

DESCRIPTION
WATER JET PROCESSING MACHINE

Field of the Invention

5 The present invention relates to a water jet processing machine for spouting a high-pressure water jet to a workpiece such as a semiconductor wafer or the like to cut it.

Prior Art

10 In the production process of semiconductor devices, semiconductor chips are produced by forming a circuit such as IC, LSI or the like in a large number of areas arranged in a lattice form on the front surface of a substantially disk-like semiconductor wafer and then, dicing the
15 semiconductor wafer into the areas that has circuit formed thereon, along predetermined cutting lines called "streets". The thus divided semiconductor chips are packaged, and widely used in electric appliances such as mobile phones, personal computers or the like.

20 Demand for lighter and smaller electric appliances such as mobile phones and personal computers is growing, and packaging technologies capable of reducing the size of a semiconductor chip package, which are called a "Chip Size Package (CSP)", have already been developed. As one of the
25 CSP technologies, a packaging technology called "Quad Flat Non-lead Package (QFN)" has been employed practically. In this QFN packaging technology, a plurality of connection terminals are formed corresponding to the connection terminals of a semiconductor chip and a plurality of
30 semiconductor chips are arranged in a matrix form on a metal sheet such as a copper sheet or the like, in which streets for sectioning the semiconductor chips have been formed in a lattice form, and a resin is molded from the back sides of the semiconductor chips to integrate the metal sheet with

the semiconductor chips, whereby a CSP substrate is formed. This CSP substrate is cut along the streets to be divided into individual chip size packages (CSP).

5 The above CSP substrate is generally cut with a precision cutting machine called "dicing machine". This dicing machine comprises a cutting blade having an annular abrasive grain layer and cuts the CSP substrate along the streets by moving this cutting blade along the streets in the CPS substrate relative to the CSP substrate while
10 rotating the cutting blade so as to divide it into individual CSP's. When the CSP substrate is thus cut with the cutting blade, however, burrs are produced in the connection terminals to cause a short circuit between adjacent connection terminals, thereby reducing the quality and
15 reliability of a chip size package (CSP).

Further, including the case of the CSP, when a workpiece such as a semiconductor wafer or the like is cut with the cutting blade, fine cuttings are adhered to the surface of the workpiece, thereby contaminating the workpiece.

20 As a cutting technology for solving problems caused by cutting with the cutting blade, for example, JP-A 2002-205298 discloses a water jet cutting technology for cutting a workpiece by spouting a high-pressure water jet containing abrasive grains such as silica, garnet or the like
25 from a nozzle to the workpiece held by a workpiece holding means.

Meanwhile, when the operation of a water jet processing machine is suspended and this suspended state is kept for a while, the abrasive grains contained in processing water
30 that collects in the nozzle settle out and occlude the hole of the nozzle. Therefore, when the water jet processing machine is used next, it cannot be used due to the occlusion of the hole of the nozzle.

Summary of the Invention

It is an object of the present invention to provide a water jet processing machine which can prevent the hole of a nozzle from being occluded with abrasive grains contained in processing water by discharging the processing water that collects in the nozzle after the processing work is suspended.

To attain the above object, according to the present invention, there is provided a water jet processing machine comprising a workpiece holding means for holding a workpiece, a nozzle for spouting a water jet to the workpiece held on the workpiece holding means and a processing water supply means for supplying high-pressure processing water containing abrasive grains to the nozzle, wherein the machine is provided with cleaning water supply means for supplying cleaning water to the nozzle.

Brief Description of the Drawings

Fig. 1 is a partially exploded perspective view of a water jet processing machine constituted according to the present invention;

Fig. 2 is an exploded perspective view of a absorbing member and a holding tray constituting a detachable table used in the water jet processing machine shown in Fig. 1;

Fig. 3 is a perspective view of the detachable table used in the water jet processing machine shown in Fig. 1 and a workpiece;

Fig. 4 is a sectional view showing that the detachable table shown in Fig. 3 is held on a base table; and

Fig. 5 is a sectional view of a nozzle for spouting a water jet used in the water jet processing machine shown in Fig. 1.

Detailed Description of the Preferred Embodiments

A preferred embodiment of a water jet processing machine constituted according to the present invention will be described in more detail with reference to the accompanying drawings.

5 Fig. 1 is a partially exploded perspective view of a water jet processing machine constituted according to the present invention. The water jet processing machine shown in Fig. 1 comprises a stationary base 2, a workpiece holding means 3 for holding a workpiece, which is mounted on the
10 stationary base 2 in such a manner that it can move in a feed direction shown by an arrow X, a water jet spouting unit supporting mechanism 4 which is mounted on the stationary base 2 in such a manner that it can move in an indexing direction shown by an arrow Y that is perpendicular to the
15 direction shown by the arrow X, and a water jet spouting unit 5 which is disposed to the water jet spouting unit supporting mechanism 4 in such a manner that it can move in a direction shown by an arrow Z.

 The above workpiece holding means 3 has a pair of guide
20 rails 31 and 31 which are disposed on the stationary base 2 in parallel to each other in the direction shown by the arrow X, a first sliding block 32 which is disposed on the guide rails 31 and 31 in such a manner that it can move in the direction shown by the arrow X, a second sliding block
25 33 which is disposed on the first sliding block 32 in such a manner that it can move in the direction shown by the arrow Y, a support table 35 which is supported on the second sliding block 33 by a cylindrical member 34, and a base table 36. The base table 36 is attached to the top end of a rotary shaft
30 340 penetrating through the cylindrical member 34, and is so constituted as to be turned within a plane perpendicular to the direction of a water jet ejected from the nozzle to be described later of the water jet spouting unit 5, that is, within the horizontal plane, by a pulse motor (not shown)

built in the cylindrical member 34. A detachable table for positioning the workpiece detachably is placed and held on this base table 36. The base table 36 and the detachable table will be described hereinbelow with reference to Figs. 2 to 4.

Fig. 2 is an exploded perspective view of the detachable table 10, Fig. 3 is a perspective view of the detachable table 10 and a CSP substrate 100 as a workpiece, and Fig. 4 is a sectional view showing a state of the detachable table 10 being held on the base table 36.

A description is first given of the base table 36 with reference to Fig. 4 and Fig. 1.

The base table 36 in the illustrated embodiment is formed in a rectangular shape, is composed of a bottom wall 361, an upper wall 362 and a frame-like side wall 363 and has a negative pressure chamber 360 formed by these walls. A negative pressure introduction hole 361a communicating with the negative pressure chamber 360 and a passage 340a formed in the rotary shaft 340 is formed in the center portion of the bottom wall 361 constituting the base table 36. The passage 340a formed in the rotary shaft 340 is communicated with a suction source through a negative pressure control circuit that is not shown. In the top wall 362 constituting the base table 36, there are formed a suction hole 362a and a communication hole 362b which communicate with the negative pressure chamber 360 and are open to the top surface as a placing surface. The suction hole 362a is formed in the center portion of the top wall 362 and the communication hole 362b is formed on the right side in Fig. 4, of the suction hole 362a.

The detachable table 10 in the illustrated embodiment consists of a rectangular parallelepiped absorbing member 11 and a holding tray 12 for holding the absorbing member 11 as shown in Fig. 2. In the illustrated embodiment, the

absorbing member 11 is formed of urethane, and its top surface serves as a support surface 11a for supporting the workpiece. The absorbing member 11 may be made of a metal such as stainless steel, tungsten, nickel, copper or the like, or
5 ceramic such as alumina or the like, besides a resin such as urethane or the like. A plurality of suction holes 11b which are open to the support surface 11a as the top surface and go through to the under surface are provided in the absorbing member 11. The suction holes 11b are formed at
10 positions corresponding to individual chips into which the workpiece on the support surface 11a is divided.

The holding tray 12 constituting the detachable table 10 is composed of a rectangular parallelepiped bottom wall 121 and a frame-like side wall 122 projecting upward from
15 the periphery of the bottom wall 121, and is open at the top. The holding tray 12 is made from a metal material such as stainless steel or the like. A frame-like support shelf 121a for placing and supporting the under surface of the above absorbing member 11 is formed at the periphery of the top
20 surface of the bottom wall 121 constituting the holding tray 12. A communication hole 121b is formed in the bottom wall 121 of the holding tray 12 at a position corresponding to the communication hole 362b formed in the top wall 362 constituting the above base table 36. A check valve 123 is
25 installed in this communication hole 121b as shown in Fig. 4. This check valve 123 permits the flow when the negative pressure on the negative pressure chamber 360 side of the base table 36 is high but cuts off the flow when the negative pressure within the holding tray 12 is high. That is, the
30 check valve 123 permits the inflow of negative pressure into the holding tray 12 but cuts off the outflow of negative pressure from the holding tray 12. A working rod 124 for releasing the function of the check valve 123 is built in the bottom wall 121 constituting the holding tray 12. The

lower portion of the absorbing member 11 is fitted in the thus constituted holding tray 12 from the top opening side as shown in Fig. 3 and Fig. 4. In this fitted state, the peripheral portion of the under surface of the absorbing member 11 is placed on the frame-like support shelf 121a formed on the bottom wall 121 constituting the holding tray 12. Therefore, a suction chamber 120 is formed between the top surface of the bottom wall 121 and the under surface of the absorbing member 11 as shown in Fig. 4. As a result, the plurality of suction holes 11b formed in the absorbing member 11 communicate with the suction chamber 120.

The detachable table 10 constituted as described above places a workpiece 100 such as a CSP substrate on the support surface 11a which is the top surface of the absorbing member 11, and is placed on the top surface that is the mounting surface of the base table 36 as shown in Fig. 4. When the detachable table 10 supporting the workpiece 100 on the support surface 11a of the absorbing member 11 is thus placed on the base table 36 and the negative pressure control circuit (not shown) is controlled to communicate the passage 340a formed in the rotary shaft 340 with the suction source that is not shown, negative pressure acts on the under surface of the holding tray 12 constituting the detachable table 10 through the negative pressure introduction hole 361a formed in the bottom wall 361 of the base table 36, the negative pressure chamber 360 and the suction hole 362a formed in the top wall 362 of the base table 36 to suction-hold the holding tray 12 on the base table 36. Meanwhile, when the negative pressure chamber 360 of the base table 36 is communicated with the suction source, negative pressure acts on the under surface of the workpiece 100 through the communication hole 362b formed in the top wall 362 of the base table 36, the check valve 123 installed in the communication hole 121b formed in the bottom wall 121 of the holding tray 12, the

suction chamber 120 and the suction holes 11b formed in the absorbing member 11 to suction-hold the workpiece 100 on the absorbing member 11.

Returning to Fig. 1, a description will be continued.

5 The above first sliding block 32 is provided with a pair of guide grooves 321 and 321 to be fitted to the above pair of guide rails 31 and 31 on the under surface and a pair of guide rails 322 and 322 formed parallel to each other in the direction shown by the arrow Y on the top surface. The thus
10 constituted first sliding block 32 is constituted to be moved along the pair of guide rails 31 and 31 in the direction shown by the arrow X, by fitting the pair of guide rails 31 and 31 to the guide grooves 321 and 321. The workpiece holding means 3 in the illustrated embodiment has a first moving means
15 37 for moving the first sliding block 32 along the pair of guide rails 31 and 31 in the direction shown by the arrow X. The first moving means 37 comprises a male screw rod 371 arranged between the pair of guide rails 31 and 31 and in parallel to the guide rails 31 and 31 and a drive source such
20 as a pulse motor 372 for rotation-driving the male screw rod 371. One end of the male screw rod 371 is rotatably supported to a bearing block 373 fixed on the stationary base 2 and the other end thereof is connected to the output shaft of the above pulse motor 372 through a speed reducer that is
25 not shown. The male screw rod 371 is screwed into an internally threaded through hole formed in a female screw block (not shown) projecting from the under surface of the central portion of the first sliding block 32. Accordingly, by turning the male screw rod 371 in a normal direction or
30 reverse direction by the pulse motor 372, the first sliding block 32 is moved along the guide rails 31 and 31 within the plane perpendicular to the direction of a water jet ejected from the nozzle to be described later of the water jet spouting unit 5, that is, within the horizontal plane in the direction

shown by the arrow X.

The above second sliding block 33 is provided with a pair of guide grooves 331 and 331 to be fitted to a pair of guide rails 322 and 322 formed on the top surface of the above first sliding block 32 on the under surface and can be moved
5 in the direction shown by the arrow Y, by fitting the pair of guide rails 322 and 322 to the guide grooves 331 and 331. The workpiece holding means 3 in the illustrated embodiment has a second moving means 38 for moving the second sliding
10 block 33 along the pair of guide rails 322 and 322 provided on the first sliding block 32 in the direction shown by the arrow Y. The second moving means 38 comprises a male screw rod 381 arranged between the pair of guide rails 322 and 322 and in parallel to the guide rails 322 and 322 and a drive
15 source such as a pulse motor 382 for rotation-driving the male screw rod 381. One end of the male screw rod 381 is rotatably supported to a bearing block 383 fixed on the top surface of the above first sliding block 32 and the other end thereof is transmission-coupled to the output shaft of
20 the above pulse motor 382 through a speed reducer that is not shown. The male screw rod 381 is screwed into an internally threaded through hole formed in a female screw block (not shown) projecting from the under surface of the center portion of the second sliding block 33. Therefore,
25 by turning the male screw rod 381 in a normal direction or reverse direction by the pulse motor 382, the second sliding block 33 is moved along the guide rails 322 and 322 in the indexing direction shown by the arrow Y perpendicular to the direction shown by the arrow X.

30 On both sides in the direction shown by the arrow X of the above support table 35, there are disposed bellows means 391 and 392, and the constituent members other than the base table 36 constituting the workpiece holding means 3 are covered by the bellows means 391 and 392. The opposed

end portions of the bellows means 391 and 392 are respectively fixed to the support table 35. The both side end portions of the bellows means 391 and 392 are fixed to the inner end walls 393a and 393b of a frame-like drainage gutter means
5 393 which is installed on the stationary base 2 and surrounds the above workpiece holding means 3.

The above water jet spouting unit supporting mechanism 4 is provided with a pair of guide rails 41 and 41 arranged parallel to each other on the stationary base 2 in the indexing
10 direction shown by the arrow Y and a movable support base 42 which is mounted on the guide rails 41 and 41 in such a manner that it can move in the direction shown by the arrow Y. This movable support base 42 comprises a movable support portion 421 movably mounted on the guide rails 41 and 41 and
15 a mounting portion 422 attached to the movable support portion 421. The mounting portion 422 is provided with a pair of guide rails 422a and 422a extending in the direction shown by the arrow Z on one flank. The water jet spouting unit supporting mechanism 4 in the illustrated embodiment has a
20 third moving means 43 for moving the movable support base 42 along the pair of guide rails 41 and 41 in the indexing direction shown by the arrow Y. The third moving means 43 comprises a male screw rod 431 arranged between the pair of the guide rails 41 and 41 and parallel to the pair of the
25 guide rails 41 and 41 and a drive source such as a pulse motor 432 for rotation-driving the male screw rod 431. One end of the male screw rod 431 is rotatably supported to a bearing block (not shown) fixed on the above stationary base 2 and the other end thereof is transmission-coupled to the output
30 shaft of the above pulse motor 432 through a speed reducer that is not shown. The male screw rod 431 is screwed into an internally threaded hole formed in a female screw block (not shown) projecting from the under surface of the center portion of the movable support portion 421 constituting the

movable support base 42. Accordingly, by turning the male screw rod 431 in a normal direction or reverse direction by the pulse motor 432, the movable support base 42 is moved along the guide rails 41 and 41 in the indexing direction
5 shown by the arrow Y.

The water jet spouting unit 5 in the illustrated embodiment comprises a unit holder 51 and a water jet spouting means 52 attached to the unit holder 51. The unit holder 51 is provided with a pair of guide grooves 51a and 51a to be
10 slidably fitted to the pair of guide rails 422a and 422a provided on the above mounting portion 422, and can be moved in the direction shown by the arrow Z by fitting the above guide rails 422a and 422a to the guide grooves 51a and 51a. The water jet spouting unit 5 in the illustrated embodiment
15 has a fourth moving means 53 for moving the unit holder 51 along the pair of guide rails 422a and 422a in the direction shown by the arrow Z. The fourth moving means 53 comprises a male screw rod (not shown) arranged between the pair of guide rails 422a and 422a, like the above first to third moving
20 means and a drive source such as a pulse motor 532 for rotation-driving the male screw rod. By turning the male screw rod in a normal direction or reverse direction by the pulse motor 532, the unit holder 51 and the water jet spouting means 52 are moved along the guide rails 422a and 422a in
25 the direction shown by the arrow Z.

The above water jet spouting means 52 has a nozzle 522 at the end of a cylindrical casing 521 that is fixed to the above unit holder 51 and extends substantially in a horizontal direction. The nozzle 522 will be described with
30 reference to Fig. 5.

The nozzle 522 shown in Fig. 5 consists of a nozzle body 522a, a passage 522b formed in the nozzle body 522a and a jet hole 522c which communicates with the passage 522b, is open to the under surface and has a diameter of 30 to 100

μm. The thus constituted nozzle 522 is provided with a processing water introduction passage 522d communicating with the passage 522b in the upper portion of the nozzle body 522a and a cleaning water introduction passage 522e communicating with the passage 522b in the intermediate portion of the nozzle body 522a. The processing water introduction passage 522d is connected to a processing water supply means 6 which will be described later and the cleaning water introduction passage 522e is connected to a cleaning water supply means 7 which will be described later.

A processing water supply means 6 and a cleaning water supply means 7 will be described with reference to Fig. 1.

The processing water supply means 6 shown in Fig. 1 comprises a processing water tank 61 and a high-pressure water producing means 62. The processing water tank 61 contains processing water which is a mixture of water and fine abrasive grains such as silica, garnet or the like, and is connected to the high-pressure water producing means 62 by a flexible pipe 63. The high-pressure water producing means 62 increases the pressure of processing water to 300 to 500 MPa. The processing water whose pressure has been increased by the high-pressure water producing means 62 is supplied to the processing water introduction passage 522d of the nozzle 522 through a passage (not shown) installed in the cylindrical casing 521.

The cleaning water supply means 7 shown in Fig. 1 comprises a cleaning water tank 71 and a pressure pump 72. The cleaning water tank 71 contains water for cleaning the nozzle 522 and is connected to the pressure pump 72 by a flexible pipe 73. Water supplied by the pressure pump 72 is fed to the cleaning water introduction passage 522e of the nozzle 522 through a flexible pipe 74 and a pipe 75. A check valve 76 for cutting off the flow from the cleaning water introduction passage 522e to the pipe 75 is provided between

the cleaning water introduction passage 522e and the pipe 75.

An imaging means 8 is mounted to the front end portion of the casing 521 constituting the above water jet spouting unit 52. This imaging means 8 is constituted by a microscope
5 or CCD camera for imaging streets or the like that have been formed in the workpiece such as a CSP substrate, and sends an obtained image signal to a control means that is not shown.

The water jet processing machine in the illustrated
10 embodiment is constituted as described above, and its cutting operation will be described with reference to mainly Fig. 1.

When the base table 36 constituting the workpiece holding means 3 is brought to a position shown in Fig. 1,
15 the holding tray 12 of the detachable table 10 is suction-held on the base table 36 as described above and the workpiece 100 is suction-held on the support surface 11a of the absorbing member 11. Thereafter, the base table 36 and the detachable table 10 are moved along the guide rails 31 and
20 31 by the operation of the first moving means 37 and positioned right below the imaging means 8.

When the base table 36 and the detachable table 10 are positioned right below the imaging means 58 as described above, image processing such as pattern matching or the like
25 for aligning a street formed in the workpiece 100 held on the detachable table 10 with the nozzle 522 of the water jet spouting unit 5 for spouting a water jet along the street is carried out by the imaging means 8 and the control means that is not shown. The alignment of the water jet spouting
30 position is thus carried out.

After the above alignment has been carried out, the base table 36 and the detachable table 10 are moved to a cutting area where the nozzle 522 of the water jet spouting unit 5 is located, and the high-pressure water producing

means 62 of the processing water supply means 6 is activated to spout a water jet of high-pressure processing water from the jet hole 522c of the nozzle 522 along the street detected as described above in the workpiece 100 in the cutting area, to cut the workpiece 100 along the street. Although a water jet penetrates the workpiece 100 in this cutting operation, the water jet after cutting is received by the absorbing member 11 of the detachable table 10 to reduce its power. Since the absorbing member 11 is gradually damaged by the function of this water jet, it is exchanged with a new one after it is used a predetermined number of times. Water whose power has been reduced after the cutting operation falls from the bellows means 391 and 392 and runs into the frame-like drainage gutter means 393.

After the workpiece is cut along the predetermined street as described above, the base table 36 and the detachable table 10 are moved by the interval between streets in the indexing direction shown by the arrow Y, and the above cutting operation is carried out. The base table 36 and the detachable table 10 are moved in the indexing direction by the second moving means 38 of the workpiece holding means 3. This indexing operation may be performed by the third moving means 43 of the water jet spouting unit supporting mechanism 4 but this affects the high-pressure water producing means 62. Therefore, the base table 36 is preferably moved. When the cutting operation and the indexing operation are carried out for all the streets extending in the predetermined direction, the base table 36 and the detachable table 10 are turned at 90°, and the above cutting operation and indexing operation are carried out along the streets extending in a direction perpendicular to the above predetermined direction to thereby divide the workpiece 100 held on the detachable table 10 into individual chips.

After the workpiece 100 is thus divided into individual chips, the operation of the high-pressure water producing means 62 is suspended to stop the spouting of processing water from the hole 522c of the nozzle 522. The detachable table 10 holding the workpiece 100 and the base table 36 are returned to the position shown in Fig. 1 where communication between the detachable table 10 and the suction source is cut off. As a result, the suction holding of the detachable table 10 to the base table 36 is canceled. Since the check valve 123 is provided in the communication hole 121b formed in the bottom wall 121 of the holding tray 12 of the detachable table 10, even when communication between the detachable table 10 and the suction source is cut off, the suction chamber 120 is kept in a negative pressure state. As a result, the suction holding of the workpiece 100 to the detachable table 10 is maintained. Although the workpiece 100 is divided into individual chips at this point, the plurality of suction holes 11b are formed in the absorbing member 11 at positions corresponding to the individual chips into which the workpiece has been divided on the support surface 11a, whereby the individual chips are kept suction-held. Therefore, the individual chips into which the workpiece 100 has been divided can be carried to a predetermined position while they are suction-held on the detachable table 10. To remove the chips carried while they are suction-held on the detachable table 10, the working rod 124 built in the holding tray 12 is pushed to open the check valve 123 so that the inside pressure of the suction chamber 120 becomes atmospheric pressure to cancel the suction holding of the chips.

When the processing work is over as described above, the pressure pump 72 of the cleaning water supply means 7 is activated to introduce cleaning water into the cleaning water introduction passage 522e of the nozzle 522 at a

pressure of 1 to 10 MPa. As a result, the processing water containing abrasive grains which remains in the passage 522b of the nozzle 522 when the above processing work is over is discharged together with cleaning water through the hole 522c and also returned to the high-pressure water producing means 62 by the pressure of cleaning water. Therefore, as only cleaning water remains in the nozzle 522, the abrasive grains contained in the processing water do not settle out and do not occlude the hole 522c even when the operation of the water jet processing machine is suspended and this suspended state is maintained. In the illustrated embodiment, cleaning water is directly introduced into the nozzle 522. Cleaning water may be introduced into the channel from the high-pressure water producing means 62 to the processing water supply passage 522d.

The water jet processing machine of the present invention is constituted as described above. The water jet processing machine which comprises a nozzle for spouting a water jet to a workpiece held on a workpiece holding means and processing water supply means for supplying high-pressure processing water containing abrasive grains to the nozzle is provided with cleaning water supply means for supplying cleaning water to the nozzle. Therefore, cleaning water is introduced into the nozzle by activating the cleaning water supply means after processing work to discharge processing water containing abrasive grains which remains in the nozzle after the processing work is over together with the cleaning water. Accordingly, only cleaning water remains in the nozzle, thereby preventing the abrasive grains contained in the processing water from settling out and occluding the hole even when the operation of the water jet processing machine is suspended and this suspended state is maintained.

Claim

1. A water jet processing machine comprising a workpiece holding means for holding a workpiece, a nozzle for spouting
5 a water jet to the workpiece held on the workpiece holding means, and processing water supply means for supplying high-pressure processing water containing abrasive grains to the nozzle, wherein
the machine is provided with cleaning water supply
10 means for supplying cleaning water to the nozzle.