

stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor die chip by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is again switched from the fourth pressure to the third pressure. It is also preferable that the semiconductor die pick-up apparatus according to the present invention is configured such that the sheet displacement detection sensor uses, as a light source, light of a wavelength whose light transmission rate through the dicing sheet is in a range from 0% to 30%, or that the sheet displacement detection sensor employs a reflection-type optical fiber using an LED of a short wavelength from 0 nm to 300 nm as a light source.

[0016]

It is preferable that the semiconductor die pick-up apparatus according to the present invention is configured such that the stepped-surface forming mechanism includes: a columnar moving element that is disposed in a center; a plurality of annular moving elements arranged around the columnar moving element in a telescopical manner; and a slider movable in a direction along the suction surface within the opening of the stage, each of the annular moving elements includes an inclined

elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure; a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism; a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die chip by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to

position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure; a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism; a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die chip by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure; and a third-separation step of separating a portion of the semiconductor die from the surface of the dicing sheet by moving at least one of the moving elements from the

pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure, that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor die chip-if the sheet displacement detected by the sheet displacement detection sensor exceeds a predetermined threshold value, and that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is unseparated from the semiconductor die chip if the sheet displacement detected by the sheet displacement detection sensor is the predetermined threshold value or smaller; and a first retry step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die chip, when the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is determined to be unseparated from the semiconductor die chip-in the first determination step, by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the

CLAIMS

1. A semiconductor die pick-up apparatus comprising:

a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied;

a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; and

an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure, wherein

when the semiconductor die is picked up, at least one of the moving elements is moved from the first position to the second position every time the opening pressure is switched from the first pressure to the second pressure.

2. The semiconductor die pick-up apparatus according to claim 1, comprising:

a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure, wherein

when the semiconductor die is picked up, the opening pressure is switched in a state in which the suction pressure is switched from the fourth pressure to the third pressure.

3. The semiconductor die pick-up apparatus according to claim 2, wherein

when the semiconductor die is picked up, the opening pressure is switched while the suction pressure is maintained at the third pressure.

4. The semiconductor die pick-up apparatus according to claim 1, wherein

the opening pressure switch mechanism switches the opening pressure for a plurality of times between the first pressure and the second pressure, before any of the moving elements is first moved from the first position to the second position.

5. The semiconductor die pick-up apparatus according to claim 2, wherein

when the semiconductor die is picked up, at least one of the moving elements is moved from the first position to the second position every time the suction pressure is switched from the third pressure to the fourth pressure and the opening pressure is switched from the first pressure to the second pressure after the opening pressure is switched from the second pressure to the first pressure in a state in which the suction pressure is switched from the fourth pressure to the third pressure.

6. The semiconductor die pick-up apparatus according to claim 1, comprising:

a separation detection means configured to detect whether or not a portion of the semiconductor die facing against any of the tip end surfaces of the moving elements that has moved from the first position to the second position is separated from the front surface of the dicing sheet, wherein

when the separation detection means has detected that the portion of the semiconductor die is unseparated from the dicing sheet, the opening pressure is switched from the first pressure to the second pressure without moving the moving elements from the first position to the second position, and then again the

opening pressure is switched from the second pressure to the first pressure.

7. The semiconductor die pick-up apparatus according to claim 6, comprising:

a collet configured to suction a semiconductor die;
a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and
a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, wherein

the separation detection means determines that separation is successful when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determines that the separation is unsuccessful when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor.

8. The semiconductor die pick-up apparatus according to claim 1, comprising:

a sheet displacement detection sensor configured to detect displacement of the dicing sheet between an inner surface of the opening of the stage and an outer circumference surface of the stepped-surface forming mechanism, the displacement

being in an approaching and departing direction with respect to the suction surface, wherein

if the sheet displacement detected by the sheet displacement detection sensor is a predetermined threshold value or smaller when the opening pressure is switched from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure, the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor chip by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is again switched from the fourth pressure to the third pressure.

9. The semiconductor die pick-up apparatus according to claim 8, wherein

the sheet displacement detection sensor uses, as a light source, light of a wavelength whose light transmission rate through the dicing sheet is in a range from 0% to 30%.

10. The semiconductor die pick-up apparatus according to claim 9, wherein

the sheet displacement detection sensor employs a reflection-type optical fiber using an LED of a short wavelength from 0 nm to 300 nm as a light source.

11. The semiconductor die pick-up apparatus according to claim 1, wherein

the stepped-surface forming mechanism includes:

a columnar moving element that is disposed in a center;

a plurality of annular moving elements arranged around the columnar moving element in a telescopical manner; and

a slider movable in a direction along the suction surface within the opening of the stage,

each of the annular moving elements includes an inclined surface that is in contact with the slider, and with which corresponding one of the annular moving elements moves between the first position and the second position based on movement of the slider, and

the inclined surface of one of the annular moving elements on an outer circumference side and a different inclined surface of a different one of the annular moving elements on an inner circumference side are arranged in a displaced manner in a

moving direction of the slider so that when the slider moves, a tip end surface of the annular moving element on the outer circumference side moves from the first position to the second position before a tip end surface of the different annular moving element on the inner circumference side moves.

12. The semiconductor die pick-up apparatus according to claim 11, wherein

the columnar moving element includes an inclined surface that is in contact with the slider, and with which the columnar moving element moves between the first position and the second position, and the inclined surface is disposed in a displaced manner in the moving direction of the slider so that when the slider moves, the tip end surface of the annular moving element on the inner circumference side moves from the first position to the second position before a tip end surface of the columnar moving element moves.

13. The semiconductor die pick-up apparatus according to claim 1, wherein

the stepped-surface forming mechanism includes:

a slider movable in a direction along the suction surface within the opening of the stage,

a plurality of plated moving elements arranged side by side in a moving direction of the slider,

each of the plated moving elements includes an inclined surface that is in contact with the slider, and with which corresponding one of the plated moving elements moves between the first position and the second position based on movement of the slider, and

the inclined surfaces of the plated moving elements are arranged in a displaced manner in the moving direction of the slider so that the corresponding plated moving elements sequentially move from the first position to the second position along the moving direction of the slider.

14. A semiconductor die pick-up method comprising:

a step of preparing a semiconductor die pick-up apparatus including: a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied; a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first

position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure;

a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism;

a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor chip by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure; and

a second-separation step of separating a portion of the semiconductor die from the surface of the dicing sheet by moving at least one of the moving elements from the first position to the second position every time the opening pressure is switched from the first pressure to the second pressure in a state in

which the suction pressure is maintained at the third pressure, the portion of the semiconductor die facing against the tip end surface of the at least one moving element.

15. A semiconductor die pick-up method comprising:
a step of preparing a semiconductor die pick-up apparatus including: a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied; a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure;

a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism;

a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor chip by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure; and

a third-separation step of separating a portion of the semiconductor die from the surface of the dicing sheet by moving at least one of the moving elements from the first position to the second position every time the suction pressure is switched from the third pressure to the fourth pressure and the opening pressure is switched from the first pressure to the second pressure after the opening pressure is switched from the second pressure to the first pressure in a state in which the suction pressure is switched from the fourth pressure to the third pressure, the portion of the semiconductor die facing against the tip end surface of the at least one moving element.

16. The semiconductor die pick-up method according to claim 14 or 15, wherein

the semiconductor die pick-up apparatus includes a sheet displacement detection sensor configured to detect displacement of the dicing sheet between an inner surface of the opening of the stage and an outer circumference surface of the stepped-surface forming mechanism, the displacement being in an approaching and departing direction with respect to the suction surface, and

the first separation step includes:

a first separation determination step of determining when the opening pressure is switched from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure, that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor chip if the sheet displacement detected by the sheet displacement detection sensor exceeds a predetermined threshold value, and that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is unseparated from the semiconductor chip if the sheet displacement detected by the

sheet displacement detection sensor is the predetermined threshold value or smaller; and

a first retry step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor chip, when the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is determined to be unseparated from the semiconductor chip in the first determination step, by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is again switched from the fourth pressure to the third pressure.

17. The semiconductor die pick-up method according to claim 14, wherein

the semiconductor die pick-up apparatus includes: a collet configured to suction a semiconductor die; a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, and

the second-separation step includes:

a second separation determination step of determining that the portion of the semiconductor die facing against the tip end surface of the moving element that has moved from the first position to the second position is separated from the front surface of the dicing sheet when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determining that the portion of the semiconductor die is unseparated from the front surface of the dicing sheet when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor; and

a second retry step of separating the portion of the semiconductor die from the front surface of the dicing sheet, when the portion of the semiconductor die is determined to be unseparated from the front surface of the dicing sheet in the second separation determination step, by switching the opening pressure from the first pressure to the second pressure without moving the moving element from the first position to the second position, and again switching the opening pressure from the second pressure to the first pressure.

18. The semiconductor die pick-up method according to claim 15, wherein

the semiconductor die pick-up apparatus includes: a collet configured to suction a semiconductor die; a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, and

the third-separation step includes:

a third separation determination step of determining that the portion of the semiconductor die facing against the tip end surface of the moving element that has moved from the first position to the second position is separated from the front surface of the dicing sheet when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determining that the portion of the semiconductor die is unseparated from the front surface of the dicing sheet when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor; and

a third retry step of separating the portion of the semiconductor die from the front surface of the dicing sheet, when the portion of the semiconductor die is determined to be unseparated from the front surface of the dicing sheet in the third separation determination step, by switching the suction pressure from the third pressure to the fourth pressure and the

opening pressure from the first pressure to the second pressure without moving the moving element from the first position to the second position, and again switching the suction pressure from the fourth pressure to the third pressure and the opening pressure from the second pressure to the first pressure.

19. The semiconductor die pick-up method according to claim 16, wherein

the sheet displacement detection sensor uses, as a light source, light of a wavelength whose light transmission rate through the dicing sheet is in a range from 0% to 30%.

20. The semiconductor die pick-up method according to claim 19, wherein

the sheet displacement detection sensor employs a reflection-type optical fiber using an LED of a short wavelength from 0 nm to 300 nm as a light source.

21. The semiconductor die pick-up method according to claim 14 or 15, wherein

the opening pressure switch mechanism switches the opening pressure for a plurality of times between the first pressure and the second pressure, before any of the moving elements is first moved from the first position to the second position.

CLAIMS

1. A semiconductor die pick-up apparatus comprising:
a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied;

a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; and

an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure, wherein

when the semiconductor die is picked up, at least one of the moving elements is moved from the first position to the second position every time the opening pressure is switched from the first pressure to the second pressure.

2. The semiconductor die pick-up apparatus according to claim 1, comprising:

a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure, wherein

when the semiconductor die is picked up, the opening pressure is switched in a state in which the suction pressure is switched from the fourth pressure to the third pressure.

3. The semiconductor die pick-up apparatus according to claim 2, wherein

when the semiconductor die is picked up, the opening pressure is switched while the suction pressure is maintained at the third pressure.

4. The semiconductor die pick-up apparatus according to claim 1, wherein

the opening pressure switch mechanism switches the opening pressure for a plurality of times between the first pressure and the second pressure, before any of the moving elements is first moved from the first position to the second position.

5. The semiconductor die pick-up apparatus according to claim 2, wherein

when the semiconductor die is picked up, at least one of the moving elements is moved from the first position to the second position every time the suction pressure is switched from the third pressure to the fourth pressure and the opening pressure is switched from the first pressure to the second pressure after the opening pressure is switched from the second pressure to the first pressure in a state in which the suction pressure is switched from the fourth pressure to the third pressure.

6. The semiconductor die pick-up apparatus according to claim 1, comprising:

a separation detection means configured to detect whether or not a portion of the semiconductor die facing against any of the tip end surfaces of the moving elements that has moved from the first position to the second position is separated from the front surface of the dicing sheet, wherein

when the separation detection means has detected that the portion of the semiconductor die is unseparated from the dicing sheet, the opening pressure is switched from the first pressure to the second pressure without moving the moving elements from the first position to the second position, and then again the

opening pressure is switched from the second pressure to the first pressure.

7. The semiconductor die pick-up apparatus according to claim 6, comprising:

a collet configured to suction a semiconductor die;
a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and
a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, wherein

the separation detection means determines that separation is successful when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determines that the separation is unsuccessful when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor.

8. The semiconductor die pick-up apparatus according to claim 1, comprising:

a sheet displacement detection sensor configured to detect displacement of the dicing sheet between an inner surface of the opening of the stage and an outer circumference surface of the stepped-surface forming mechanism, the displacement

being in an approaching and departing direction with respect to the suction surface, wherein

if the sheet displacement detected by the sheet displacement detection sensor is a predetermined threshold value or smaller when the opening pressure is switched from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure, the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor die by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is again switched from the fourth pressure to the third pressure.

9. The semiconductor die pick-up apparatus according to claim 8, wherein

the sheet displacement detection sensor uses, as a light source, light of a wavelength whose light transmission rate through the dicing sheet is in a range from 0% to 30%.

10. The semiconductor die pick-up apparatus according to claim 9, wherein

the sheet displacement detection sensor employs a reflection-type optical fiber using an LED of a short wavelength from 0 nm to 300 nm as a light source.

11. The semiconductor die pick-up apparatus according to claim 1, wherein

the stepped-surface forming mechanism includes:

a columnar moving element that is disposed in a center;

a plurality of annular moving elements arranged around the columnar moving element in a telescopical manner; and

a slider movable in a direction along the suction surface within the opening of the stage,

each of the annular moving elements includes an inclined surface that is in contact with the slider, and with which corresponding one of the annular moving elements moves between the first position and the second position based on movement of the slider, and

the inclined surface of one of the annular moving elements on an outer circumference side and a different inclined surface of a different one of the annular moving elements on an inner circumference side are arranged in a displaced manner in a

moving direction of the slider so that when the slider moves, a tip end surface of the annular moving element on the outer circumference side moves from the first position to the second position before a tip end surface of the different annular moving element on the inner circumference sided moves.

12. The semiconductor die pick-up apparatus according to claim 11, wherein

the columnar moving element includes an inclined surface that is in contact with the slider, and with which the columnar moving element moves between the first position and the second position, and the inclined surface is disposed in a displaced manner in the moving direction of the slider so that when the slider moves, the tip end surface of the annular moving element on the inner circumference side moves from the first position to the second position before a tip end surface of the columnar moving element moves.

13. The semiconductor die pick-up apparatus according to claim 1, wherein

the stepped-surface forming mechanism includes:

a slider movable in a direction along the suction surface within the opening of the stage,

a plurality of plated moving elements arranged side by side in a moving direction of the slider,

each of the plated moving elements includes an inclined surface that is in contact with the slider, and with which corresponding one of the plated moving elements moves between the first position and the second position based on movement of the slider, and

the inclined surfaces of the plated moving elements are arranged in a displaced manner in the moving direction of the slider so that the corresponding plated moving elements sequentially move from the first position to the second position along the moving direction of the slider.

14. A semiconductor die pick-up method comprising:

a step of preparing a semiconductor die pick-up apparatus including: a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied; a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first

position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure;

a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism;

a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure; and

a second-separation step of separating a portion of the semiconductor die from the surface of the dicing sheet by moving at least one of the moving elements from the first position to the second position every time the opening pressure is switched from the first pressure to the second pressure in a state in

which the suction pressure is maintained at the third pressure, the portion of the semiconductor die facing against the tip end surface of the at least one moving element.

15. A semiconductor die pick-up method comprising:

a step of preparing a semiconductor die pick-up apparatus including: a stage having a suction surface for suctioning a back surface of a dicing sheet with a front surface to which a semiconductor die to be picked up is applied; a stepped-surface forming mechanism configured to form a stepped surface for the suction surface, the stepped-surface forming mechanism having a plurality of moving elements disposed in an opening provided in the suction surface of the stage, the moving elements being movable between a first position and a second position, the first position being a position at which tip end surfaces of the moving elements are higher than the suction surface, the second position being a position at which the tip end surfaces of the moving elements are lower than the first position; an opening pressure switch mechanism configured to switch an opening pressure of the opening between a first pressure that is near vacuum and a second pressure that is near an atmospheric pressure; and a suction pressure switch mechanism configured to switch a suction pressure of the suction surface between a third pressure that is near vacuum and a fourth pressure that is near the atmospheric pressure;

a positioning step of, assuming that a tip end surface of each of the moving elements of the stepped-surface forming mechanism is at the first position, moving the stage in a direction along the suction surface so that the semiconductor die to be picked up comes immediately above the stepped surface of the stepped-surface forming mechanism;

a first-separation step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die by switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure; and

a third-separation step of separating a portion of the semiconductor die from the surface of the dicing sheet by moving at least one of the moving elements from the first position to the second position every time the suction pressure is switched from the third pressure to the fourth pressure and the opening pressure is switched from the first pressure to the second pressure after the opening pressure is switched from the second pressure to the first pressure in a state in which the suction pressure is switched from the fourth pressure to the third pressure, the portion of the semiconductor die facing against the tip end surface of the at least one moving element.

16. The semiconductor die pick-up method according to claim 14 or 15, wherein

the semiconductor die pick-up apparatus includes a sheet displacement detection sensor configured to detect displacement of the dicing sheet between an inner surface of the opening of the stage and an outer circumference surface of the stepped-surface forming mechanism, the displacement being in an approaching and departing direction with respect to the suction surface, and

the first separation step includes:

a first separation determination step of determining when the opening pressure is switched from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is switched from the fourth pressure to the third pressure, that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is separated from the semiconductor die if the sheet displacement detected by the sheet displacement detection sensor exceeds a predetermined threshold value, and that the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is unseparated from the semiconductor die if the sheet displacement detected by the

sheet displacement detection sensor is the predetermined threshold value or smaller; and

a first retry step of separating the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism from the semiconductor die, when the dicing sheet between the inner surface of the opening of the stage and the outer circumference surface of the stepped-surface forming mechanism is determined to be unseparated from the semiconductor die in the first determination step, by switching the suction pressure from the third pressure to the fourth pressure and the opening pressure from the first pressure to the second pressure, and thereafter switching the opening pressure from the second pressure to the first pressure after a predetermined time elapses after the suction pressure is again switched from the fourth pressure to the third pressure.

17. The semiconductor die pick-up method according to claim 14, wherein

the semiconductor die pick-up apparatus includes: a collet configured to suction a semiconductor die; a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, and

the second-separation step includes:

a second separation determination step of determining that the portion of the semiconductor die facing against the tip end surface of the moving element that has moved from the first position to the second position is separated from the front surface of the dicing sheet when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determining that the portion of the semiconductor die is unseparated from the front surface of the dicing sheet when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor; and

a second retry step of separating the portion of the semiconductor die from the front surface of the dicing sheet, when the portion of the semiconductor die is determined to be unseparated from the front surface of the dicing sheet in the second separation determination step, by switching the opening pressure from the first pressure to the second pressure without moving the moving element from the first position to the second position, and again switching the opening pressure from the second pressure to the first pressure.

18. The semiconductor die pick-up method according to claim 15, wherein

the semiconductor die pick-up apparatus includes: a collet configured to suction a semiconductor die; a suctioning mechanism connected to the collet, and configured to suction air from a surface of the collet; and a flow rate sensor configured to detect an amount of air flow suctioned by the suctioning mechanism, and

the third-separation step includes:

a third separation determination step of determining that the portion of the semiconductor die facing against the tip end surface of the moving element that has moved from the first position to the second position is separated from the front surface of the dicing sheet when a number of times that a derivative signal changes over a predetermined threshold range is an even number, and determining that the portion of the semiconductor die is unseparated from the front surface of the dicing sheet when the number of times is an odd number, the derivative signal being obtained by derivation of a signal of the amount of suctioned air flow detected by the flow rate sensor; and

a third retry step of separating the portion of the semiconductor die from the front surface of the dicing sheet, when the portion of the semiconductor die is determined to be unseparated from the front surface of the dicing sheet in the third separation determination step, by switching the suction pressure from the third pressure to the fourth pressure and the

opening pressure from the first pressure to the second pressure without moving the moving element from the first position to the second position, and again switching the suction pressure from the fourth pressure to the third pressure and the opening pressure from the second pressure to the first pressure.

19. The semiconductor die pick-up method according to claim 16, wherein

the sheet displacement detection sensor uses, as a light source, light of a wavelength whose light transmission rate through the dicing sheet is in a range from 0% to 30%.

20. The semiconductor die pick-up method according to claim 19, wherein

the sheet displacement detection sensor employs a reflection-type optical fiber using an LED of a short wavelength from 0 nm to 300 nm as a light source.

21. The semiconductor die pick-up method according to claim 14 or 15, wherein

the opening pressure switch mechanism switches the opening pressure for a plurality of times between the first pressure and the second pressure, before any of the moving elements is first moved from the first position to the second position.