

DRESSING TOOL

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a dressing tool for dressing grinding stones of a grinding wheel.

Description of the Related Art

According to one processing method of dividing a wafer having a plurality of devices formed on a face side thereof into chips that include the respective devices, the reverse side of the wafer is ground and then the wafer is cut into the chips by a cutting blade, for example. The wafer is ground on a grinding apparatus having a grinding wheel that includes grinding stones, for example. The wafer is held on a holding table of the grinding apparatus, and the grinding wheel that is rotating is pressed against the surface to be processed of the wafer, thereby grinding the wafer (see, for example, JP 2000-288881A). The grinding stones are formed by mixing abrasive grains of diamond, cubic boron nitride (cBN), or the like with a bonding agent of vitrified, resinoid, or the like and sintering the mixture. When the wafer is ground by the grinding stones, a number of abrasive grains that protrude from the surfaces, i.e.,

grinding surfaces, of the grinding stones act as cutting edges, scraping off the surface to be processed of the wafer.

As the grinding process progresses, the grinding stones are worn, making new abrasive grains appear successively on the surfaces of the grinding stones that are held in contact with the surface to be processed of the wafer. This action, referred to as spontaneous edge resharping, prevents the grinding capability of the grinding wheel from being lowered due to shedding, loading, and dulling of the abrasive grains and realizes good grinding processing. New grinding stones that have not been used have abrasive grains left unprotruded from their surfaces and have their grinding surfaces at various heights. For this reason, before the new grinding stones are used to grind wafers, a dressing process is carried out to dress the grinding stones with a dressing board, also referred to as a dresser board, partly removing the bonding agent that has covered the abrasive grains to allow abrasive grains to protrude appropriately from the surfaces of the grinding stones (see, for example, JP 2009-142906A).

The dressing board is formed to a thickness ranging from approximately 1 mm to 5 mm, for example, with a

support plate of resin fixed to the reverse side thereof by an adhesive or the like. The dressing board is progressively worn as it dresses the grinding stones, and will be replaced when it is thinned to a predetermined thickness. The time when the dressing board is to be replaced is decided by visually checking the thickness of the dressing board, for example.

SUMMARY OF THE INVENTION

However, the visual check may not necessarily be able to properly decide the time when the dressing board is to be replaced. If a dressing board that has been worn to a usage-limit thickness is not replaced but used on grinding stones and the grinding stones happen to grind the support plate fixed to the dressing board, then the grinding stones may possibly be damaged. It is therefore an object of the present invention to provide a dressing tool that is able to indicate whether or not a dressing board thereof has been worn to a usage-limit thickness.

In accordance with an aspect of the present invention, there is provided a dressing tool for dressing a plurality of grinding stones disposed in an annular array on a surface of a grinding wheel, including a dressing part for dressing the grinding stones and a

support part supporting a reverse side of the dressing part, in which the reverse side of the dressing part has a recess defined therein that has a depth terminating short of a face side of the dressing part that is opposite the reverse side thereof and corresponding to a usage-limit thickness of the dressing part.

Preferably, the recess of the dressing part may be of a straight shape in the case where the dressing part is viewed from the reverse side thereof. Preferably, the recess of the dressing part may be disposed radially outwardly of a center of the dressing part in the case where the dressing part is viewed from the reverse side thereof.

Preferably, the recess of the dressing part may be of an annular shape in the case where the dressing part is viewed from the reverse side thereof. Preferably, the recess of the dressing part may include a first recess having a first depth and a second recess having a second depth larger than the first depth. Preferably, the first recess and the second recess may overlap each other in depthwise directions thereof.

According to the aspect of the present invention, the dressing tool includes the dressing part (dressing board) for dressing the grinding stones and the support

part (support plate) supporting the reverse side of the dressing part. The reverse side of the dressing part has the recess defined therein that has the depth terminating short of the face side of the dressing part and corresponding to the usage-limit thickness of the dressing part. When the dressing part is progressively worn as it dresses the grinding stones and thinned to a predetermined thickness, i.e., a usage-limit thickness, the recess appears on the face side of the dressing part. Therefore, it can be decided through a visual check that the dressing part has been worn to the usage-limit thickness, and the time when the dressing tool has reached a usage limit can be decided properly.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view of a dressing tool according to a first embodiment of the present invention;

FIG. 1B is a cross-sectional view taken along line A - A of FIG. 1A, illustrating the dressing tool according to the first embodiment;

FIG. 2 is a side elevational view illustrating the manner in which the dressing tool according to the first embodiment is used;

FIG. 3 is a cross-sectional view taken along line A - A of FIG. 1A, illustrating the dressing tool according to the first embodiment that has reached a usage limit;

FIG. 4A is a perspective view of a dressing tool according to a second embodiment of the present invention;

FIG. 4B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating the dressing tool according to the second embodiment;

FIG. 5A is a perspective view of a dressing tool according to a third embodiment of the present invention;

FIG. 5B is a cross-sectional view taken along line C - C of FIG. 5A, illustrating the dressing tool according to the third embodiment;

FIG. 6A is a perspective view of a dressing tool according to a fourth embodiment of the present invention;

FIG. 6B is a cross-sectional view taken along line

D - D of FIG. 6A, illustrating the dressing tool according to the fourth embodiment;

FIG. 7A is a cross-sectional view taken along line A - A of FIG. 1A, illustrating a dressing tool according to a first modification of the first embodiment;

FIG. 7B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating a dressing tool according to a first modification of the second embodiment;

FIG. 7C is a cross-sectional view taken along line C - C of FIG. 5A, illustrating a dressing tool according to a first modification of the third embodiment;

FIG. 7D is a cross-sectional view taken along line D - D of FIG. 6A, illustrating a dressing tool according to a first modification of the fourth embodiment;

FIG. 8A is a cross-sectional view taken along line A - A of FIG. 1A, illustrating a dressing tool according to a second modification of the first embodiment;

FIG. 8B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating a dressing tool according to a second modification of the second embodiment;

FIG. 8C is a cross-sectional view taken along line C - C of FIG. 5A, illustrating a dressing tool according to a second modification of the third embodiment; and

FIG. 8D is a cross-sectional view taken along line

D - D of FIG. 6A, illustrating a dressing tool according to a second modification of the fourth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Preferred embodiments of the present invention will hereinafter be described below with reference to the accompanying drawings. FIG. 1A is a perspective view of a dressing tool 2 according to a first embodiment of the present invention. FIG. 1B is a cross-sectional view taken along line A - A of FIG. 1A, illustrating the dressing tool 2 according to the first embodiment. As illustrated in FIG. 1A, the dressing tool 2 according to the first embodiment includes a dressing board, i.e., a dressing part, 4 in the form of a flat disk. The dressing board 4 is not limited to a disk shape, but may be formed as a rectangular plate.

The dressing board 4 has a reverse side 4b to which there is bonded a face side 6a of a support plate, i.e., a support part, 6 supporting the dressing board 4. The support plate 6 is in the form of a disk that is larger in diameter than the dressing board 4 such that the support plate 6 can support the dressing board 4 in its entirety thereon. The support plate 6 is made of resin, for example. The dressing board 4 is made of a mixed

material including abrasive grains such as white alundum (WA), green carbon (GC), or the like mixed with a bonding agent of vitrified, resinoid, or the like. However, the bonding agent and abrasive grains that make up the dressing board 4 may vary depending on the structure or the like of a plurality of grinding stones 26 (see FIG. 2).

The dressing board 4 has a thickness ranging from 3 mm to 5 mm, for example, with a recess 8 defined in the reverse side 4b thereof. The recess 8 is a generally cylindrically shaped hole defined substantially centrally in the reverse side 4b of the dressing board 4 as illustrated in FIG. 1B. The cross section illustrated in FIG. 1B along line A - A of FIG. 1A is taken along a plane passing through the center of a circular face side 4a, which is opposite the reverse side 4b, of the dressing board 4 and extending perpendicularly to the face side 4a across the dressing board 4 and the support plate 6.

The recess 8 is formed to a predetermined depth extending from the reverse side 4b and terminating short of the face side 4a. The depth of the recess 8 is adjusted such that when the dressing board 4 is worn to a usage-limit thickness, the recess 8 appears on the face

side 4a of the dressing board 4, i.e., the depth of the recess 8 corresponds to the usage-limit thickness of the dressing board 4. For example, if the usage-limit thickness of the dressing board 4 is set to 400 μm , then the depth of the recess 8 is adjusted to 400 μm from the reverse side 4b. However, the usage-limit thickness of the dressing board 4 and the depth of the recess 8 are not limited to 400 μm , but may be any of various values. When the dressing board 4 is progressively worn as it dresses the grinding stones 26 and thinned to the usage-limit thickness, the recess 8 appears on the face side 4a of the dressing board 4. Therefore, the worker who is handling the dressing tool 2 can decide through a visual check whether or not the dressing board 4 has been worn to the usage-limit thickness, and hence can decide the time when the dressing tool 2 has reached a usage limit, appropriately.

The dressing board 4 described above can be manufactured by a manufacturing process similar to the manufacturing process for conventional dressing boards. For example, the mixed material referred to above is shaped into a flat disk-shaped compact. At this time, a hole corresponding to the recess 8 is defined centrally in a surface of the compact. Thereafter, the compact is

sintered into the dressing board 4 having the recess 8. Alternatively, rather than forming a hole corresponding to the recess 8 in the compact, a hole corresponding to the recess 8 may be formed in the sintered body. For example, after the mixed material is shaped into a flat disk-shaped compact, the compact is sintered. Thereafter, the disk-shaped sintered body is cut to form the recess 8 therein. In this manner, the dressing board 4 having the recess 8 can be manufactured.

A dressing process for dressing the grinding stones 26 using the dressing tool 2 according to the first embodiment will be described below. FIG. 2 is a side elevational view illustrating the manner in which the dressing tool 2 according to the first embodiment is used. As illustrated in FIG. 2, a grinding apparatus 12 that is used in the dressing process has a hollow cylindrical spindle housing 16 by which a spindle 14 is rotatably supported. The spindle housing 16 is movably mounted on a support column, not illustrated, of the grinding apparatus 12 by a moving mechanism, not illustrated, and is vertically movable by the moving mechanism. A wheel mount 20 on which a grinding wheel 18 is mounted is fixed to the lower end of the spindle 14.

The spindle 14 has an upper end portion coupled to

a rotating mechanism 22 including an electric motor, etc. A grinding wheel 18 that is mounted on the wheel mount 20 can be rotated about an axis aligned with the axis of the spindle 14 by rotating forces transmitted from the rotating mechanism 22. The grinding wheel 18 includes a hollow cylindrical wheel base 24 made of a metal material such as aluminum, stainless steel, or the like. The wheel base 24 has an annular surface opposite the wheel mount 20. The grinding stones 26 are fixed to the annular surface of the wheel base 24 and arrayed along the circumferential directions thereof. In other words, the grinding stones 26 are disposed in an annular array on the annular surface of the wheel base 24.

The grinding apparatus 12 includes a holding table , i.e., a chuck table, 28 disposed beneath the wheel mount 20. The holding table 28 is coupled to an actuating mechanism, not illustrated, such as an electric motor or the like, and can be rotated about an axis parallel to the axis of the spindle 14 by rotating forces from the actuating mechanism. The holding table 28 has an upper surface 28a acting as a holding surface for holding a workpiece such as a wafer or the like under suction thereon. A vacuum from a suction source, not illustrated, such as an ejector or the like acts on the holding

surface through a fluid channel, not illustrated, defined in the holding table 28, producing suction forces for attracting the workpiece under suction on the holding surface of the holding table 28. For dressing the grinding stones 26 with the dressing board 4, a reverse side 6b of the support plate 6 is held under suction on the holding table 28. The grinding wheel 18 and the holding table 28 are rotated about their own axes, and the spindle housing 16 is lowered. The rate at which the spindle housing 16 is lowered is adjusted to press the grinding stones 26 against the face side 4a of the dressing board 4, thereby dressing the grinding stones 26 with the dressing board 4.

FIG. 3 is a cross-sectional view taken along line A - A of FIG. 1A, illustrating the dressing tool 2 according to the first embodiment that has reached a usage limit. As the dressing board 4 dresses the grinding stones 26, the dressing board 4 is progressively worn and thinned. When the dressing board 4 is worn to a usage-limit thickness, the recess 8 appears on the face side 4a of the dressing board 4. As described above, the depth of the recess 8 of the dressing tool 2 according to the first embodiment corresponds to the usage-limit thickness of the dressing board 4. Consequently, the worker can

decide whether or not the dressing board 4 has been worn to the usage-limit thickness by visually checking whether or not the recess 8 has appeared on the face side 4a of the dressing board 4.

For example, the worker may determine whether or not the recess 8 has appeared on the face side 4a of the dressing board 4 as follows. After the dressing process is finished, the dressing tool 2 is transferred from the holding table 28 to a cassette, not illustrated. The worker then observes the face side 4a of the dressing board 4 while the dressing tool 2 is being kept still in the cassette. The worker thus can determine whether or not the recess 8 has appeared on the face side 4a of the dressing board 4. Alternatively, the worker may observe the face side 4a of the dressing board 4 while the dressing tool 2 is held on the holding table 28 and is rotating therewith, i.e., while in the dressing process. The worker is thus able to determine whether the recess 8 has appeared on the face side 4a of the dressing board 4 by visually checking the dressing board 4 in rotation.

Whether or not the recess 8 has appeared on the face side 4a of the dressing board 4 may not necessarily be determined by the worker, but may be determined in other ways. For example, a determining device including a

camera for capturing an image of the face side 4a and a determining unit such as a central processing unit (CPU) or the like for determining whether or not the recess 8 has appeared on the face side 4a from the image captured by the camera, may be used to automatically determine whether or not the recess 8 has appeared on the face side 4a. The recess 8 may be of any of various shapes. Though the recess 8 defined in the dressing board 4 according to the first embodiment is a generally cylindrically shaped hole, the shape of the recess 8 is not limited to a cylindrical hole.

FIG. 4A is a perspective view of a dressing tool 2 according to a second embodiment of the present invention, and FIG. 4B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating the dressing tool 2 according to the second embodiment. As illustrated in FIGS. 4A and 4B, the dressing tool 2 according to the second embodiment includes a disk-shaped dressing board 4 having a recess 8a defined in a reverse side 4b thereof. The recess 8a is in the form of a straight groove extending longitudinally diametrically across the dressing board 4. Specifically, the recess 8a is of a straight shape extending through the center O of the circular reverse side 4b in the case where the dressing

board 4 is viewed from the reverse side 4b. The recess 8a has a longitudinal length that is substantially the same as the diameter of the circular reverse side 4b. However, the recess 8a may be of a straight shape not extending through the center 0 of the circular reverse side 4b in the case where the dressing board 4 is viewed from the reverse side 4b.

The recess 8a is formed to a predetermined depth extending from the reverse side 4b and terminating short of a face side 4a of the dressing board 4. The depth of the recess 8 is adjusted such that when the dressing board 4 is worn to a usage-limit thickness, the recess 8 appears on the face side 4a of the dressing board 4. According to the second embodiment, therefore, the worker or the like can decide whether or not the dressing board 4 has been worn to the usage-limit thickness on the basis of whether or not the recess 8 has appeared on the face side 4a of the dressing board 4.

Furthermore, as the recess 8a is of a straight shape extending through the center 0, the recess 8a is visible all over the face side 4a when the dressing board 4 is in rotation. Conversely, in the case where the recess 8 has its central position located on the center 0 as is the case with the first embodiment, the recess 8 is

visible as a circular dot on the face side 4a when the dressing board 4 is in rotation. According to the second embodiment, therefore, when the recess 8a appears on the face side 4a while the dressing board 4 is rotating, since the recess 8a can be observed in a wider area than the first embodiment, it is easy to determine whether or not the recess 8b has appeared on the face side 4a compared with the recess 8 according to the first embodiment.

FIG. 5A is a perspective view of a dressing tool 2 according to a third embodiment of the present invention. FIG. 5B is a cross-sectional view taken along line C - C of FIG. 5A, illustrating the dressing tool 2 according to the third embodiment. As illustrated in FIGS. 5A and 5B, the dressing tool 2 according to the third embodiment includes a disk-shaped dressing board 4 having a recess 8b defined in a reverse side 4b thereof. The recess 8b is a generally cylindrically shaped hole located radially outwardly of the center O of the circular reverse side 4b in the case where the dressing board 4 is viewed from the reverse side 4b. The recess 8b according to the third embodiment has its central position located at a distance of $7r/8$ from the center O where r represents the radius of the reverse side 4b. Alternatively, the central

position of the recess 8b in the reverse side 4b may be located radially outwardly of a position that is spaced a distance of $r/2$ from the center 0 or may be located at a distance of $3r/4$ from the center 0.

The recess 8b is formed to a predetermined depth extending from the reverse side 4b and terminating short of a face side 4a of the dressing board 4. The depth of the recess 8b is also adjusted such that when the dressing board 4 is worn to a usage-limit thickness, the recess 8b appears on the face side 4a of the dressing board 4. According to the third embodiment, therefore, it is possible to decide whether or not the dressing board 4 has been worn to the usage-limit thickness on the basis of whether or not the recess 8b has appeared on the face side 4a of the dressing board 4. Moreover, as the central position of the recess 8b is located radially outwardly of the center 0 of the reverse side 4b, the recess 8b is visually recognized as an annular locus on the face side 4a while the dressing board 4 is rotating. Conversely, in the case where the recess 8 has its central position located on the center 0 as is the case with the first embodiment, the recess 8 is visible as a circular dot on the face side 4a when the dressing board 4 is in rotation. According to the third embodiment, therefore, when the

recess 8b appears on the face side 4a while the dressing board 4 is rotating, since the recess 8b can be observed in a wider area than the first embodiment, it is easy to determine whether or not the recess 8b has appeared on the face side 4a compared with the recess 8 according to the first embodiment.

FIG. 6A is a perspective view of a dressing tool 2 according to a fourth embodiment of the present invention. FIG. 6B is a cross-sectional view taken along line D - D of FIG. 6A, illustrating the dressing tool 2 according to the fourth embodiment. As illustrated in FIGS. 6A and 6B, the dressing tool 2 according to the fourth embodiment includes a disk-shaped dressing board 4 having an annular recess 8c defined in a reverse side 4b thereof and smaller in diameter than the dressing board 4. The recess 8c is in the form of an annular groove located radially outwardly of the center O of the circular reverse side 4b in the case where the dressing board 4 is viewed from the reverse side 4b. The recess 8c is of a circular shape as viewed from the reverse side 4b. However, it may not necessarily be of a true circle. The recess 8c is formed to a predetermined depth extending from the reverse side 4b and terminating short of a face side 4a of the dressing board 4.

The depth of the recess 8c is adjusted such that when the dressing board 4 is worn to a usage-limit thickness, the recess 8c appears on the face side 4a of the dressing board 4 that contacts the grinding stones 26. According to the fourth embodiment, therefore, it is possible to decide whether or not the dressing board 4 has been worn to the usage-limit thickness on the basis of whether or not the recess 8c has appeared on the face side 4a of the dressing board 4. According to the fourth embodiment, since the recess 8c is annular in shape, it can be determined whether or not the recess 8c has appeared on the face side 4a when any local region of the dressing board 4 over the recess 8c in circumferential directions is partly thinned. In addition, when the recess 8c appears on the face side 4a while the dressing board 4 is rotating, since the recess 8c can be observed in a wider area than the first embodiment, it is easier to visually recognize the recess 8c than the recess 8 according to the first embodiment.

Each of the recesses 8, 8a, 8b, and 8c in the dressing boards 4 according to the first through fourth embodiments described above is defined as a single recess. However, each of the recesses 8, 8a, 8b, and 8c may be replaced with two independent recesses. FIG. 7A is a

cross-sectional view taken along line A - A of FIG. 1A, illustrating a dressing tool 2 according to a first modification of the first embodiment. As illustrated in FIG. 7A, the dressing tool 2 according to the first modification of the first embodiment includes a dressing board 4 having a first recess 8-1 and a second recess 8-2 defined in a central area of a reverse side 4b thereof. The first recess 8-1 and the second recess 8-2 are in the form of generally cylindrical holes, respectively, that are independent of each other and spaced from each other.

The first recess 8-1 is formed to a first depth d_1 from the reverse side 4b. The second recess 8-2 is formed from the reverse side 4b to a second depth d_2 larger than the first depth d_1 , i.e., closer to a face side 4a of the dressing board 4. The second depth d_2 extends from the reverse side 4b and terminates short of the face side 4a. As the second depth d_2 is larger than the first depth d_1 , when the face side 4a of the dressing board 4 is worn, the second recess 8-2 appears on the face side 4a earlier than the first recess 8-1. Therefore, the second recess 8-2 that has appeared on the face side 4a can be used as a warning indicating that the current thickness of the dressing board 4 is approaching its usage-limit thickness.

The depth of the first recess 8-1 is adjusted such

that when the dressing board 4 is worn to the usage-limit thickness, the first recess 8-1 appears on the face side 4a of the dressing board 4 that contacts the grinding stones 26. In other words, as with the first embodiment, the first recess 8-1 that has appeared on the face side 4a indicates that the dressing board 4 has been worn to its usage-limit thickness. According to the first modification of the first embodiment, therefore, the first recess 8-1 and the second recess 8-2 are capable of indicating information regarding the usage limit of the dressing board 4 in two steps. The worker or the like can thus recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8-1 has appeared on the face side 4a. Consequently, at the time the second recess 8-2 has appeared on the face side 4a, the worker can take preparatory action to make a backup dressing tool 2 ready to use, for example. Furthermore, at the time the first recess 8-1 has appeared on the face side 4a, the worker can reliably prevent the grinding stones 26 from being damaged by replacing the dressing tool 2 with a new dressing tool 2.

FIG. 7B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating a dressing tool 2 according to a first modification of the second embodiment. As illustrated in FIG. 7B, the dressing tool 2 according to the first modification of the second embodiment includes a dressing board 4 having a first recess 8a-1 and a second recess 8a-2 defined in a reverse side 4b thereof. The first recess 8a-1 and the second recess 8a-2 are in the form of straight grooves, respectively, parallel to each other in the case where the dressing board 4 is viewed from the reverse side 4b. The first recess 8a-1 and the second recess 8a-2 are independent of each other and spaced from each other. Specifically, each of the first recess 8a-1 and the second recess 8a-2 is in the form of a straight groove extending longitudinally diametrically across the dressing board 4. Specifically, the first recess 8a-1 is of a straight shape extending through the center O of the circular reverse side 4b, whereas the second recess 8b-2, indicated by the broken lines in FIG. 7B, is of a straight shape extending parallel to the first recess 8a-1, but not extending through the center O of the circular reverse side 4b.

The first recess 8a-1 is formed to a first depth d1

from the reverse side 4b. The second recess 8a-2 is formed from the reverse side 4b to a second depth d2 larger than the first depth d1, i.e., closer to a face side 4a of the dressing board 4. The second depth d2 extends from the reverse side 4b and terminates short of the face side 4a. According to the first modification of the second embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8a-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8a-1 has appeared on the face side 4a.

FIG. 7C is a cross-sectional view taken along line C - C of FIG. 5A, illustrating a dressing tool 2 according to a first modification of the third embodiment. As illustrated in FIG. 7C, the dressing tool 2 according to the first modification of the third embodiment includes a dressing board 4 having a first recess 8b-1 and a second recess 8b-2 defined in a reverse side 4b thereof. The first recess 8b-1 and the second recess 8b-2 are in the form of generally cylindrical holes located radially outwardly of the center O of the circular reverse side 4b. The first recess 8b-1 and the second

recess 8b-2 are located at radially different positions on the circular reverse side 4b in the case where the dressing board 4 is viewed from the reverse side 4b. Specifically, the first recess 8b-1 in the reverse side 4b has its center positioned at a distance of $r/2$ from the center 0.

On the other hand, the second recess 8b-2 in the reverse side 4b has its center positioned at a distance of $7r/8$ from the center 0. The second recess 8b-2 is disposed diametrically opposite the first recess 8b-1 across the center 0. However, the second recess 8b-2 is not limited to such a position with respect to the first recess 8b-1. The first recess 8b-1 and the second recess 8b-2 may be disposed at any two positions, respectively, spaced from the center 0, provided their distances from the center 0 are different from each other. The first recess 8b-1 is formed to a first depth d_1 from the reverse side 4b. The second recess 8b-2 is formed to a second depth d_2 larger than the first depth d_1 , i.e., closer to a face side 4a of the dressing board 4. The second depth d_2 extends from the reverse side 4b and terminates short of the face side 4a. According to the first modification of the third embodiment, the worker or the like can recognize that the current thickness of the

dressings board 4 is approaching its usage-limit thickness when the second recess 8b-2 has appeared on the face side 4a and that the dressings board 4 has been worn to the usage-limit thickness when the first recess 8b-1 has appeared on the face side 4a.

FIG. 7D is a cross-sectional view taken along line D - D of FIG. 6A, illustrating a dressings tool 2 according to a first modification of the fourth embodiment. As illustrated in FIG. 7D, the dressings tool 2 according to the first modification of the fourth embodiment includes a dressings board 4 having a first recess 8c-1 and a second recess 8c-2 defined in a reverse side 4b thereof. The first recess 8c-1 and the second recess 8c-2 are in the form of annular grooves, respectively, located radially outwardly of the center O of the circular reverse side 4b in the case where the dressings board 4 is viewed from the reverse side 4b. The first recess 8c-1 has a first diameter smaller than the diameter of the dressings board 4. The second recess 8c-2 has a second diameter larger than the first diameter of the first recess 8c-1 and smaller than the diameter of the dressings board 4.

The first recess 8c-1 is disposed radially inwardly of the second recess 8c-2. In the case where the first

diameter is larger than the second diameter, the first recess 8c-1 may be disposed radially outwardly of the second recess 8c-2. Each of the first recess 8c-1 and the second recess 8c-2 may not necessarily be of a true circle as viewed from the reverse side 4b. The first recess 8c-1 is formed to a first depth d1 from the reverse side 4b. The second recess 8c-2 is formed from the reverse side 4b to a second depth d2 larger than the first depth d1, i.e., closer to a face side 4a of the dressing board 4. The second depth d2 extends from the reverse side 4b and terminates short of the face side 4a.

According to the first modification of the fourth embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8c-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8c-1 has appeared on the face side 4a. The dressing board 4 according to the first modification of the first embodiment has the first recess 8-1 and the second recess 8-2 that are independent of each other. The dressing board 4 may have a third recess 8-3 in which the first recess 8-1 and the second recess 8-2 are joined together in depthwise directions of the first recess 8-1.

In other words, the first recess 8-1 and the second recess 8-2 may overlap each other completely or partially in the depthwise directions of the first recess 8-1.

FIG. 8A is a cross-sectional view taken along line A - A of FIG. 1A, illustrating a dressing tool 2 according to a second modification of the first embodiment. As illustrated in FIG. 8A, the dressing tool 2 according to the second modification of the first embodiment includes a dressing board 4 having a third recess 8-3 defined centrally in a reverse side 4b thereof. The third recess 8-3 includes the first recess 8-1 and the second recess 8-2 referred to above. The first recess 8-1 is in the form of a generally cylindrical hole having a first depth d_1 . On the other hand, the second recess 8-2 is disposed substantially centrally in the first recess 8-1 as viewed from the reverse side 4b. The second recess 8-2 is in the form of a generally cylindrical hole having a second depth d_2 that extends from the reverse side 4b and is larger than the first depth d_1 . The second recess 8-2 is smaller in diameter than the first recess 8-1.

The second recess 8-2 may not necessarily be disposed substantially centrally in the first recess 8-1 as viewed from the reverse side 4b. The second recess 8-2 may be disposed in any position, provided it is located

within the first recess 8-1 as viewed from the reverse side 4b. According to the second modification of the first embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8-1 has appeared on the face side 4a.

FIG. 8B is a cross-sectional view taken along line B - B of FIG. 4A, illustrating a dressing tool 2 according to a second modification of the second embodiment. As illustrated in FIG. 8A, the dressing tool 2 according to the second modification of the second embodiment includes a dressing board 4 having a straight third recess 8a-3 defined in a reverse side 4b thereof and extending longitudinally diametrically across the dressing board 4. The third recess 8a-3 is of a straight shape extending through the center O of the reverse side 4b longitudinally diametrically across the dressing board 4. The third recess 8a-3 also includes the first recess 8a-1 and the second recess 8a-2 referred to above. The first recess 8a-1 is in the form of a straight groove having a first depth d1. On the other hand, the second

recess 8a-2 is in the form of a straight groove disposed substantially centrally in the first recess 8a-1 as viewed from the reverse side 4b, having a second depth d2 larger than the first depth d1, and having a width smaller than the first recess 8a-1, i.e., a length perpendicular to the longitudinal directions of the first recess 8a-1.

According to the second modification of the second embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8a-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8a-1 has appeared on the face side 4a. The second recess 8a-2 may not necessarily be disposed substantially centrally in the first recess 8a-1 as viewed from the reverse side 4b. The second recess 8a-2 may be disposed in any position, provided it is located within the first recess 8a-1 as viewed from the reverse side 4b.

FIG. 8C is a cross-sectional view taken along line C - C of FIG. 5A, illustrating a dressing tool 2 according to a second modification of the third embodiment. As illustrated in FIG. 8C, the dressing tool

2 according to the second modification of the third embodiment includes a dressing board 4 having a third recess 8b-3 defined in a reverse side 4b thereof radially outwardly of the center 0 of the reverse side 4b. The third recess 8b-3 also includes the first recess 8b-1 and the second recess 8b-2 referred to above. The first recess 8b-1 is in the form of a generally cylindrical hole having a first depth d_1 . On the other hand, the second recess 8b-2 is in the form of a generally cylindrical hole disposed substantially centrally in the first recess 8b-1 as viewed from the reverse side 4b, having a second depth d_2 larger than the first depth d_1 , and smaller in diameter than the first recess 8b-1.

The first recess 8b-1 and the second recess 8b-2 in the reverse side 4b have respective central positions at the same location radially outward of the center 0. The central positions of the first recess 8b-1 and the second recess 8b-2 are spaced from the center 0 by a distance of $7r/8$. However, the central positions of the first recess 8b-1 and the second recess 8b-2 are not limited to the location spaced from the center 0 by the distance of $7r/8$, but may be located at a position spaced from the center 0 by a distance of $r/2$ or a position spaced from the center 0 by a distance of $3r/4$.

According to the second modification of the third embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8b-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8b-1 has appeared on the face side 4a. The second recess 8b-2 may not necessarily be disposed substantially centrally in the first recess 8b-1 as viewed from the reverse side 4b. The second recess 8b-2 may be disposed in any position, provided it is located within the first recess 8b-1 as viewed from the reverse side 4b.

FIG. 8D is a cross-sectional view taken along line D - D of FIG. 6A, illustrating a dressing tool 2 according to a second modification of the fourth embodiment. As illustrated in FIG. 8D, the dressing tool 2 according to the second modification of the fourth embodiment includes a dressing board 4 having an annular third recess 8c-3 defined in a reverse side 4b. The third recess 8c-3 includes the first recess 8c-1 and the second recess 8c-2 referred to above that are annular in shape. The first recess 8c-1 is in the form of an annular groove having a first depth d1. On the other hand, the second

recess 8c-2 is in the form of an annular groove disposed in a position overlapping the first recess 8c-1 as viewed from the reverse side 4b, having a second depth d_2 larger than the first depth d_1 , and having a radial width smaller than the first recess 8c-1.

The intermediate position between the inside and outside diameters of the second recess 8c-2 is aligned with the intermediate position between the inside and outside diameters of the first recess 8c-1. However, the second recess 8c-2 is not limited to the illustrated position. The second recess 8c-2 may be disposed in any position, provided it is located within the first recess 8c-1 as viewed from the reverse side 4b. According to the second modification of the fourth embodiment, the worker or the like can recognize that the current thickness of the dressing board 4 is approaching its usage-limit thickness when the second recess 8c-2 has appeared on the face side 4a and that the dressing board 4 has been worn to the usage-limit thickness when the first recess 8c-1 has appeared on the face side 4a.

The structural and processing details according to the above embodiments and modifications may be changed or modified within the scope of the present invention. For example, the recesses 8, 8a, 8b, 8c, etc. are not limited

to the illustrated cylindrical, straight, and annular shapes, but may be of other shapes including grid shapes, polygonal shapes, etc. Furthermore, an area of the face side 6a of the support plate 6 that is aligned with, close to, or otherwise associated with any of the recesses 8, 8a, 8b, 8c, etc. may be marked with letters, symbols, or signs for attracting attention of the worker or the like. For example, the area of the face side 6a of the support plate 6 may be marked with letters such as "DANGER," "STOP," "END," "Life End," or the like that are likely to draw attention of the worker who visually recognizes them when any of the recesses 8, 8a, 8b, 8c, etc. has appeared on the face side 4a. The dressing tool 2 may be used for shaping or dressing the grinding stones 26. For shaping the grinding stones 26, the dressing tool 2 uses a dressing board 4 including abrasive grains that are of a relatively large size. For dressing the grinding stones 26, the dressing tool 2 uses a dressing board 4 including abrasive grains that are of a relatively small size.

The present invention is not limited to the details of the above described preferred embodiments. The scope of the invention is defined by the appended claims and all changes and modifications as fall within the

equivalence of the scope of the claims are therefore to be embraced by the invention.

WHAT IS CLAIMED IS:

1. A dressing tool for dressing a plurality of grinding stones disposed in an annular array on a surface of a grinding wheel, comprising:

a dressing part for dressing the grinding stones;
and

a support part supporting a reverse side of the dressing part;

wherein the reverse side of the dressing part has a recess defined therein that has a depth terminating short of a face side of the dressing part that is opposite the reverse side thereof and corresponding to a usage-limit thickness of the dressing part.

2. The dressing tool according to claim 1,
wherein the recess of the dressing part is of a straight shape in a case where the dressing part is viewed from the reverse side thereof.

3. The dressing tool according to claim 1,
wherein the recess of the dressing part is disposed radially outwardly of a center of the dressing part in a case where the dressing part is viewed from the reverse side thereof.

4. The dressing tool according to claim 1,
wherein the recess of the dressing part is of an annular

shape in a case where the dressing part is viewed from the reverse side thereof.

5. The dressing tool according to claim 1, wherein the recess of the dressing part includes a first recess having a first depth and a second recess having a second depth larger than the first depth.

6. The dressing tool according to claim 5, wherein the first recess and the second recess overlap each other in depthwise directions thereof.