

DESCRIPTION
WATER JET PROCESSING MACHINE

Field of the Invention

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

Description of the Related Art

10 In the production process of a semiconductor device, semiconductor chips are produced by forming a circuit such as IC , LSI or the like in a large number of areas disposed in a lattice form on the surface of a substantially disk-like semiconductor wafer and then dicing the semiconductor wafer
15 into the areas having 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 called "chip size package (CSP)" which can reduce the size of a semiconductor chip package have been developed. As one of the CPS technologies, a
25 packaging technology called "Quad Flat Non-lead Package (QFN)" has been employed practically. In this packaging technology called "QFN", a CPS substrate is first formed by arranging a plurality of semiconductor chips in a matrix form on a metal plate such as a copper plate, on which a plurality
30 of connection terminals corresponding to the connection terminals of the semiconductor chips are formed and streets for sectioning semiconductor chips arranged in a lattice form are formed, and by integrating the metal plate with the semiconductor chips by a resin portion molded from the back

side of each semiconductor chip. This CSP substrate is cut, along the streets, to be divided into individually packaged chip size packages (CSP).

The above CSP substrate is generally cut by using a precision cutting machine called "dicing machine". This dicing machine comprises a cutting blade having annular abrasive grain layers and cuts the CSP substrate along the streets by relatively moving this cutting blade along the streets formed in the CSP substrate while rotating the cutting blade, thereby dividing it into individual CSP's. When the CPS substrate is cut with the cutting blade, however, a problem occurs that burrs are produced on the connection terminals to cause a short circuit between adjacent connection terminals, whereby the quality and reliability of a chip size package (CSP) are reduced.

Further, when a workpiece such as a semiconductor wafer or the like is cut with the cutting blade like the CSP substrate, a problem also occurs that fine cuttings are adhered to the surface of the workpiece with the result of the contamination of the workpiece.

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

Meanwhile, a pressure-increasing unit for increasing the pressure of processing water comprises a cylinder having a large-diameter piston chamber and a small-diameter plunger chamber, a piston disposed in the piston chamber, and a plunger connected to the piston and put in the plunger chamber. When processing water is introduced into the plunger chamber and hydraulic pressure is introduced into the piston chamber,

it is so constituted that the processing water has an increased pressure due to a difference in the pressure receiving area between the piston and the plunger. In the pressure-increasing unit constituted as described above, there exists a difference in pressure between the piston chamber and the plunger chamber, which corresponds to the difference in the above pressure receiving areas. Therefore, processing water enters the piston chamber from the plunger chamber having a higher pressure than the piston chamber. Since processing water contains fine abrasive grains, the abrasive grains become the cause of wearing away the wall of the plunger chamber and the plunger quickly. Consequently, the maintenance of the pressure unit must be carried out frequently, thereby boosting the running cost.

Summary of the Invention

It is an object of the present invention to provide a water jet processing machine which comprises a processing water supply means capable of reducing abrasion due to abrasive grains contained in processing water.

According to the present invention, the above object can be attained by a water jet processing machine comprising a workpiece holding means for holding a workpiece, a nozzle for spurting a water jet to the workpiece held by the workpiece holding means, and a processing water supply means for supplying processing water containing abrasive grains to the nozzle, wherein

the processing water supply means comprises a high-pressure water generating means and a processing water delivery means for delivering processing water to the nozzle by high-pressure water from the high-pressure water generating means;

the processing water delivery means comprises a cylinder and a partition member which partitions the inside

of the cylinder into a first chamber and a second chamber and can be moved by the pressures of the both chambers;

the first chamber is communicated with the high-pressure water generating means and with a draining means
5 for properly discharging high-pressure water of the first chamber; and

the second chamber is communicated with a processing water storage means for storing processing water and is communicated with the nozzle.

10 The above draining means comprises a suction means for sucking high-pressure water supplied into the first chamber of the cylinder. The above processing water storage means comprises a pressuring means for pressurizing processing water. The water jet processing machine has a plurality of
15 the processing water delivery means, and the plurality of the processing water delivery means are operated alternately.

Brief Description of the Drawings

20 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 an absorbing member and a holding tray that constitute a detachable table
25 used in the water jet processing machine shown in Fig. 1;

Fig. 3 is a perspective view of a 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
30 table shown in Fig. 3 is held on a base table;

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

Fig. 6 is a fluid circuit diagram of a processing water

supply means provided in the water jet processing machine shown in Fig. 1.

Detailed Description of the Preferred Embodiments

5 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.

10 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 stationary base 2 in such a manner that it can move in a
15 cut-feeding direction shown by an arrow X, a water jet spurting unit supporting mechanism 4 mounted on the stationary base 2 in such a manner that it can move in an indexing direction shown by an arrow Y perpendicular to the direction shown by the arrow X, and a water jet spurting unit
20 5 which is disposed to the water jet spurting 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 comprises a pair of guide rails 31 and 31 arranged parallel to each other on
25 the stationary base 2 in the direction shown by the arrow X, a first sliding block 32 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 33 disposed on the first sliding block 32 in such a manner that it can move
30 in the direction shown by the arrow Y, a support table 35 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 340 which is inserted through the cylindrical member 34, and is so constituted as to be

turned on a plane perpendicular to the direction of a water jet spurting from the nozzle to be described later of the water jet spurting unit 5, that is, within the horizontal plane, by a pulse motor (not shown) installed in the cylindrical member 34. A detachable table for positioning a workpiece detachably is placed and held on this base table 36. The base table 36 and the detachable table will be described with reference to Fig. 2 and Fig. 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 consisting 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. A suction hole 362a and a communication hole 362b both of which communicate with the negative pressure chamber 360 and are open to the top surface as a placing surface are formed in the top wall 362 constituting the base table 36. The suction hole 362a is formed in the center portion and the communication hole 362b is formed on the right side of the suction hole 362a in Fig. 4.

As shown in Fig. 2, 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. In the illustrated embodiment, the absorbing member 11 is formed from urethane, and the top surface thereof serves as a support face 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 ceramic such as alumina or the like, besides a resin such as urethane or the like. A plurality of suction holes 11b extending from the support face 11a as the top surface to the under surface are formed in the absorbing member 11. The suction holes 11b are formed at positions corresponding to individual chips into which the workpiece on the support face 11a is divided.

As shown in Fig. 2, the holding tray 12 constituting the detachable table 10 consists of a rectangular parallelepiped bottom wall 121 and a frame-like side wall 122 projecting upward from the periphery of the bottom wall 121, and is open at the top. The holding tray 12 is made of 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 surface of the bottom wall 121 constituting the holding tray 12. A communication hole 121b is formed in the bottom wall 121 constituting the holding tray 12 at a position corresponding to the communication hole 362b formed in the top wall 362 constituting the base table 36. A check valve 123 is installed in the communication hole 121b as shown in Fig. 4. This check valve 123 allows circulation when the negative pressure of the negative pressure chamber 360 side of the base table 36 is larger but cuts off circulation when the negative pressure in the holding tray 12 is larger. That is, the check valve 123 allows the inflow of negative pressure into the holding tray

12 but cuts off an outflow of negative pressure from the holding tray 12. For the check valve 123, an operating rod 124 for releasing the function of the check valve 123 is installed in the bottom wall 121 constituting the holding tray 12. As shown in Fig. 3 and Fig. 4, the lower portion of the above absorbing member 11 is fitted in the holding tray 12 constituted as described above from the top open side. In this fitting 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, as shown in Fig. 4, 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 a result, the plurality of suction holes 11b formed in the absorbing member 11 are communicated with the suction chamber 120.

The detachable table 10 constituted as described above, the workpiece 100 such as a CSP substrate places on the support face 11a which is the top surface of the absorbing member 11 and is placed on the top surface which will become the placing surface of the base table 36 as shown in Fig. 4. When the detachable table 10 supporting the workpiece 100 on the support face 11a of the absorbing member 11 is thus placed on the base table 36 and when 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

to the suction source as described above, 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

5 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, the above first sliding block 32

10 is provided with a pair of guided 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 constituted first sliding block 32

15 constituted as described above can be moved in the direction shown by the arrow X along the pair of guide rails 31 and 31 by fitting the guided grooves 321 and 321 to the pair of guide rails 31 and 31. The workpiece holding means 3 in the illustrated embodiment has a first moving means 37 for moving

20 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 above pair of guide rails 31 and 31 in parallel to these guide rails and a drive source such as a pulse motor 372 for

25 rotationally 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 above 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 not shown. The male

30 screw rod 371 is screwed into an internally threaded screw through hole formed in a female screw block (not shown) projecting from the under surface of the center portion of the first sliding block 32. Therefore, by turning the male screw rod 371 in a normal direction or reverse direction by

the pulse motor 372, the first sliding block 32 is moved along the guide rails 31 and 31 in the direction shown by the arrow X within a plane perpendicular to the direction of a water jet spurted from the nozzle, which will be described later, of the water jet spurting unit 5, that is, within the horizontal plane.

The above second sliding block 33 is provided with a pair of guided 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 in the direction shown by the arrow Y by fitting the pair of guide rails 322 and 322 to the guided grooves 331 and 331. The workpiece holding means 3 in the illustrated embodiment has a second moving means 38 for moving the second sliding 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 above pair of guide rails 322 and 322 in parallel to these guide rails and a drive source such as a pulse motor 382 for rotationally 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 the above pulse motor 382 through a speed reducer that is not shown. The male screw rod 381 is screwed into an internally threaded screw 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, 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 that is perpendicular to the direction shown by the arrow X.

Bellows means 391 and 392 are provided on both sides in the direction shown by the arrow X of the above support table 35 to cover the constituent members excluding the base table 36 constituting the workpiece holding means 3 therewith.

5 Opposing end portions of the bellows means 391 and 392 are respectively attached to the support table 35. Both end portions of the bellows means 391 and 392 are attached to the inner end walls 393a and 393b of a frame-like drainage gutter means 393 that is arranged on the stationary base 2

10 and surrounds the above workpiece holding means 3.

The above water jet spurting unit supporting mechanism 4 has a pair of guide rails 41 and 41 arranged parallel to each other on the stationary base 2 in the indexing direction shown by the arrow Y and a movable support base 42 mounted

15 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 disposed on the guide rails 41 and 41 and a mounting portion 422 attached to the movable support portion 421. The

20 mounting portion 422 is provided with a pair of guide rails 422a and 422a that are arranged parallel to each other and extend in the direction shown by the arrow Z on one side face. The water jet spurting unit supporting mechanism 4 in the

25 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 guide rails 41 and 41 and in parallel to these guide rails and a drive source such as a

30 pulse motor 432 for rotationally 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 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 screw hole formed in a female screw block (not shown) projecting from the under surface of the center portion of the movable support portion 421
5 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 shown by the arrow Y.

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

The above water jet application 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 horizontally direction. The nozzle 522 will be described

with reference to Fig. 5.

The nozzle 522 shown in Fig. 5 comprises a nozzle body 522a, a passage 522b formed in the nozzle body 522a and an spurting hole 522c having a diameter of 30 to 100 μm , which
5 communicates with the passage 522b and is open to the under surface. 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
10 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 hereinafter, and the cleaning water introduction passage 522e is connected to a
15 cleaning water supply means 7 which will be described hereinafter.

A description is subsequently given of the processing water supply means 6 and the cleaning water supply means 7 with reference to Fig. 6.

20 The processing water supply means 6 shown in Fig. 6 comprises a water tank 61, a high-pressure water generating means 62, a processing water storage means 63 and a processing water delivery means 64. The water tank 61 contains freshwater such as tapped water or pure water. The high-
25 pressure water generating means 62 increase the pressure of water supplied from the water tank 61 to 300 to 500 MPa and supplies it to the processing water delivery means 64.

The above processing water storage means 63 comprises a processing water storage tank 631 and a pressuring means
30 632 for pressurizing processing water stored in the processing water storage tank 631. The processing water storage tank 631 contains processing water that is a mixture of water and fine abrasive grains such as silica, garnet or the like. The pressuring means 632 comprises an air pump 633,

a pressure pipe 634 for communicating the air pump 633 with an air introduction port formed in the top wall of the above processing water storage tank 631, and an electromagnetic changeover valve 635 disposed in the pressure pipe 634.

5 The above processing water delivery means 64 has a first processing water delivery means 64a and a second processing water delivery means 64b in the illustrated embodiment. The first processing water delivery means 64a comprises a first cylinder 641a and a first piston 644a that is slidably
10 arranged in the first cylinder 641a and partitions the inside of the first cylinder 641a into a first chamber 642a and a second chamber 643a. The second processing water delivery means 64b comprises a second cylinder 641b and a second piston 644b that is slidably arranged in the second cylinder 641b
15 and partitions the inside of the second cylinder 641b into a first chamber 642b and a second chamber 643b. A diaphragm may be used to partition the inside of the cylinder into a first chamber and a second chamber in place of the first piston 644a and the second piston 644b. That is, the piston or
20 diagram for partitioning the inside of the cylinder into the first chamber and the second chamber functions as a partition member which partitions the inside of the cylinder into the first chamber and the second chamber and can be moved by the pressures of the both chambers.

25 The first chambers 642a and 642b of the first cylinder 641a and the second cylinder 641b constituting the first processing water delivery means 64a and the second processing water delivery means 64b are communicated with the above high-pressure water generating means 62 via high-pressure
30 pipes 651a and 651b, respectively. The high-pressure pipes 651a and 651b are provided with electromagnetic changeover valves 661a and 661b, respectively. The first chambers 642a and 642b of the first cylinder 641a and the second cylinder 641b are communicated with a draining means 67. This

draining means 67 comprises a vacuum pump 671 as a suction means, drain pipes 672a and 672b for communicating the vacuum pump 671 to the first chambers 642a and 642b, respectively, and electromagnetic changeover valves 673a and 673b
5 installed in the drain pipes 672a and 672b, respectively.

The second chambers 643a and 643b of the first cylinder 641a and the second cylinder 641b constituting the first processing water delivery means 64a and the second processing water delivery means 64b are communicated with the above
10 processing water storage tank 631 via introduction pipes 652a and 652b, respectively. The introduction pipes 652a and 652b are provided with electromagnetic changeover valves 662a and 662b, respectively. The second chambers 643a and 643b of the first cylinder 641a and the second cylinder 641b are
15 communicated with the processing water introduction passage 522d of the above nozzle 522 via delivery pipes 653a and 653b, respectively. The delivery pipes 653a and 653b are provided with electromagnetic changeover valves 663a and 663b, respectively.

20 A description is subsequently given of the cleaning water supply means 7.

The cleaning water supply means 7 shown in Fig. 6 comprises a cleaning pipe 71 for communicating the above high-pressure pipe 651a to the cleaning water introduction
25 passage 522e of the nozzle 522 and an electromagnetic changeover valve 72 provided in the cleaning pipe 71. When the electromagnetic changeover valve 72 is turned on, high-pressure water generated by the high-pressure water generating means 62 is introduced into the nozzle 522 through
30 the cleaning pipe 71.

The processing water supply means 6 and the cleaning water supply means 7 shown in Fig. 6 are constituted as described above, and their functions will be described hereinbelow.

At the start of the operation of the processing water supply means 6, the high-pressure water generating means 62, the vacuum pump 671 and the air pump 633 are activated and all the electromagnetic changeover valves are turned off as shown in Fig. 6. To activate the first processing water delivery means 64a from the state shown in Fig. 6, the electromagnetic changeover valve 673a of the draining means 67 is turned on and also the electromagnetic changeover valve 662a is turned on. As a result, high-pressure water in the first chamber 642a of the first cylinder 641a is sucked by the vacuum pump 671 through the drain pipe 672a and the electromagnetic changeover valve 673a and also processing water in the processing water storage tank 631 is introduced into the second chamber 643a of the first cylinder 641a through the introduction pipe 652a and the electromagnetic changeover valve 662a to move upward the first piston 644a in Fig. 6. When the first piston 644a is moved to an upper position shown by a two-dot chain line in Fig. 6, the above electromagnetic changeover valve 673a and the electromagnetic changeover valve 662a are turned off. Then, the electromagnetic changeover valve 663a is turned on and also the electromagnetic changeover valve 661a is turned on. Thereby, high-pressure water generated by the high-pressure water generating means 62 is introduced into the first chamber 642a of the first cylinder 641a through the high-pressure pipe 651a and the electromagnetic changeover valve 661a to press the first piston 644a so as to move it downward in Fig. 6. As a result, processing water in the second chamber 643a of the first cylinder 641a is introduced into the nozzle 522 through the delivery pipe 653a and the electromagnetic changeover valve 663a and spurted as a water jet from the spurting hole 522c. When the first piston 644a of the first cylinder 641a reaches a lower position shown by a solid line in Fig. 6, the electromagnetic changeover

valve 661a is turned off and also the electromagnetic changeover valve 663a is turned off to return to the state shown in Fig. 6.

A description is subsequently given of the operation
5 of the second processing water delivery means 64b.

The state shown in Fig. 6 is a state of the second piston 644b constituting the second processing water delivery means 64b moving to an upper position shown by a solid line and processing water being introduced into the second chamber 643b of the second cylinder 641b. When the electromagnetic changeover valve 663b is turned on and the electromagnetic changeover valve 661b is turned on from this state,
10 high-pressure water generated by the high-pressure water generating means 62 is introduced into the first chamber 642b of the second cylinder 641b through the high-pressure pipe 651b and the electromagnetic changeover valve 661b to press the piston 644b so as to move it downward in Fig. 6. As a result, processing water in the second chamber 643b of the second cylinder 641b is introduced into the nozzle 522
15 through the delivery pipe 653b and the electromagnetic changeover valve 663b and spurted as a water jet from the spurting hole 522c. When the second piston 644b of the second cylinder 641b reaches a lower position shown by a two-dot chain line in Fig. 6, the electromagnetic changeover valve 661b is turned off and also the electromagnetic changeover valve 663b is turned off. Then, when the electromagnetic changeover valve 673b is turned on and the electromagnetic changeover valve 662b is turned on, high-pressure water in the first chamber 642b of the second cylinder 641b is sucked
20 by the vacuum pump 671 through the drain pipe 672b and the electromagnetic changeover valve 673b and processing water in the processing water storage tank 631 is introduced into the second chamber 643b of the second cylinder 641b through the introduction pipe 652b and the electromagnetic
25
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changeover valve 662b to move upward the piston 644b in Fig. 6 and return to the state shown in Fig. 6.

By activating the above first processing water delivery means 64a and the second processing water delivery means 64b alternately, processing water can be spurted continuously from the spurting hole 522c of the nozzle 522. While the first processing water delivery means 64a and the second processing water delivery means 64b for delivering processing water to the nozzle 522 are in operation, the pressure in the first chamber 642a and the second chamber 643a of the first cylinder 641a is nearly the same as that in the first chamber 642b and the second chamber 643b of the second cylinder 641b and hence, no difference in pressure occurs therebetween. Accordingly, processing water in the second chamber 643a and the second chamber 643b does not enter the first chamber 642a and the first chamber 642b, respectively. Therefore, wear of the walls of the first cylinder 641a and the second cylinder 641b and wear of the first piston 644a and the second piston 644b caused by abrasive grains contained in processing water are reduced.

In the illustrated embodiment, the draining means 67 is provided with the vacuum pump 671 as a suction means and the pressuring means 632 for pressurizing processing water contained in the processing water storage tank 631 is provided. Either one of the vacuum pump 671 and the pressuring means 632 may suffice. For example, when the vacuum pump 671 is equipped and not the pressuring means 632, the processing water storage tank 631 is made open to the air. In this case, the electromagnetic changeover valves 662a and 662b provided in the introduction pipes 652a and 652b for communicating the processing water storage tank 631 to the second chamber 643a of the first cylinder 641a and to the second chamber 643b of the second cylinder 641b may be a check valve which allows circulation from the processing

water storage tank 631 side to the first cylinder 641a side and to the second cylinder 641b side and cuts off circulation in the opposite direction. On the other hand, when the pressuring means 632 is provided and not the vacuum pump 671, the vacuum pump 671 sides from the electromagnetic changeover valves 673a and 673b in the drain pipes 672a and 672b are made open to the air.

A description is subsequently given of the operation of the cleaning water supply means 7 with reference to Fig. 6.

In the state where the water jet operation by the processing water supply means 6 is completed as described above, all the above electromagnetic changeover valves are turned off. When the electromagnetic changeover valve 72 is turned on, high-pressure water generated by the high-pressure water generating means 62 is introduced into the cleaning water introduction passage 522e of the nozzle 522 through the cleaning pipe 71 and the electromagnetic changeover valve 72. As a result, processing water containing abrasive grains, which remains in the passage 522b of the nozzle 522 at the end of the above water jet operation is discharged from the injection hole 522c together with high-pressure water and pushed back toward the delivery pipes 653a and 653b sides by the pressure of the high-pressure water. It is desired that the electromagnetic changeover valves 663a and 663b be turned on at the time when high-pressure water is introduced into the nozzle 522, whereby most of the processing water containing abrasive grains remaining in the passage 522b of the nozzle 522 can be returned to the first cylinder 641a and the second cylinder 641b sides. When the introduction of high-pressure water into the nozzle is stopped, the electromagnetic changeover valves 663a and 663b are turned off. Consequently, as only freshwater remains in the nozzle 322, abrasive grains contained in processing water

will not be precipitated and will not block the spurting hole 522c even if the operation of the water jet processing machine is kept in a suspended state.

The cleaning water supply means 7 in the illustrated embodiment introduces high-pressure water generated by the high-pressure water generating means 62 into the nozzle 522. Another cleaning water supply means for introducing cleaning water into the nozzle 522 may be provided separately. In this case, a water supply pump for supplying cleaning water may deliver cleaning water at a pressure of about 1 to 10 MPa.

Returning to Fig. 1, an imaging means 8 is mounted to the front end portion of the casing 521 constituting the above water jet application means 52. This imaging means 8 is constituted by a microscope or CCD camera for imaging streets or the like formed in the workpiece such as a CSP substrate and sending the obtained image signal to a control means that is not shown.

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

In the state of the base table 36 constituting the workpiece holding means 3 being brought to a position shown in Fig. 1, 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. Then, the base table 36 and the detachable table 10 are moved along the guide rails 31 and 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 8 as described above, image processing such as pattern matching or the like, for aligning streets formed in the workpiece 100 held on the

detachable table 10 with the nozzle 522 of the water jet
spurting unit 5 for spurting a water jet along the street
is carried out by means of the imaging means 8 and the control
means that is not shown. The alignment of the water jet
5 spurting position is thus carried out.

After the alignment has been carried out as described
above, the base table 36 and the detachable table 10 are moved
to a cutting area where the nozzle 522 of the water jet
spurting unit 5 is located, and the processing water supply
10 means 6 is operated, as described above, to spurt high-
pressure processing water as a water jet from the sputing
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. During this cutting
15 operation, the water jet penetrates the workpiece 100 and
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 and hence, it is exchanged with a new one after it is
20 used a predetermined number of times. Water whose power has
been reduced after cutting operation falls from the bellows
means 391 and 392 and flows into the frame-like drainage
gutter means 393.

After the workpiece 100 is cut along the predetermined
25 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 to further
carry out the above cutting operation. The base table 36 and
the detachable table 10 are moved in the indexing direction
30 by the second moving means 38 constituting the workpiece
holding means 3. This indexing operation may be carried out
by the third moving means 43 constituting the water jet
spurting unit supporting mechanism 4, but since this affects
the high-pressure water generating means 62, 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 above predetermined direction, the base table 36 and the detachable 10 are turned at 90° to carry out the above cutting operation and moving operation in the indexing direction along the streets extending perpendicular to the above predetermined direction, whereby the workpiece 100 held on the detachable table 10 is divided into individual chips.

When the workpiece 100 is thus divided into individual chips, the detachable table 10 holding the workpiece 100 and the base table 36 are returned to the position shown in Fig. 1 where the communication between the detachable table 10 and the suction source are then cut off. As a result, the suction-holding of the detachable table 10 on the base table 36 is canceled. On the other hand, since the check valve 123 is provided in the communication hole 121b formed in the bottom wall 121 of the holding tray 12 constituting the detachable table 10, even when a communication with 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 on the detachable table 10 is maintained. Although the workpiece 100 is divided into individual chips at this point, as the plurality of suction holes 11b are formed in the absorbing member 11 at positions corresponding to the respective individual chips into which the workpiece 100 has been divided on the support surface 11a, the suction-holding of the chips is maintained. Therefore, the individual chips into which the workpiece 100 has been divided can be carried to a predetermined site while they are suction-held on the detachable table 10. To take off the chips which are carried in the state of being suction-held on the detachable table 10, the check valve 123 is opened by pushing the operating rod 124 in the holding

tray 12 so as to make the inside pressure of the suction chamber 120 equal to the atmospheric pressure, thereby canceling the suction-holding of the chips.

When the processing operation is completed as
5 described above, the cleaning water supply means 7 is operated as described above to introduce high-pressure water generated by the high-pressure water generating means 62 into the nozzle 522, let processing water containing abrasive
10 grains remaining in the nozzle 522 through the spurting hole 522c to be discharged together with high-pressure water and also push it back toward the delivery pipes 653a and 653b by the pressure of high-pressure water.

Since the water jet processing machine of the present invention is constituted as described above, and as the
15 pressure in the first chamber is nearly the same as that of the second chamber in the cylinders and no difference in pressure occurs therebetween during the operation of the processing water delivery means for delivering processing water to the nozzle, processing water in the second chamber
20 does not enter the first chamber. Therefore, the wear of the wall of the cylinder and the partition member due to the abrasive grains contained in processing water is reduced, thereby making it possible to reduce the maintenance cost.

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What is claimed is:

1. A water jet processing machine comprising a workpiece holding means for holding a workpiece, a nozzle for spurting a water jet to the workpiece held by the workpiece holding means, and a processing water supply means for supplying processing water containing abrasive grains to the nozzle, wherein

the processing water supply means comprises a high-pressure water generating means and a processing water delivery means for delivering processing water to the nozzle by high-pressure water from the high-pressure water generating means;

the processing water delivery means comprises a cylinder and a partition member which partitions the inside of the cylinder into a first chamber and a second chamber and can be moved by the pressures of the both chambers;

the first chamber is communicated with the high-pressure water generating means and with a draining means for properly discharging high-pressure water of the first chamber; and

the second chamber is communicated with a processing water storage means for storing processing water and is communicated with the nozzle.

2. The water jet processing machine of claim 1, wherein the draining means comprises a suction means for sucking high-pressure water supplied into the first chamber of the cylinder.

3. The water jet processing machine of claim 1, wherein the processing water storage means comprises a pressuring means for pressurizing processing water.

4. The water jet processing machine of any one of claims

1 to 3 which comprises a plurality of the processing water delivery means and the plurality of the processing water delivery means are operated alternately.