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SPECIFICATION

BUMP LEVELLING METHOD AND BUMP LEVELLING APPARATUS

Field of the Invention

The present invention relates to a bump levelling method and a bump levelling apparatus for levelling bumps formed on the electrode of an IC chip for a flip chip bonding.

Background of the Invention

In recent years, for packaging an IC chip on a circuit substrate, a flip chip bonding, by which a connecting distance between an inner electrode provided on the IC chip and an outer electrode on the circuit substrate can be decreased, has been carried out in order to improve its noise resistance as the frequency of the IC chip becomes high.

In a process for manufacturing electrodes for forming protrusion electrodes (generally, called bumps) through which the inner electrode of the IC chip is connected to the outer electrode on the circuit substrate on the IC chip, a bump levelling apparatus has been conventionally employed so as to level uniformly a plurality of bumps formed on the electrode of the IC chip to the same height.

A conventional bump levelling method and a bump levelling apparatus are illustrated in, for example, in FIG. 3A. According to the bump levelling method shown in FIG. 3A, spacers are held between a stage and a leveller depending on

the thickness of the IC chip and the height of the bumps after they are levelled and a distance between the stage and the leveller is maintained to a prescribed distance, so that the bumps are levelled to a prescribed height.

Such conventional bump levelling methods and bump levelling apparatuses will be described hereinafter with reference to the drawings.

FIG. 3A is a schematic cross-sectional view showing a construction of a conventional bump levelling apparatus. In FIG. 3A, 1 designates a stage for 1 holding an IC chip 2. indicates a spacer and 4 indicates a leveller for levelling the height of bumps 5.

Now, an operation of the bump levelling apparatus constructed as mentioned above will be described below.

When the bumps 5 respectively formed with uneven height are levelled so that they have the same height, the leveller 4 is moved toward a direction a by a pressing means (not illustrated). When the leveller 4 is held by the spacers 3 provided between the stage 1 and the leveller 4 to retain a prescribed distance from the stage 1, the tip ends 5a of the bumps 5 respectively having uneven height are made flat, seen in FIG. 3B and a plurality of bumps 5 are levelled so as to have the same prescribed height.

FIG. 3B shows the form of one bump after a plurality of bumps are levelled. In FIG. 3B, b designates a pedestal diameter, c designates a levelled diameter, d designates the thickness of a pedestal, and e represents the overall height of

the bump. 2 designates an IC chip, 6 designates an inner electrode, and 7 denotes a pedestal. After the bumps are levelled to a prescribed height as described above, the pedestal diameter b, the levelled diameter c, the thickness d of the pedestal, the overall height e of the bump and the misregistration or positional deviation between the inner electrode 6 of the IC chip 2 and the pedestal 7 are visually examined. Thus, whether the bumps 5 are non-defective articles or not is decided.

However, in the above described conventional bump levelling apparatus, there have occurred problems that a plurality of spacers 3 need to be maintained and these spacers 3 must be replaced by new spacers so as to meet the individually measured thickness of the IC chips in order to locate and maintain the accuracy in the overall height of the bumps 5 within a range of 2 詢 in the IC chips 2 having unevenness in thickness between lots within a range of 0 詢. In this connection, when the height of the bumps 5 is varied to obtain 2 a plurality of bump height, there has arisen a problem that further additional spacers 3 must be retained.

Further, since it takes long time separately from a levelling process, as a time for examining the pedestal thickness d or the overall height e of the bump 5 or the like, other inspections except a sampling inspection cannot be undesirably done.

Disclosure of the Invention

The present invention was made to overcome the above mentioned problems and it is an object of the present invention to provide a bump levelling method and a bump levelling apparatus in which the overall height of bumps can be changed based on the thickness of the IC chips even when the thickness of the IC chips changes depending on spaces between the lots of the IC chips or the kinds thereof and in which the forms of the levelled bumps can automatically undergo a 100% inspection.

For achieving the above stated object, according to one aspect of the present invention, there are provided the bump levelling method and the bump levelling apparatus in which a pressing force under which one bump can be deformed to a prescribed height is measured, so that a prescribed pressing force under which a plurality of bumps can be simultaneously deformed and levelled to the prescribed height can be set, and then, while the prescribed pressing force is continuously exerted on a leveller, the bumps can be levelled to the prescribed height.

Further, according to another aspect of the present invention, there are provided the bump levelling method and the bump levelling apparatus in which the height of the upper surface of the IC chip is previously measured and the leveller is stopped and held at a position higher by the overall height of each of the bumps than the upper surface of the IC chip so that the bumps can be levelled to the prescribed height.

Still further, according to other aspect of the present invention, there 3 are provided a bump levelling method and a

bump levelling apparatus in which the height of the upper surface of the IC chip and the difference of height between the respective parts of each of the bumps are measured after the bumps are levelled to the prescribed height, and the dimensions and the positions of the respective parts of each of the bumps are automatically inspected.

As stated above, according to the present invention, even when the thickness of the chip changes depending on the spaces between the lots of the IC chips or the kinds of the IC chips, the overall height of each of the bumps can be varied based on the thickness of the IC chips, and the forms of the levelled bumps can be automatically totally inspected.

Specifically stated, the bump levelling apparatus claimed in claim 1 for levelling bumps formed on the electrode of an IC chip for a flip chip bonding comprises : a stage for holding the IC chip; a leveller opposed to and in parallel with the stage through the IC chip held on the stage; and a pressing member for generating a pressing force to the leveller, the pressing member being constructed so as to maintain the pressing force to the leveller to a prescribed pressing force under which a plurality of bumps are simultaneously levelled to a prescribed height.

The bump levelling apparatus claimed in claim 2 further comprises a pressure detecting member for detecting the pressing force of the pressing member to the leveller arranged between the pressing member and the leveller according to claim 1, the pressing member being designed so as to maintain the

detected value of the pressure detecting member to the prescribed pressing force.

The bump levelling apparatus claimed in claim 3 for levelling bumps formed on the electrode of an IC chip for a flip chip bonding, comprises: a stage for holding the IC chip; a leveller opposed to and in parallel with the stage through the IC chip held on the stage; and a pressing member for generating a pressing force to the leveller, the pressing member being designed so as to stop a pressing operation to the leveller when the leveller comes to a position higher by the overall height of the bump than the upper surface of the IC chip. The bump levelling apparatus claimed in claim 4 further comprises a height measuring member for measuring the height of the upper surface of the IC chip, the pressing member according to claim 3 being designed so as to stop its pressing operation to the leveller when the leveller comes to a position higher by the overall height of the bump than the measured value of the height measuring member.

The bump levelling apparatus claimed in claim 5 is characterized in that the height measuring member according to claim 4 is designed to automatically inspect a height, a levelled diameter, a pedestal diameter and an amount of positional deviation of the bump after the bumps are levelled.

The bump levelling apparatus claimed in claim 6 according to any one of claims 1 to 4 further comprises a measuring member for inspecting the height, the levelled diameter, the pedestal diameter and the amount of positional

deviation of the bump, as inspection items, the measuring member being designed to automatically inspect the inspection items after the bumps are levelled.

Further, the bump levelling method claimed in claim 7 for levelling bumps formed on the electrode of an IC chip for a flip chip bonding in the bump levelling apparatus comprises the steps of: holding the IC chip on a stage; pressing a leveller arranged in an opposed position to and in parallel with the stage through the IC chip; and maintaining a pressing force to a prescribed pressing force under which a plurality of bumps are simultaneously levelled to a prescribed height.

The bump levelling method claimed in claim 8 for levelling bumps formed on the electrode of an IC chip for a flip chip bonding in the bump levelling apparatus comprises the steps of: measuring the height of the upper surface of the IC chip while the IC chip is held on a stage; pressing on a leveller arranged in an opposed position to and in parallel with the stage through the IC chip; and stopping the pressing operation when the leveller comes to a position higher by the overall height of the bump than the measured height of the upper surface of the IC chip.

The bump levelling method claimed in claim 9 further comprises a step of automatically inspecting the height of the bump, the levelled diameter, the pedestal diameter and the amount of positional deviation of the bump as inspection items after levelling the bumps according to claim 7 or 8.

According to the constitution of the apparatus described

in claim 1 or 2 or the method described in claim 7, the pressing force under which one bump is deformed to the prescribed height is measured, so that the prescribed pressing force for simultaneously levelling a plurality of bumps to the prescribed height can be set, and while a state in which the prescribed pressing force is applied onto the leveller is kept, the bumps can be levelled to the prescribed height.

Further, according to the constitution of the apparatus described in claim 3 or 4 or the method described in claim 8, the height of the upper surface of the IC chip is previously measured and the leveller is stopped and held at a position higher by the overall height of the bump than the upper surface of the IC chip, so that the bumps can be levelled to the prescribed height.

In addition, according to the constitution of the apparatus described in claim 6 or the method described in claim 9, the height of the upper surface of the IC chip and the difference in height between the respective parts of each of the bumps can be measured and the dimensions and positions of the respective parts of each of the bumps can be automatically examined after the bumps are levelled.

As apparent from the foregoing description, according to the present invention, the pressing force under which one bump is deformed to the prescribed height is previously measured. Therefore, the prescribed pressing force under which a plurality of bumps are deformed and levelled to the prescribed height at the same time can be set and the bumps can be

levelled to the prescribed height while a state in which the prescribed pressing force is exerted on the leveller 6 is kept.

Still further, according to the present invention, since the height of the upper surface of the IC chip is previously measured and the leveller is stopped and held at a position higher by the whole height of the bump than the upper surface of the IC chip, the bumps can be levelled to the prescribed height.

Besides, according to the present invention, the height of the upper surface of the IC chip and the difference in height between the respective parts of each of the bumps can be measured and the dimensions and positions of the respective parts of each of the bumps can be automatically inspected after the bumps are all levelled.

Accordingly, according to the present invention, even when the thickness of the chips changes depending on the spaces between the lots of the IC chips or various kinds thereof, the overall height of the bump can be changed so as to meet the thickness of the IC chips and the forms of the levelled bumps can automatically undergo a 100% inspection.

Brief Description of the Drawings

The present invention will now be described by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic structural diagram of a bump levelling apparatus according to a first embodiment of the present invention.

FIG. 2 is a schematic structural diagram of a bump levelling apparatus according to a second embodiment of the present invention.

FIG. 3A is a schematic structural diagram of a conventional bump levelling apparatus.

FIG. 3B is an explanatory view of the form of a levelled bump.

Description of the Embodiments

Referring to the drawings, a detailed explanation will be given to a bump levelling method and a bump levelling apparatus showing embodiments of the present invention, hereinafter.

(First Embodiment)

A bump levelling method and a bump levelling apparatus according to a first embodiment of the present invention will be described below.

FIG. 1 is a schematic structural diagram of a bump levelling apparatus employing a bump levelling method according to the first embodiment of the present invention. In FIG. 1, 11a designates a stage for holding an IC chip 12, 13a designates a leveller arranged in parallel with the stage 11a and 14 indicates a load cell serving as a pressure detecting means. The load cell 14 is provided between the leveller 13a and an arm 15 serving as a pressing means for applying a pressing force to the leveller 13a. The load cell 14 is sandwiched between the leveller 13a and the pressing arm 15

under a prescribed force by means of a spring 16. The pressure applying arm 15 receives a thrust when a ball screw 18 is rotated by a motor 17 and moves along a guide 19 in the direction shown by an arrow g.

The operation of the bump levelling apparatus constructed as mentioned above will be described hereinbelow.

When the ball screw 18 is rotated by the motor 17, the pressing or pressure applying arm 15, the load cell 14 and the leveller 13a are moved along the guide 19 toward the IC chip 12 located below them. When the leveller 13a collides with bumps 20 formed on the IC chip 12, a reaction force applied to the leveller 13a is transmitted to the load cell 14. The pressing or pressure applying arm 15 is continuously lowered until the load cell 14 detects a prescribed pressing force. The pressure applying arm 15 stops its lowering operation as soon as the load cell 14 detects the prescribed pressing force and maintains this state. After the pressing arm 15 stops its movement for several seconds, the arm 15 is elevated.

In such a way, the bumps are levelled to a prescribed height. Since the load cell 14 for detecting the pressing force of the pressure applying arm 15 applied to the leveller 13a is provided in accordance with the above described operation, 8 the prescribed force can be exerted on the bumps 20 so that the plurality of bumps 20 can be simultaneously levelled to the same prescribed height.

As a result, even when the thickness of the chips changes depending on the spaces between the lots of the IC

chips or various kinds thereof, the whole height of each of the bumps can be properly varied so as to meet the thickness of the IC chips.

(Second Embodiment)

Now, an explanation will be given to a bump levelling method and a bump levelling apparatus according to a second embodiment of the present invention.

FIG. 2 is a schematic structural diagram of a bump levelling apparatus using a bump levelling method according to a second embodiment of the present invention. FIG. 2 is different from FIG. 1 in view of following points that a leveller 13b is fixed to a pressing or pressure applying arm 15 and a stage 11b can be moved along a stage guide 21 in the direction shown by an arrow h to a position just below a height measuring means 22. The constitutions of a motor 17, a ball screw 18 and a guide 19 are similar to those of FIG. 1.

The operation of the bump levelling apparatus constructed as mentioned above will be described.

When the stage 11b is located at a position of h1, the thickness i of an IC chip 12 is measured by the height measuring means 22. When the stage 11b is located at a position of h2, a distance j between the upper surface of the stage 11b and the lower surface of the leveller 13b is previously measured and set to a prescribed value. The overall height l of each of bumps 20 is obtained after the bumps are levelled from the following expression:

$$l = j - i - k$$

When the stage 11b is moved to the position of h2 and the leveller 13b is moved by a distance k under the feed of the ball screw 18, the overall height of the bumps 20 can reach a dimension l. Further, the height measuring means 22 may be designed to measure and inspect the pedestal diameter b, the levelled diameter c, the pedestal thickness d and the overall height e of each of the bumps 20 and the positions of the bumps 20, while the height measuring means 22 is moved in the directions shown by arrows x and y on a plane relatively to the IC chip 12, when the stage bl is returned to the position of hl after the bumps are all levelled.

As stated above, since the height of the upper surface of the IC chip 12 is previously measured by the height measuring means 22, the leveller 13b can be lowered to the prescribed height so that the bumps 20 can be levelled to the prescribed height. Additionally, the dimensions of the forms and the positions of the bumps 20 can be automatically inspected by the height measuring means 22 after the bumps are completely levelled.

Although, in the bump levelling apparatus according to the first embodiment of the invention, the pressure of the pressure applying arm 15 is designed to be exerted onto the leveller 13a by using the thrust of the ball screw 18, it is to be understood that the thrust of a cylinder may be employed in place of the thrust of the ball screw 18.

Further, although, in the bump levelling apparatus according to the second embodiment of the invention, the forms

and positions of the bumps 20 are examined by using the height measuring means 22, it is to be noted that dimensions in the directions of x and y on the plane may be obtained by employing a measuring means having a camera or the like.

Furthermore, it is to be recognized that the bump levelling apparatus according to the above described embodiments of the invention may be installed in a bump bonding device for forming bumps, IC chips 12 on which the bumps are formed may be moved to the stage 11a or the stage 11b, and then, the bumps may be levelled. Thus, the formation, levelling and inspection of the bumps can be carried out at the same time.

CLAIMS

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1. A bump levelling apparatus for levelling bumps formed on the electrode of an IC chip for a flip chip bonding, said bump levelling apparatus comprising:

a stage for holding the IC chip;

a leveller opposed to and in parallel with said stage through the IC chip held on said stage; and

a pressing member for generating a pressing force to said leveller,

said pressing member being constructed so as to maintain the pressing force to the leveller to a prescribed pressing force under which a plurality of bumps are simultaneously levelled to a prescribed height.

2. A bump levelling apparatus according to claim 1, further comprising a pressure detecting member for detecting the pressing force of the pressing member to the leveller arranged between the pressing member and the leveller, said pressing member being constructed so as to maintain the detected value of the pressure detecting member to the prescribed pressing force.

3. A bump levelling apparatus for levelling bumps formed on the electrode of an IC chip for a flip chip bonding, said bump levelling apparatus comprising:

a stage for holding the IC chip;

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a leveller opposed to and in parallel with said stage through the IC chip held on said stage; and

a pressing member for generating a pressing force to said leveller,

said pressing member being constructed so as to stop a pressing operation to the leveller when the leveller comes to a position higher by the overall height of the bump than the upper surface of the IC chip.

4. A bump levelling apparatus according to claim 3, further comprising a height measuring member for measuring the height of the upper surface of the IC chip, said pressing member being constructed so as to stop its pressing operation to the leveller when the leveller comes to a position higher by the overall height of the bump than the measured value of said height measuring member.

5. A bump levelling apparatus according to claim 4, wherein said height measuring member is designed to automatically inspect a height, a levelled diameter, a pedestal diameter and an amount of positional deviation of the bump after the bumps are levelled.

6. A bump levelling apparatus according to any one of claims 1 to 4, further comprising a measuring member for inspecting the height, the levelled diameter, the pedestal diameter and the amount of positional deviation of the bump, as

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inspection items, said measuring member being designed to automatically inspect said inspection items after the bumps are levelled.

7. A bump levelling method for levelling bumps formed on the electrode of an IC chip for a flip chip bonding in a bump levelling apparatus, said bump levelling method comprising the steps of:

holding said IC chip on a stage;

pressing a leveller arranged in an opposed position to and in parallel with the stage through the IC chip; and

maintaining a pressing force to a prescribed pressing force under which a plurality of bumps are simultaneously levelled to a prescribed height.

8. A bump levelling method for levelling bumps formed on the electrode of an IC chip for a flip chip bonding in a bump levelling apparatus, said bump levelling method comprising the steps of:

measuring the height of the upper surface of said IC chip while the IC chip is held on a stage;

pressing a leveller arranged in an opposed position to and in parallel with the stage through the IC chip; and

stopping the pressing operation when the leveller comes to a position higher by the overall height of the bump than said measured height of the upper surface of the IC chip.

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9. A bump levelling method according to claim 7 or 8, further comprising a step of automatically inspecting the height, the levelled diameter, the pedestal diameter and the amount of positional deviation of the bump as inspection items after the bumps are levelled.

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