0014] FIG. 2 is a simplified view of a main part of a press apparatus according to the present invention. The press apparatus is an apparatus to be used for, for example, coining for flattening tops of particle members 2 of an IC chip, a chip capacitor, a chip resistor, or a substrate (particle member forming body) 1 comprising those components mounted thereon. In this embodiment, the particle members 2 may be referred to as "bumps," and the particle member forming body 1 may be referred to as "bump forming body." The substrate 1 comprises a plurality of circuit patterns formed thereon. That is, the press apparatus is used to manufacture an electronic component. Here, the term "electronic component" refers to a component that forms an electronic circuit. As such an electronic component, an electronic component using a semiconductor can be referred to as "semiconductor device." The term "semiconductor device" means

a device utilizing semiconductor characteristics, and refers to a circuit comprising semiconductor elements (for example, a transistor, a diode, and a photodiode), a device comprising such a circuit, and the like. Further, the term "semiconductor device" also refers to all devices that can function by utilizing semiconductor characteristics. For example, an integrated circuit, a chip comprising an integrated circuit, and an electronic component comprising a chip housed in a package are each an example of the semiconductor device. In addition, each of a storage device, a display device, a light emitting device, a lighting device, and an electronic device may itself be a semiconductor device, or may comprise a semiconductor device. Further, an electro-optical device comprising a semiconductor chip connected to a substrate, a semiconductor circuit board, and an electronic component comprising each of such device and circuit board are all comprised in the semiconductor device.

[0015] As illustrated in FIG. 2, the press apparatus comprises an upper press head 5 and a lower press head 6, and the substrate 1 is placed on a placement surface 6a of the lower press head 6. A heating mechanism 7 is attached to the upper press head 5 so as to heat the upper press head 5. The heating mechanism 7 is formed of a heating block body 9 comprising built-in electric heating wires 8. The upper press head 5 and the heating block body 9 are moved upward and downward integrally with each other, by an upper press head-side upward-downward

movement mechanism 10 illustrated in FIG. 1. In this case, the upper press head 5 comprises a bump pressing surface 11 being a flat lower surface of the upper press head 5.

[0016] Further, the lower press head 6 may be a head that is not moved upward and downward, or may be a head configured to be movable upward and downward by a lower press head-side upward-downward movement mechanism 12 as illustrated in FIG. 1. Accordingly, the upper press head-side upward-downward movement mechanism 10 and the lower press head-side upward-downward movement mechanism 12 can each be formed of a reciprocating mechanism such as a publicly known and used cylinder mechanism. As illustrated in FIG. 2, the substrate 1 is supplied onto the placement surface 6a of the lower press head 6 by a substrate conveyance mechanism 13, and after being subjected to press working (coining processing for flattening the tops of the bumps 2) by the press apparatus, the substrate 1 is discharged from between the upper press head 5 and the lower press head 6. The substrate conveyance mechanism 13 comprises an XYZ-direction driver configured to be capable of conveying the substrate 1 in an X direction and a Y direction orthogonal to each other in a horizontal plane, and in a Z direction being a vertical direction orthogonal to the X and Y directions.

[0017] Further, as illustrated in FIG. 1, the press apparatus comprises a temperature adjustment mechanism 15 configured to adjust a temperature of the upper press head 5 to

a temperature within a predetermined proper range. The temperature adjustment mechanism 15 comprises: a contact body 16 configured to be brought into contact with the upper press head 5; and a contact body moving mechanism 17 configured to move the contact body 16. As illustrated in FIG. 3, the contact body 16 in this case is formed of a metal flat plate body, and the contact body moving mechanism 17 comprises an XYZ-direction driver configured to be capable of moving the contact body 16 in an X direction and a Y direction orthogonal to each other in a horizontal plane, and in a Z direction being a vertical direction orthogonal to the X and Y directions, to bring the contact body 16 into contact with the pressing surface 11, which is formed as the flat surface, of the upper press head 5. Further, the contact body 16 can be separated from the pressing surface 11 of the upper press head 5 by the XYZ-direction driver of the contact body moving mechanism 17. It is required that a movement route for the contact body 16 be set so as to be prevented from overlapping with a conveyance route for the substrate 1.

[0018] The upper press head-side upward-downward movement mechanism 10, the lower press head-side upward-downward movement mechanism 12, the heating mechanism 7, the contact body moving mechanism 17, and the substrate conveyance mechanism 13 are controlled by a computer 20.

[0019] In this case, the computer 20 basically comprises an input part having an input function, an output part having an

output function, a storage part having a storing function, a calculation part having a calculating function, and a controller having a control function. The input function enables information from an outside to be read into the computer 20. The read data and program are converted into signals in a format suitable for a computer system. The output function enables, for example, a result of calculation and stored data to be displayed on the outside. The storage part stores and saves, for example, a program, data, and a result of processing. The calculating function enables processing of data through a calculation or comparison in accordance with a command in the program. The control function enables the command in the program to be deciphered and an instruction to be issued to each of the parts. The control function enables overall control of all the parts of the computer. Examples of the input part include a keyboard, a mouse, a tablet, a microphone, a joystick, a scanner, and a capture board. Further, examples of the output part include a monitor, a speaker, and a printer. Examples of the storage part include a memory, a hard disk, a CD, a CD-R, a PD, and an MO. Examples of the calculation part include a CPU, and examples of the controller include a CPU and a motherboard.

[0020] Next, with reference to FIG. 4 and FIG. 5, description is given of coining processing for flattening the tops of the bumps 2 on the substrate 1 by the press apparatus configured as described above. First, the upper press head 5 is

heated by applying an electric current to the electric heating wires 8 that form the heating mechanism 7 (Step S1). In this case, a set temperature is set to be higher than a temperature within the predetermined proper range (processing temperature) for flattening the tops of the bumps 2.

[0021] Then, the contact body 16 is brought into contact with the upper press head 5 via the contact body moving mechanism 17 (Step S2), to thereby decrease a temperature of the pressing surface 11 of the upper press head 5 that has become higher in temperature. (That is, with the set temperature of the heating mechanism 7 being set to be higher than a predetermined proper temperature, the pressing surface 11 of the upper press head 5 has become higher in temperature.) Subsequently, determination is made on whether or not the temperature of the upper press head 5 has reached a temperature that allows product pressing (has decreased so as to allow processing to be performed) (Step S3). When the temperature that allows product pressing has been reached, the process proceeds to Step S4 to start product press working. Here, the phrase "temperature that allows product pressing" refers to a temperature within the predetermined proper range (processing temperature), which can be variously set in accordance with a material, a size, a height, and the like of the bumps 2. Further, the contact body 16 can be made of a metal such as aluminum or stainless steel, or a material such as epoxy glass, which is similar to a material for the

substrate, and thermal conductivity of the contact body 16 is set to from about 0.1 (W/m·K) to about 300 (W/m·K).

[0022] When the temperature that allows product pressing has not been reached in Step S3, the contact body 16 is kept in contact with the pressing surface 11 of the upper press head 5 until the temperature that allows product pressing is reached. When the product press working is to be started, the contact body 16 is moved from between the upper press head 5 and the lower press head 6 by the contact body moving mechanism 17, and the substrate 1 to be a product is moved to between the upper press head 5 and the lower press head 6 by the substrate conveyance mechanism 13. Under this state, the upper press head 5 is moved downward to press the pressing surface 11 of the upper press head 5 against the tops of the bumps 2. Then, the tops of the bumps 2 are pressed for a predetermined time (for example, from about 0.5 second to about 5 seconds) to be flattened. This press working is performed at a plurality of different places on one substrate 1. That is, the temperature of the upper press head 5 is decreased from the set temperature to the processing temperature as shown in FIG. 5, to start the product press working. In FIG. 5, a section from the set temperature to the processing temperature can be referred to as "non-product pressing section," and a section given after the processing temperature is reached can be referred to as "product pressing section."

[0023] The process proceeds from Step S4 to Step S5, and determination is made on whether or not to replace the substrate 1. As a result of the determination in Step S5, in the case of replacing the substrate 1, the process proceeds to Step S6 to replace the substrate 1. In the case of not replacing the substrate 1, this processing work is ended. Here, the phrase "the case of replacing the substrate 1" refers to a case in which flattening processing has been performed on all bumps 2 or desired bumps 2 on one substrate 1, and then flattening processing is to be performed on bumps 2 on the subsequent substrate 1.

[0024] Accordingly, after the replacement of the substrate, the process returns to Step S2, and the contact body 16 is brought into contact with the pressing surface 11 of the upper press head 5 to decrease the temperature of the upper press head 5. That is, while the substrate 1 is being replaced, the temperature of the upper press head 5 increases. This is because the set temperature is set to be higher than the temperature that allows product pressing.

[0025] After that, the process proceeds to Step S3, and the similar subsequent steps are sequentially carried out so that flattening processing of tops of bumps 2 can be performed sequentially on a large number of substrates 1.

[0026] With the press apparatus of the present invention, press working (flattening processing) can be performed with the

temperature of the upper press head 5 being set at a temperature within the predetermined proper range. Accordingly, occurrence of a product defect can be prevented.

[0027] Further, the temperature adjustment mechanism 15 can be configured to comprise the contact body 16, which is to be brought into contact with the upper press head 5 to remove a heat amount from the upper press head 5 to thereby decrease the temperature of the upper press head 5. When the temperature adjustment mechanism 15 is configured to comprise such a contact body 16, the temperature adjustment mechanism 15 can be configured with a simple structure. A plurality of semiconductor elements are connected to one substrate 1, and hence press working is performed a plurality of times. Accordingly, in the product pressing section of FIG. 5, the temperature increases and decreases.

[0028] The contact body 16 may be formed of a block body made of a metal or a resin material that has a thermal conductivity of from 0.1 (W/m·K) to 300 (W/m·K). With the contact body 16 being formed of such a block body, heat can be rapidly and stably taken away from the upper press head 5 to set the temperature of the upper press head 5 at a temperature within the predetermined proper range. Further, when heat is stored on the contact body 16 of the temperature adjustment mechanism 15 to increase a temperature of the contact body 16 so that the effect of temperature adjustment is reduced, the following may

be adopted as a countermeasure against such a case. Examples of the countermeasure that may be adopted include: a configuration that an air-cooled or water-cooled cooling mechanism or the like is provided so as to cool the contact body 16; a configuration that the contact body 16 is provided with heat-radiating fins; and a configuration that a plurality of contact bodies 16 are provided so as to prevent a situation in which one contact body 16 is continuously brought into contact with the upper press head 5. However, the countermeasure is not limited thereto. Further, the countermeasure may comprise all of the configurations, or may comprise at least any one of the configurations.

[0029] It is preferred that the temperature adjustment mechanism 15 comprise the contact body moving mechanism 17 configured to bring the contact body 16 into contact or non-contact with the upper press head 5. With the temperature adjustment mechanism 15 comprising such a contact body moving mechanism 17, the contact body 16 can be reliably switched between the contact state and the non-contact state with respect to the upper press head 5. In this case, it is preferred that the substrate 1 be moved through a route different from supply and discharge routes for the substrate 1. A portion of the upper press head 5 with which the contact body 16 is to be brought into contact is not limited to the pressing surface 11, but may be any portion, such as a side surface of the upper press head

5, at which heat can be taken away from the upper press head 5.

[0030] Further, when pressing is performed repeatedly, some of the bumps 2 mounted on the substrate 1 may adhere to the bump pressing surface 11 to affect quality of pressing of the subsequent substrate 1. Accordingly, it is preferred that the contact body 16 comprise a cleaning mechanism 18. With the contact body 16 comprising the cleaning mechanism 18 as described above, when being brought into contact with the upper press head 5, the contact body 16 can clean the head surface while taking away heat from the upper press head 5 to decrease the temperature thereof. The cleaning mechanism 18 may be formed of a material that has high cleanness and does not scratch the bump pressing surface 11 of the upper press head 5, for example, a polyester waste cloth. Accordingly, the bump pressing surface 11 can be stably cleaned by operation of the contact body moving mechanism 17. Further, alcohol (cleaning alcohol) may be sprayed onto the cleaning mechanism 18, or a rotary mechanism may be separately added to clean the bump pressing surface 11 while rotating the cleaning mechanism 18.

[0031] The press apparatus of the present invention is used for an electronic component, and the electronic component comprises a semiconductor element connected to a substrate via bumps 2. Accordingly, the semiconductor element is connected to the substrate via the bumps 2 flattened using the press apparatus. As a result, the electronic component in which the semiconductor

element has no portion that is not connected to the substrate 1 is achieved.

[0032] According to the press method of the present invention, press working (flattening processing) can be performed with the temperature of the upper press head 5 being set at a temperature within the predetermined proper range.

[0033] The step of bringing the contact body 16 into contact with the upper press head 5 to adjust (decrease) the temperature of the upper press head 5 to a temperature within a predetermined range may be carried out at an initial stage after the start of flattening processing. With such a configuration, product press working can be performed after the temperature of the upper press head 5 is stabilized.

[0034] The step of bringing the contact body 16 into contact with the upper press head 5 to adjust the temperature of the upper press head 5 to a temperature within the predetermined range may be carried out at the time of replacing the substrate. With such a configuration, even when the substrate 1 has been replaced, product press working can be performed with the temperature of the upper press head 5 being stable.

[0035] According to the method of manufacturing an electronic component of the present invention, press working (flattening processing) can be performed with the temperature of the upper press head 5 being set at a temperature within the predetermined proper range, to enable manufacturing an

electronic component in which a semiconductor element has no portion that is not connected to the substrate 1.

[0036] The present invention is not limited to the embodiment described above, but may be variously modified. Thus, with the lower press head 6 being configured to be movable upward and downward by the lower press head-side upward-downward movement mechanism 12 on the lower press head 6 side, the lower press head 6 may be moved upward at the time of press working. That is, when press working is performed, only the upper press head 5 may be moved upward and downward as in the embodiment, the upper press head 5 and the lower press head 6 may be moved upward and downward, or only the lower press head 6 may be moved upward and downward. Further, not only at the time of press working, but, for example, at the time of replacing the substrate, the upper press head 5 and the lower press head 6 may be relatively separated from each other to increase a distance between the upper press head 5 and the lower press head 6 so that the substrate is easily replaced.

[0037] Further, the configuration example has been given in which the contact body 16 is brought into contact with and separated from the pressing surface 11 of the upper press head 5 by the XYZ-direction driver of the contact body moving mechanism 17. However, the configuration is not limited thereto. An upper press head moving mechanism configured to be capable of driving the upper press head 5 in the X and Y directions and the

Z direction may be provided, and the contact body 16 may be brought into contact with and separated from the pressing surface 11 of the upper press head 5 by moving the upper press head 5 by the upper press head moving mechanism. Alternatively, the contact body 16 may be brought into contact with and separated from the pressing surface 11 of the upper press head 5 by combining movement of the contact body 16 in at least one of the X and Y directions or the Z direction by the contact body moving mechanism 17, and movement of the upper press head 5 in at least one of the X and Y directions or the Z direction by the upper press head moving mechanism.

[0038] In addition, a heating mechanism may also be provided on the lower press head 6 side to heat the substrate 1. This heating mechanism can also be formed of, for example, electric heating wires. The heating mechanism on the upper press head 5 side may be employed, the heating mechanism on the lower press head 6 side may be employed, or a mechanism in which a heat medium is allowed to circulate may be employed.

[0039] The temperature adjustment mechanism 15 is configured to decrease the temperature in the embodiment, but conversely, may be configured to increase the temperature, or may be configured to maintain the temperature at a constant temperature.

Industrial Applicability

[0040] For example, the present invention is used for coining for flattening tops of bumps, which are particle members, of an IC chip, a chip capacitor, a chip resistor, or a substrate comprising those components mounted thereon.

Reference Signs List

[0041] 1 particle member forming body (substrate)
2 particle member (bump)
5 upper press head
6 lower press head
6a placement surface
7 heating mechanism
11 bump pressing surface
13 substrate conveyance mechanism
15 temperature adjustment mechanism
16 contact body
17 contact body moving mechanism
18 cleaning mechanism

Claims

[Claim 1] A press apparatus, which is configured to flatten bumps on a substrate by pressing the bumps with an upper press head, the press apparatus comprising:

a heating mechanism configured to heat the upper press head; and

a temperature adjustment mechanism configured to adjust a temperature of the upper press head,

wherein the temperature adjustment mechanism comprises a contact body configured to be brought into contact with the upper press head,

wherein the contact body is configured to be brought into contact with the upper press head under a state of being free of flattening processing by the pressing with the upper press head, to adjust the temperature of the upper press head to a temperature within a predetermined proper range, and

wherein, when the temperature of the upper press head has reached a temperature that allows product pressing, the flattening processing with the upper press head is performed, and when the temperature of the upper press head has been free of the temperature that allows product pressing, the contact body is configured to be kept in contact with the upper press head.

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

contact body is configured to remove a heat amount from the upper press head to adjust the temperature of the upper press head.

[Claim 3] The press apparatus according to claim 1, wherein the contact body is configured to be brought into contact with a bump pressing surface of the upper press head to adjust the temperature of the upper press head.

[Claim 4] The press apparatus according to claim 1, wherein the temperature adjustment mechanism comprises a contact body moving mechanism configured to bring the contact body into contact or non-contact with the upper press head, through a route different from supply and discharge routes for the substrate.

[Claim 5] A press method of pressing bumps on a substrate with an upper press head under a state in which the upper press head has been heated with a heating mechanism, to flatten the bumps,

the press method comprising:

bringing a contact body into contact with the upper press head at the time of being free of flattening processing with the upper press head, to adjust a temperature of the upper press head to a temperature within a predetermined range;

performing the flattening processing with the upper press head, when the temperature of the upper press head has reached a temperature that allows product pressing; and

keeping the contact body in contact with the upper press head, when the temperature of the upper press head has been free of the temperature that allows product pressing.

[Claim 6] The press method according to claim 5, further comprising bringing the contact body into contact or non-contact with the upper press head, through a route different from supply and discharge routes for the substrate.

[Claim 7] The press method according to claim 5, wherein, at an initial stage of press working, a step of bringing the contact body into contact with the upper press head to adjust the temperature of the upper press head is carried out, and then product press working is performed with the temperature of the upper press head being set at a temperature within a predetermined proper range.

[Claim 8] The press method according to claim 5, wherein a step of bringing the contact body into contact with the upper press head to adjust the temperature of the upper press head to a temperature within a predetermined proper range is carried out at the time of replacing the substrate.

[Claim 9] A method of manufacturing an electronic component, the electronic component comprising a semiconductor element

connected to a substrate via bumps,

the method comprising flattening the bumps on the substrate by the press method of any one of claims 5 to 8, to connect the semiconductor element to the substrate via the flattened bumps.