

Double-Side or One-Side Machine Tool

The invention relates to a double-side or one-side machine tool, comprising a preferably annular bottom first working disk and a top counter-bearing element, wherein the first working disk and the counter-bearing element can be driven to rotate relative to each other via a rotary drive, wherein a working gap is formed between the first working disk and the counter-bearing element to machine both sides or one side of flat workpieces, wherein the double-side or one-side machine tool also has a machine base part with feet with which the machine base part rests on a floor of a production area when the double-side or one-side machine tool is in the installed state, wherein the machine base part supports the first working disk and the counter-bearing element.

For example, flat workpieces, such as wafers, are simultaneously machined on both sides in double-side machine tools. For this purpose, double-side machine tools have a top working disk and a bottom working disk between which a, generally annular, working gap is formed in which the workpieces to be machined are guided during machining. The top working disk is generally fastened to a top support disk, and the bottom working disk is generally fastened to a bottom support disk. For machining, a relative rotation between the working disks is produced by rotatably driving at least one of the working disks, in particular together with its support disk. Double-side machine tools are known in which so-called rotor disks are guided in the working gap. The rotor disks generally accommodate workpieces to be machined in circular openings in a floating manner. By means of suitable kinematics, it is ensured that the rotor disks also rotate within the working gap during the relative rotation of the working disks. As a result, the workpieces move along cycloid paths within the working gap. Particularly consistent surface machining is hereby achieved. The machining can take place, for example, by grinding, lapping, or polishing. For example in double-side polishing machines, a plurality of silicon wafers, for example

more than ten silicon wafers, with a diameter of, for example, 300 mm can be simultaneously machined in this way.

The machining of workpieces in a specified machining step should take place with the load on the workpieces being as stable as possible over time, wherein the load should be distributed as homogeneously as possible over the entire disk surface. An ideal homogeneous distribution is achieved in particular when the bottom working disk is aligned perfectly horizontally and the drive shafts of both disks are aligned in parallel, in particular coaxially. The alignment of the working disks depends on a series of factors, for example manufacturing tolerances of the individual components, in sum. Another factor is the evenness of the surface of the disk. The more uneven the surface of the disk, the poorer the resulting workpiece quality. Another factor is the location of installation of the machine. For example, an uneven installation surface leads to a misalignment between the working disks, which must be laboriously corrected. With regard to the manufacturing tolerance, an attempt is made to continuously minimize a permissible production error of individual components. The surface evenness of the working disks is improved by means of suitable surface-planing processes. To compensate for unevenness of the floor at the location of installation of the machine, the use of height-adjustable feet of the machine base part supporting the working disks is known. Such feet can be equipped with a damper.

The primary goal when setting the feet is to align the bottom working disk horizontally. After this has been done, the top working disk or a counter-bearing element is aligned with the surface of the bottom working disk, in particular its drive shaft. However, this alignment, which is set for operation as part of setup of the machine tool, is not stable over an arbitrary period of time, but is rather changed by various factors. For example, damping elements in feet are not stable over time, but rather lose elasticity with time, in particular with increasing age and increasing duration of use. The floor of a production area supporting the machine tool is also not generally the same everywhere, such that the machine must be realigned, for example,

when it is repositioned. In addition, such a floor is often not stable over time. This applies in particular to cleanroom floors with pedestals or when arranged on upper stories. In these cases, changes in the floor surface and thus in the alignment of the working disks of the machine tool can occur over time. The alignment of the drive shafts of working disks is also subject to an influence of a load, for example, on the feet, such that an unknown change in the alignment can occur.

Such changes in the alignment of the working disks are not visible from the outside, but rather only become apparent through a deterioration in workpiece quality after a production process is completed despite the process parameters staying the same. It is possible to detect a general state change of the machining process due to changed process parameters, for example of the working gap. However, it cannot be determined here in which manner and to which degree individual factors, such as aging of process components such as slurries or working pads (polishing pads) or a misalignment of the working disks, contribute to the state change. As a result, a deviation from the perfect window of process parameters and alignment of the working disk is only detected later, leading to considerable rejects.

Both a tilting of the working disks relative to each other and a non-coaxial alignment of the working disks in relation to each other can lead to the misalignment. Another problem occurs in double-side or one-side machine tools in which a top working disk can be moved by means of a pivot arm between a position above the bottom working disk and a position that is pivoted away from it. Here, on the one hand, an undesired change in the alignment between the working disks can occur during the pivoting movement when the working disks are pivoted back into the position arranged above the bottom working disk. On the other hand, such machine tools often have an asymmetrical weight distribution due to the pivot arm arrangement, which makes the alignment of the working disks in relation to each other even more difficult. This applies in particular in the case of the considerable overall weight of such machines of more than 10 t, for example approximately 20 t.

Deteriorations in the workpiece quality occur due to the aforementioned misalignments. During the counter-measures, a reduction in the service life of working disk components can occur, in particular more frequently required surface planing, reduced throughput, and thus increased costs.

Starting from the explained prior art, the object of the invention is to provide a double-side or one-side machine tool of the type in question, with which workpieces can be machined reliably and cost-effectively at high quality with reduced rejects.

The invention achieves the object with the subject matter of independent claim 1. Advantageous embodiments can be found in the dependent claims, the description, and the figures.

For a double-side or one-side machine tool of the type in question, the invention achieves the object in that the feet have sensors for monitoring an alignment of the first working disk.

The machine tool can, for example, be a polishing machine or a lapping machine or a grinding machine. The machined workpieces can be, for example, wafers. A working gap is formed between the first working disk and a counter-bearing element, for example a simple weight or pressure cylinder in one-side machine tools, or respectively a second working disk in double-side machine tools, in which workpieces to be machined are machined on both sides or one side. In a double-side machine tool, the top side and bottom side of the workpieces can be machined simultaneously in the working gap. Correspondingly, both working disks can have a working surface that machines the workpiece surface. With a one-side machine tool, only one workpiece side is contrastingly machined; for example, the bottom side by the bottom working disk. In this case, only one working disk has a working surface that machines the

workpiece surface. The counter-bearing element in this case only serves to form a corresponding counter bearing for machining by the working disk.

The workpieces can be accommodated for machining to float in a known manner in openings in rotor disks arranged in the working gap. The first working disk and the counter-bearing element are driven to rotate relative to each other during operation, for example by a first and/or a second drive shaft and at least one drive motor. Both the counter-bearing element as well as the first working disk can be driven to rotate, for example in opposite directions. It is, however, possible to only rotatably drive either the counter-bearing element or first working disk. For example, with a double-side machine tool, rotor disks can be moved by suitable kinematics to rotate through the working gap during this relative rotation so that workpieces arranged in the rotor disks describe cycloid paths in the working gap. For example, the rotor disks can have teeth on their outer edge and/or on their inner edge that engage in associated teeth, for example of the first working disk. Such machines with so-called planetary kinematics are well-known.

The bottom first working disk can be designed to be annular. The top counter-bearing element, or respectively the second working disk, can also be designed to be annular. The first working disk and the counter-bearing element, for example the second working disk, then possess facing annular working surfaces between which the annular working gap is formed. The working surfaces can be covered with a working covering such as polishing cloths. Any support disks that hold the working disks can also be designed to be annular, or at least possess annular support sections to which the working disks are fastened. More than one support disk per working disk can also be provided. The first working disk and/or the counter-bearing element can be designed in one or more layers. The same applies to a support disk supporting the first working disk or the counter-bearing element.

In the first working disk and/or the counter-bearing element and/or in a first support disk supporting the first working disk and/or a second support disk supporting the counter-bearing element, temperature-control channels can be designed, through which a temperature-control fluid, for example, a temperature-control liquid, is conveyed for temperature control of the respective components during operation.

The machine base part supporting the first working disk and the counter-bearing element can be designed as a housing. It can also support a rotary drive for rotating the first working disk and/or the counter-bearing element. Likewise, the machine base part can support a pivot arm which may be provided for pivoting the counter-bearing element. The machine base part can also support first and/or second support disks which may be provided.

According to the invention, the feet with which the machine base part rests on a floor of a production area has sensors which monitor, in particular indirectly monitor, an alignment of the bottom first working disk. The feet can also comprise damping elements. As will be explained in the following, the sensors can take different forms. The invention is based on the knowledge that, for example due to monitoring of a weight force acting on the feet and/or a vertical position of the feet, the correct alignment of the first working disk for optimal workpiece quality can be inferred. The sensors of the feet thus allow an undesired deviation from a specified optimal alignment of the first working disk to be detected early, and thus the risk of a deterioration in workpiece quality to be detected early or, respectively, to be counteracted in good time through suitable countermeasures in order to minimize rejects. The feet with sensors according to the invention thereby allow a reliable differentiation from other possible causes of reduced workpiece quality. An operator can be notified, for example, of a deviation of the alignment from a specified alignment, such that suitable countermeasures can be taken in good time to continue to ensure the desired workpiece quality. It is thus simply and reliably ensured according to the invention that the workpiece quality is maintained at all times and

even in the case of the aforementioned changes in influencing factors acting on the alignment of the first working disk. The alignment of the counter-bearing element is generally set depending on the alignment of the first working disk. For example, the top counter-bearing element can be connected to the drive shaft via a flexible connecting element, for example a curved-tooth coupling, such that it adapts flexibly to the alignment of the bottom first working disk. Therefore, if a correct alignment of the first working disk is ensured, this also achieves a desired alignment of the counter-bearing element.

According to one embodiment, the counter-bearing element can be formed by a preferably annular second working disk, wherein the working gap is formed between the first and the second working disks to machine both sides or one side of flat workpieces. In particular in the case of correct alignment, the first and second working disks can be arranged coaxially in relation to each other. The first working disk can be fastened to a first support disk which is also supported by the machine base part and/or the second working disk can be fastened to a second support disk which is also supported by the machine base part.

According to another embodiment, the counter-bearing element can be arranged on a pivot arm arranged on the machine base part and can be pivotable with the pivot arm relative to the first working disk. A rotary drive for the counter-bearing element arranged on the pivot arm can be integrated into the pivot arm. As explained above, in particular in the case of such machine tools with a then asymmetrical weight distribution on the machine base part, there are special challenges with regard to the alignment of the first working disk, in particular in securely maintaining the right alignment, which can be reliably addressed according to the invention.

According to another embodiment, the sensors of the feet can comprise weight sensors which measure a weight force acting on the respective feet. In this embodiment, the weight distribution on the different feet of the machine base part is taken into account.

Scales, for example, can be considered as weight sensors. As part of a process of setting up the machine for operation, it is possible to set the weight distribution on the feet such that the same weight force acts on all the feet and then to perform the final alignment of the first working disk. It is also possible to first perform the alignment of the first working disk at any weight distribution between the weight forces acting on the feet. In both cases, the weight distribution acting on the feet after the setup process is completed can be assumed as the specified weight distribution which is subsequently monitored by the sensors. In particular, the sensors can measure the weight distribution after each production process is completed and these measured values can be compared with the measured values after a preceding production process and/or with values associated with the specified weight distribution, in particular values measured at the specified weight distribution. A static monitoring of the alignment of the bottom first working disk thus takes place, in each case after a production process is completed, in particular after the counter-bearing element is no longer in contact with the first working disk. If changes in the alignment of the first working disk occur, this leads to a change in the weight distribution on the feet which can be measured by the sensors, even in the case of the smallest deviations from the original alignment. For example, if a limit deviation from the originally specified weight distribution is exceeded, a warning can be output for an operator and countermeasures can be taken manually or automatically in order to reset the alignment of the first working disk for optimal workpiece quality.

According to another embodiment, the sensors can comprise optical sensors, which each optically measure a position of the feet, in particular a vertical position of the feet. The optical sensors can comprise, for example, laser sensors which measure a position of the feet, preferably using a propagation time measurement. In particular, an optical transmitter, for example a laser, which directs optical radiation onto a reflector can be provided. Depending on the propagation time of the radiation from the transmitter to the reflector and to a receiver for the radiation, the receiver being arranged, for example, at the location of the transmitter, the distance between the

transmitter and the reflector and thus, for example, the vertical position of a support foot can be measured. In this embodiment, use is made of the fact that a misalignment of the first working disk can lead to a change in, for example, the height of individual feet compared to other feet. This can be recorded by measuring, such that, in turn, as explained above, suitable countermeasures can be taken to maintain the specified alignment for optimal workpiece quality.

The double-side or one-side machine tool can also comprise an evaluation apparatus which receives the measurement data from the sensors. The evaluation apparatus can be designed to output a warning signal when a deviation of the alignment of the first working disk from a specified alignment is detected. On the basis of such a warning signal, an operator can take measures to reestablish the optimal alignment of the first working disk. For this purpose, for example, a change in the position of the first working disk, for example a vertical, lateral, or tilting movement, and/or of feet, for example a vertical movement of feet, is possible. The change in the position of the first working disk can thus be, for example, a vertical adjustment and/or a lateral adjustment. It can also be a tilting of the first working disk, for example, to correct a non-coaxial alignment of axes of rotation of the first working disk and the counter-bearing element.

According to another embodiment, the evaluation apparatus can be designed, when a deviation of the alignment of the first working disk from a specified alignment is detected, to actuate the double-side or one-side machine tool such that the alignment of the first working disk corresponds again to the specified alignment. In this embodiment, when a deviation of the alignment from the specified alignment is detected, an automatic realignment can take place in order to maintain the optimal workpiece quality at all times. For this purpose, the evaluation apparatus can actuate suitable adjusting apparatuses with which the position of the first working disk and/or of feet can be adapted in the manner explained above.

According to another embodiment, the first working disk and/or a first support disk supporting the first working disk and/or the feet can be provided with an adjusting apparatus which can be actuated by the evaluation apparatus such that the alignment of the first working disk corresponds again to the specified alignment.

According to a particularly practical embodiment, the adjusting apparatus can comprise at least one adjusting element, such as an adjusting wedge, which can be moved in a translatable manner by means of an adjusting drive and due to the translatable movement of which the first working disk and/or a first support disk supporting the first working disk and/or the feet are height-adjustable and/or laterally adjustable and/or tiltable. The adjusting apparatus can comprise in particular multiple adjusting elements of this type which can be moved in a translatable manner by means of an adjusting drive. Due to the translatable movement of the adjusting elements, the position, for example the height, of the desired components can be adjusted in a mechanically simple manner in order to adapt the alignment of the first working disk.

According to another embodiment, the specified alignment can be an alignment of the first working disk which is set for operation as part of setup of the double-side or one-side machine tool. The first working disk is thus optimally aligned before a machining process and this alignment is applied as the target alignment. If the sensors of the feet discern a change compared to this target alignment, countermeasures can be taken in response in the manner explained above. As explained above, the sensors can record measured values characterizing the alignment of the first working disk after each production process is completed and these measured values can be compared with the measured values after a preceding production process and/or with measured values associated with the specified alignment, in particular values measured for the specified alignment. As explained, a static monitoring of the alignment of the bottom first working disk thus takes place, in each case after a production process is completed, in particular after the counter-bearing element is no longer in contact with the first working disk.

Exemplary embodiments of the invention are explained below in greater detail using figures. They schematically show:

- Fig. 1 a double-side machine tool according to the invention in a side view in a first operating state,
- Fig. 2 the double-side machine tool from Fig. 1 in a second operating state,
- Fig. 3 a top view of the double-side machine tool according to Fig. 1 in the operating state from Figure 2,
- Fig. 4 the representation from Fig. 3 in a further operating state,
- Fig. 5 a sectional view of an adjusting apparatus of the double-side machine tool according to the invention according to a first exemplary embodiment, and
- Fig. 6 a sectional view of an adjusting apparatus of the double-side machine tool according to the invention according to another exemplary embodiment.

The same reference signs refer to the same objects in the figures unless indicated otherwise.

The double-side machine tool shown merely by way of example in Figures 1 to 4 has a machine base part 10 which rests on a floor 14 of a production area via a plurality of feet 12. The machine base part 10, designed, for example, as a housing, supports an annular bottom first support disk 16, which in turn supports an annular bottom first working disk 18. Furthermore, the machine base part 10 supports a pivot arm 22 which is arranged on a pivot housing 20 and which supports an annular top second support disk 24, which in turn supports an annular top second working disk 26. Via a rotary drive arranged in the pivot arm 22, the, for example, top second support disk 24 with the top second working disk 26 can be rotated about a drive shaft 28. By means of a rotary drive (not shown in more detail), the bottom first support disk 16 and with it

the bottom first working disk 18 can also be rotatable, for example in the opposite direction to top second support disk 24 with the top second working disk 26. An annular working gap is formed between the working disks 18, 26, wherein Figure 1 shows a state of the working disks 18, 26 in which they are spread apart from each other in the axial direction and in which the working disks are not in contact with each other. Figure 2 shows the state of the working disks 18, 26 in which they are pressed against each other. By rotating the working disks 18, 26 in opposite directions, the workpieces, which are, for example, mounted in a floating manner in rotor disks, can be machined in a well-known manner in the annular working gap, for example ground, lapped, or polished.

As can be seen when comparing Figures 1 and 2, the pivot arm 22 can be displaced in height to adjust between the operating states in Figures 1 and 2. It can also be seen in Figures 3 and 4 that, after the working disks 18, 26 are no longer in contact, as shown in Figure 1, the pivot arm 22 can be pivoted together with the pivot housing 20 in order to pivot the top second support disk 24 and with it the top second working disk 26 between a position that is facing the bottom first working disk 18 and a position that is remote from it, in particular to load rotor disks with workpieces to be machined.

The feet 12 each comprise sensors 30, which can be, for example, weight sensors 30 which each measure a weight force acting on the feet 12. The measured values from the sensors 30 are applied to an evaluation apparatus 32 of the double-side machine tool. For example, in the state shown in Figure 1, the bottom first working disk 18 can be optimally aligned horizontally together with the bottom first support disk 16. After this alignment has been completed, the sensors 30, actuated, for example, by the evaluation apparatus 32, can measure the weight force acting on each of the feet 12. These measured values are stored in particular by the evaluation apparatus 32 as target measured values of a specified alignment of the bottom first working disk 18. Then, in the state shown in Figure 2, a workpiece can be machined. After this production process is completed and the working disks 18, 26 are no longer in contact with each

other again, the sensors, actuated again, for example, by the evaluation apparatus 32, can again measure the weight force acting on each of the feet 12. These measured values can be compared by the evaluation apparatus 32 with the previously stored target measured values.

If, for example, the weight distribution between the feet 12 measured by the sensors 30 after a production process is completed and the working disks 18, 26 are moved apart changes compared to a weight distribution, set at the beginning of this or a preceding machining process, of an optimal alignment of the working disk 18, the evaluation apparatus 32 can output a warning signal. On this basis, an operator, for example, can adapt the alignment of the first working disk 18 until the weight distribution measured by the sensors 30 corresponds again to the specified value and thus the alignment corresponds again to the specified alignment. Alternatively or additionally, the sensors 30 can also comprise optical sensors 30 which measure, for example, a vertical position of the feet 12, such that, on this basis, a deviation of the alignment from the specified alignment can be detected.

Figures 5 and 6 show adjusting apparatuses with which the alignment of the top second working disk 26 can be adapted, for example, by setting the height of the top second support disk 24 and the top second working disk 26. In the example shown, an adjusting element 34, in particular an adjusting wedge 34, which can be retracted or extended in a translatory manner manually in a conical adjusting holder 38 via an adjusting screw 36 in the example shown in Fig. 5, is provided for this purpose. For example due to translatory movement of the adjusting wedge 34 into the conical adjusting holder 38 by rotating in the screw 36, the second support disk 24 and with it the second working disk 26 are moved downward in Fig. 5, as a result of which the alignment of the second working disk 26 can be set in the desired manner. The alignment of the bottom first support disk 16 and the bottom first working disk 18 can be set in a corresponding manner with such an adjusting apparatus.

Figure 6 shows a further exemplary embodiment in which the adjusting screw 36 and with it the adjusting wedge 34 can be adjusted in a translatory manner in relation to the adjusting holder 38 by means of an adjusting drive 40. In the example shown in Fig. 5, for example, an operator can manually actuate the adjusting screw 36 to set the alignment between the working disks 18, 26. In the example shown in Fig. 6, the adjusting screw 36 can be actuated automatically via the adjusting drive 40, for example by the evaluation apparatus 32, if the evaluation apparatus discerns an impermissible deviation of the alignment measured by the sensors 30 until the alignment corresponds again to the specified alignment. In turn, the alignment of the bottom first support disk 16 and the bottom first working disk 18 can be set in a corresponding manner.

Reference Signs

10	Machine base part
12	Feet
14	Floor
16	First support disk
18	First working disk
20	Pivot housing
22	Pivot arm
24	Second support disk
26	Second working disk
28	Drive shaft
30	Sensors
32	Evaluation apparatus
34	Adjusting element
36	Adjusting screw
38	Adjusting holder
40	Adjusting drive

Claims

1. A double-side or one-side machine tool, comprising a preferably annular bottom first working disk (18) and a top counter-bearing element (26), wherein the first working disk (18) and the counter-bearing element (26) can be driven to rotate relative to each other via a rotary drive, wherein a working gap is formed between the first working disk (18) and the counter-bearing element (26) to machine both sides or one side of flat workpieces, wherein the double-side or one-side machine tool also has a machine base part (10) with feet (12) with which the machine base part (10) rests on a floor (14) of a production area when the double-side or one-side machine tool is in the installed state, wherein the machine base part (10) supports the first working disk (18) and the counter-bearing element (26), characterized in that the feet (12) have sensors (30) for monitoring an alignment of the first working disk (18).
2. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the counter-bearing element (26) is formed by a preferably annular second working disk (26), wherein the working gap is formed between the first and second working disks (18, 26) to machine both sides or one side of flat workpieces.
3. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the first working disk (18) is fastened to a first support disk (16) which is also supported by the machine base part (10) and/or in that the second working disk (26) is fastened to a second support disk (24) which is also supported by the machine base part (10).
4. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the counter-bearing element (26) is arranged on a

pivot arm (22) arranged on the machine base part (10) and can be pivoted relative to the first working disk (18) using the pivot arm (22).

5. The double-side or one-side machine tool according to claim 4, characterized in that a rotary drive for the counter-bearing element (26) arranged on the pivot arm (22) is integrated into the pivot arm (22).
6. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the sensors (30) comprise weight sensors (30) which measure a weight force acting on the feet (12).
7. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the sensors (30) comprise optical sensors (30) which optically measure a position of the feet (12), in particular a vertical position of the feet (12).
8. The double-side or one-side machine tool according to claim 7, characterized in that the optical sensors (30) comprise laser sensors which measure a position of the feet (12), preferably via a propagation time measurement.
9. The double-side or one-side machine tool according to one of the preceding claims, characterized in that an evaluation apparatus (32) which receives the measurement data from the sensors (30) is provided.
10. The double-side or one-side machine tool according to claim 9, characterized in that the evaluation apparatus (32) is designed to output a warning signal when a deviation of the alignment of the first working disk (18) from a specified alignment is detected.

11. The double-side or one-side machine tool according to one of claims 9 or 10, characterized in that the evaluation apparatus (32) is designed, when a deviation of the alignment of the first working disk (18) from a specified alignment is detected, to actuate the double-side or one-side machine tool such that the alignment of the first working disk (18) corresponds again to the specified alignment.
12. The double-side or one-side machine tool according claim 11, characterized in that the first working disk (18) and/or a first support disk (16) supporting the first working disk (18) and/or the feet (12) are provided with an adjusting apparatus which can be actuated by the evaluation apparatus (32) such that the alignment of the first working disk (18) corresponds again to the specified alignment.
13. The double-side or one-side machine tool according to claim 12, characterized in that the adjusting apparatus comprises at least one adjusting element (34) which can be moved in a translatable manner by means of an adjusting drive (40) and due to the translatable movement of which the first working disk (18) and/or a first support disk (16) supporting the first working disk (18) and/or the feet (12) are height-adjustable and/or laterally adjustable and/or tiltable.
14. The double-side or one-side machine tool according to one of claims 10 to 13, characterized in that the specified alignment is an alignment of the first working disk (18) which is set for operation as part of setup of the double-side or one-side machine tool.
15. The double-side or one-side machine tool according to one of the preceding claims, characterized in that the double-side or one-side machine tool is a double-side or one-side polishing machine or a double-side or one-side lapping machine or a double-side or one-side grinding machine.