METHOD AND APPARATUS FOR CORRECTING POSITION OF PREDETERMINED PROCESSING LINE, AND PROCESSING METHOD AND APPARATUS

[0001] This application claims the priority to Chinese Patent Application No. 202311743466.6, titled "METHOD AND APPARATUS FOR CORRECTING POSITION OF PREDETERMINED PROCESSING LINE, AND PROCESSING METHOD AND APPARATUS", filed on December 18, 2023 with the China National Intellectual Property Administration, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the technical field of image processing, and in particular to a method for calibrating a position of a predetermined processing line, a processing method, an apparatus for calibrating a position of a predetermined processing line, a processing apparatus, an electronic device, and a storage medium.

BACKGROUND

[0003] In the manufacturing industry, various devices are used in conjunction with an X, Y, R system and a visual positioning camera for positioning and processing of a to-be-processed workpiece. For example, in the wafer cleaving procedure of the semiconductor industry, a cleaving blade of a cleaving system (also referred to as a cleaving machine) is utilized to cleave the diced wafer along a dicing street, so as to separate dies from the wafer. During the wafer cleaving process, the angle θ° of the wafer processing dicing street is determined through vision positioning, and then the R-axis is rotated by θ° to make the wafer processing dicing street horizontal.

[0004] When performing horizontal calibration on the processing dicing street, the horizontal calibration is generally performed on a dicing street near the center of a product. The to-be-processed workpiece is typically processed from the edge of the to-be-processed workpiece. Due to the inability to ensure 100% perpendicularity between the X and Y axes during installation, errors accumulate progressively with each cleaving operation during the wafer

processing process, resulting in a deviation of the processing position away from the center of the processing dicing street.

SUMMARY

[0005] In view of the above issues, the present disclosure is provided. Provided in the present disclosure are a method for calibrating a position of a predetermined processing line, a processing method, an apparatus for calibrating a position of a predetermined processing line, a processing apparatus, an electronic device, and a storage medium.

[0006] According to a first aspect of the present disclosure, a method for calibrating a position of a predetermined processing line is provided. The method is applied to a processing device. The processing device includes a processing tool, and the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction. The method includes:

acquiring first position information of a target predetermined processing line, where the target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line;

determining a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool;

comparing the position deviation with a target deviation threshold; and

calibrating a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold, where the to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

[0007] In an embodiment, the target predetermined processing line is calibrated in a preset order. Before the comparing the position deviation with a target deviation threshold, the method further includes:

determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, where

in a case that the expected spacing falls within any one specific spacing range among at least two spacing ranges, the target deviation threshold is equal to a preset deviation threshold which corresponds to the specific spacing range among at least two preset deviation thresholds, where the at least two spacing ranges and the at least two preset deviation thresholds are in one-to-one correspondence, and among the at least two spacing ranges, a spacing range containing greater values corresponds to a greater preset deviation threshold.

[0008] In an embodiment, the at least two preset deviation thresholds include a first preset deviation threshold and a second preset deviation threshold. The first preset deviation threshold is greater than the second preset deviation threshold. The first preset deviation threshold and the second preset deviation threshold are in one-to-one correspondence with the two spacing ranges. A preset spacing threshold is equal to a boundary between the two spacing ranges. The determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, includes:

determining, in response to the expected spacing being greater than or equal to the preset spacing threshold, the first preset deviation threshold as the target deviation threshold; and

determining, in response to the expected spacing being less than the preset spacing threshold, the second preset deviation threshold as the target deviation threshold.

[0009] In an embodiment, the to-be-processed workpiece is a wafer. The preset spacing threshold is equal to a specific multiple of a die spacing of the wafer, and the first preset deviation threshold is equal to the specific multiple of a minimum deviation threshold. The die spacing is spacing between two adjacent predetermined processing lines. The minimum deviation threshold is equal to a difference between a position of any first predetermined processing line after the to-be-processed workpiece is moved by one die spacing in a second direction and a position of a second predetermined processing line before the movement. The second predetermined processing line is adjacent to the first predetermined processing line and located on a side facing a movement direction of the to-be-processed workpiece. The second direction is along a second coordinate axis that is perpendicular to a first coordinate axis corresponding to the first direction in a mechanical coordinate system employed by the processing device.

[0010] In an embodiment, before the comparing the position deviation with a target deviation

threshold, the method further includes:

determining the at least two preset deviation thresholds based on first parameter setting information inputted by a user.

[0011] In an embodiment, after the comparing the position deviation with a target deviation threshold, the method further includes:

outputting alarm information in response to the position deviation being greater than the target deviation threshold.

[0012] In an embodiment, before the comparing the position deviation with a target deviation threshold, the method further includes:

determining the target deviation threshold based on second parameter setting information inputted by a user.

[0013] In an embodiment, the processing device includes a first image acquisition apparatus. A physical position of the processing tool remains aligned with a physical position of a center of field of view of the first image acquisition apparatus. The first position information of the target predetermined processing line is represented by a first image position of a feature point in a detection image or a first physical position corresponding to the first image position. The feature point is located on the target predetermined processing line in the detection image that is acquired by the first image acquisition apparatus. The second position information of the processing tool is represented by a second image position of the center of the field of view of the first image acquisition apparatus or a second physical position corresponding to the second image position.

[0014] In an embodiment, the calibrating a position of the target predetermined processing line based on the position deviation, includes:

moving the image acquisition apparatus by a distance according to the position deviation, to calibrate the position of the target predetermined processing line.

[0015] In an embodiment, before the acquiring first position information of a target predetermined processing line, the method further includes:

identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, where the first feature point is a feature point on any one of the at least

one predetermined processing line;

calibrating, based on the first direction, a third predetermined processing line where the first feature point is located;

moving, after the calibration, the center of the field of view of the first image acquisition apparatus to a physical position, where the center of the field of view of the first image acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image;

acquiring a second detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus;

identifying a second feature point from the second detection image, where the second feature point is a feature point located on any one of the at least one predetermined processing line;

moving the center of the field of view of the first image acquisition apparatus by a distance corresponding to an expected spacing, where the expected spacing is between a fourth predetermined processing line where the second feature point is located and a starting target predetermined processing line in a first processing stage among at least one processing stage; and

acquiring a third detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus, where the third detection image includes the starting target predetermined processing line in the first processing stage, and performing the process of acquiring first position information of a target predetermined processing line for the starting target predetermined processing line in the first processing stage based on the third detection image.

[0016] In an embodiment, the processing device further includes a second image acquisition apparatus. An image acquisition range of the second image acquisition apparatus is greater than an image acquisition range of the first image acquisition apparatus. Before the identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, the method further includes:

identifying a contour of the to-be-processed workpiece from a fourth detection image acquired by the second image acquisition apparatus, where when the second image acquisition

apparatus acquires the fourth detection image, a center of field of view of the second image acquisition apparatus coincides with a center of a carrying apparatus for carrying the to-be-processed workpiece;

determining a third image position of a product center of the to-be-processed workpiece in the fourth detection image based on the contour of the to-be-processed workpiece;

determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference;

moving the carrying apparatus to a position within the field of view of the first image acquisition apparatus to enable a center of the carrying apparatus to coincide with the center of the field of view of the first image acquisition apparatus;

adjusting the position of the carrying apparatus based on the physical position difference to enable a physical position of the product center of the to-be-processed workpiece on the carrying apparatus to coincide with the physical position of the center of the field of view of the first image acquisition apparatus; and

acquiring, after the adjustment, the first detection image by the first image acquisition apparatus.

[0017] In an embodiment, before the determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference, the method further includes:

acquiring multiple fifth detection images, where the multiple fifth detection images of the to-be-processed workpiece are acquired by the first image acquisition apparatus when the to-be-processed workpiece is located at multiple fourth physical positions, the quantity of the multiple fifth detection images is greater than or equal to 3, and the multiple fourth physical positions are different from each other;

for each fifth detection image of the multiple fifth detection images, determining an image position of an identification feature in the fifth detection image based on a template image,

where the template image includes the identification feature on the to-be-processed workpiece; and

determining the conversion relationship based on the image positions of the identification feature in the multiple fifth detection images and the multiple fourth physical positions.

[0018] In an embodiment, the calibrating, based on the first direction, a third predetermined processing line where the first feature point is located, includes:

determining the first feature point as a reference position point, and sequentially determining multiple groups of position points based on the reference position point, where each group of the plurality groups of position points includes a first position point and a second position point that are located on different sides of the reference position point, a spacing between the first position point and the second position point in the multiple groups of position points gradually increases along the first direction across the groups, and different position points among the reference position point and the multiple groups of position points correspond to different feature points on the third predetermined processing line;

calculating, each time after one group of the multiple groups of position points is determined, an angle of a connecting line relative to the first direction, where the connecting line is between the first position point and the second position point in the group of position points, and performing a calibration operation which includes:

determining an adjustment angle based on the angle of the connecting line in a case that the angle of the connecting line is greater than a preset angle threshold, and adjusting a position of the to-be-processed workpiece according to the adjustment angle to calibrate a position of the third predetermined processing line on the to-be-processed workpiece; and

stopping the calibration operation in a case that the angle of the connecting line is less than or equal to the preset angle threshold, where

for the multiple groups of position points, after a current group of the multiple groups of position points is determined and the calibration operation for the current group is performed, a next group of position points is determined, and along the first direction, a spacing between the first position point and the second position point in the next group of position points is greater than a spacing between the first position point and the second position point in the current group of position points.

[0019] According to a second aspect of the present disclosure, a processing method is further provided. The processing method is applied to a processing device. The processing device includes a processing tool, and the processing tool is configured to process a to-be-processed workpiece along a predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction. The processing method includes:

performing a first processing operation, which includes:

determining a position of a target predetermined processing line during actual processing by using the method for calibrating the position of the predetermined processing line according to the first aspect described above; and

controlling the processing tool to perform processing at the position of the target predetermined processing line.

[0020] In an embodiment, processing is performed along the at least one predetermined processing line in a preset order, and the first processing operation is performed when processing is performed along any one of the at least one target predetermined processing line.

[0021] In an embodiment, the processing method further includes:

performing, when processing is performed along any one non-target predetermined processing line other than the target predetermined processing line, a second processing operation, which includes:

determining a position of the non-target predetermined processing line based on a position of a previous predetermined processing line in a previous processing operation; and

controlling the processing tool to perform processing at the position of the non-target predetermined processing line.

[0022] According to a third aspect of the present disclosure, an apparatus for calibrating a position of a predetermined processing line is provided. The apparatus is applied to a processing device. The processing device includes a processing tool, and the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction.

[0023] The apparatus includes: an acquisition module, a first determination module, a comparison module, and a calibration module.

[0024] The acquisition module is configured to acquire first position information of a target predetermined processing line. The target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line.

[0025] The first determination module is configured to determine a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool.

[0026] The comparison module is configured to compare the position deviation with a target deviation threshold.

[0027] The calibration module is configured to calibrate a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold. The to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

[0028] According to a fourth aspect of the present disclosure, a processing apparatus is further provided. The processing apparatus is applied to a processing device. The processing device includes a processing tool, and the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction. The processing apparatus includes an execution module, and the execution module includes a determination sub-module and a control sub-module.

[0029] The determination sub-module is configured to determine a position of a target predetermined processing line during actual processing by using the apparatus for calibrating the position of the predetermined processing line according to the third aspect described above.

[0030] The control sub-module is configured to control the processing tool to perform processing at the position of the target predetermined processing line.

[0031] According to a fifth aspect of the present disclosure, an electronic device is further provided. The electronic device includes a processor and a memory. The memory stores a computer program instruction, and the computer program instruction, when executed by the

processor, performs the method for calibrating the position of the predetermined processing line according to the first aspect described above and/or the processing method according to the second aspect described above.

[0032] According to a sixth aspect of the present disclosure, a storage medium is further provided. The storage medium stores a computer program/instruction. The computer program/instruction, when executed, performs the method for calibrating the position of the predetermined processing line according to the first aspect and/or the processing method according to the second aspect described above.

[0033] According to the method for calibrating the position of the predetermined processing line, the apparatus for calibrating the position of the predetermined processing line, the processing method, the processing apparatus, the electronic device, and the storage medium in the embodiments of the present disclosure, the position deviation is determined based on the first position information of the target predetermined processing line and the second position information of the processing tool. After comparing the position deviation with the target deviation threshold, in response to the position deviation being less than or equal to the target deviation threshold, the position of the target predetermined processing line is calibrated based on the position deviation. The to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line. This solution involves acquiring the first position information of the target predetermined processing line and the second position information of the processing tool, so as to determine whether it is required to calibrate the position of a current target predetermined processing line, and involves calibrating the position of the current target predetermined processing line on determining to calibrate. In this way, the accuracy of a current cleaving position of a cleaving blade is ensured, thereby preventing damage to the to-be-processed workpiece. In addition, an installation requirement for the perpendicularity between an X-axis and a Y-axis in the processing device is reduced, thereby reducing the hardware cost of the processing device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Above and other objects, features, and advantages of the present disclosure will become more apparent with reference to the detailed description of the embodiments of the present disclosure made in conjunction with the drawings. The drawings are intended to provide

further understanding of the embodiments of the present disclosure, and constitute a part of the specification. The drawings are intended to describe the present disclosure in conjunction with the embodiments of the present disclosure, and do not limit the present disclosure. In the drawings, same reference numerals generally represent same parts or steps.

[0035] FIG. 1 illustrates a flowchart of a method for calibrating a position of a predetermined processing line according to an embodiment of the present disclosure;

[0036] FIG. 2 illustrates a schematic diagram of an image coordinate system established for a detection image according to an embodiment of the present disclosure;

[0037] FIG. 3 illustrates a schematic diagram of a to-be-processed workpiece according to an embodiment of the present disclosure;

[0038] FIG. 4 illustrates a schematic diagram of a template image according to an embodiment of the present disclosure;

[0039] FIG. 5 illustrates a schematic diagram of a fourth detection image according to an embodiment of the present disclosure;

[0040] FIG. 6 illustrates a flowchart of a first processing operation according to an embodiment of the present disclosure;

[0041] FIG. 7 illustrates a schematic block diagram of an apparatus for calibrating a position of a predetermined processing line according to an embodiment of the present disclosure;

[0042] FIG. 8 illustrates a schematic block diagram of a processing apparatus according to an embodiment of the present disclosure; and

[0043] FIG. 9 illustrates a schematic block diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0044] Exemplary embodiments of the present disclosure are described in detail with reference to the drawings to make objects, technical solutions, and advantages of the present disclosure more apparent. Apparently, the described embodiments are only some embodiments instead of all embodiments of the present disclosure. It should be understood that, the present disclosure is not limited by the exemplary embodiments described herein. Based on the

embodiments of the present disclosure described herein, all other embodiments obtained by those skilled in the art without creative efforts are deemed to fall into the protection scope of the present disclosure.

[0045] To at least partially address the above issues, a method for calibrating a position of a predetermined processing line is provided according to the embodiments of the present disclosure. The method for calibrating the position of the predetermined processing line may be applied to any processing device, such as a cleaving system or the like, capable of processing a to-be-processed workpiece along the predetermined processing line on the workpiece. The processing device may include a processing tool. The processing tool is configured to process the to-be-processed workpiece along the predetermined processing line. For example, in a case that the processing device is a cleaving system, the processing tool may be a cleaving blade which cleaves the to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction thereon. In an embodiment, the first direction may refer to a direction of a cleaving line generated when the cleaving blade cleaves the to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece may be, for example, any product to be processed, such as a ceramic, a wafer and the like. The predetermined processing line is any feature line on the to-be-processed workpiece. In an example, the predetermined processing line may be a dicing street on a wafer. FIG. 1 illustrates a flowchart of a method 100 for calibrating a position of a predetermined processing line according to an embodiment of the present disclosure. As shown in FIG. 1, the method 100 may include the following steps S110, S120, S130, and S140.

[0046] In step S110, first position information of a target predetermined processing line is acquired. The target predetermined processing line is a predetermined processing line to be calibrated among at least one predetermined processing line.

[0047] In an embodiment, the to-be-processed workpiece is provided with one or more predetermined processing lines extending in a first direction thereon. In a case that the to-be-processed workpiece is provided with multiple predetermined processing lines extending in the first direction thereon, a calibration may be performed before the processing of the to-be-processed workpiece along each predefined processing line is performed, or a calibration may be performed after skipping a preset number of predetermined processing lines. The target

predetermined processing line may be a predetermined processing line to be calibrated. The first position information of the target predetermined processing line indicates a physical position or an image position of the target predetermined processing line.

[0048] In an embodiment, the processing device includes a first image acquisition apparatus. A physical position of the processing tool remains aligned with a physical position of the center of the field of view of the first image acquisition apparatus. The first position information of the target predetermined processing line is represented by a first image position of a feature point in a detection image or a first physical position corresponding to the first image position, where the feature point is located on the target predetermined processing line in the detection image that is acquired by the first image acquisition apparatus. The second position information of the processing tool is represented by a second image position of the center of the field of view of the first image acquisition apparatus or a second physical position corresponding to the second image position.

[0049] To facilitate understanding, a determination process of an image position mentioned in the present disclosure is described below.

[0050] FIG. 2 illustrates a schematic diagram of an image coordinate system established for a detection image according to an embodiment of the present disclosure. For example, the image coordinate system as shown in FIG. 2 is established as follows: a vertex at the upper left corner of the detection image is determined as an origin O, an axis passing through the origin O and parallel to an upper edge of the detection image is determined as an X-axis, and an axis passing through the origin O and perpendicular to the X-axis and parallel to a left edge of the detection image is determined as an y-axis. The point A represents a feature point. For example, a first detection image includes 1000×1000 pixels. The feature point A is located at a pixel in row 150 and column 300, and thus an image position of the feature point A is represented as (150, 300). Feature points described herein (including a first feature point, a second feature point, and the like hereinafter) may be any recognizable feature points on a to-be-processed workpiece. In an embodiment, the feature points may represent inherent feature points on the to-be-processed workpiece, such as feature points on certain shapes or structures. In an embodiment, the feature points may also be feature points that are additionally marked on the to-be-processed workpiece manually or by the processing device, such as some easily recognizable symbols, patterns and the like. The feature points may be of any shape, for example, circular, cross-shaped, star-

shaped, and the like. The to-be-processed workpiece may be provided with at least two predetermined processing lines thereon. The predetermined processing line is any feature line on the to-be-processed workpiece. The feature point is located on the predetermined processing line. In an example, the predetermined processing line is a dicing street on a wafer. Preferably, the feature point is a center point of an intersection region between two mutually perpendicular dicing streets (referred to as "dicing-street center").

[0051] Various physical positions described herein may be represented by coordinates in a same world coordinate system. The world coordinate system may be further referred to as a mechanism coordinate system. An example of establishing the world coordinate system is described as follows. A to-be-processed workpiece may be placed on a movable carrying apparatus, such as a movable stage. The movable stage is capable of translating within a plane (which may be referred to as a "movement plane") or rotating around a fixed axis within the movement plane. The to-be-processed workpiece and the movable stage move synchronously. Therefore, a physical position of the movable stage and a physical position of the to-be-processed workpiece described herein are regarded as the same, and both of which may be represented interchangeably. Within a movement range of the movable stage, two mutually perpendicular grating scales are configured. For example, in a case that the movable stage stays at a predetermined initial physical position, the readings on the grating scales in this case may be set to 0, and the physical position is determined as the origin O of the world coordinate system. A first grating scale is arranged along a first direction and passing through the origin O, and the axis on which the first grating scale is located serves as the X-axis of the world coordinate system. A second grating scale is arranged perpendicular to the X-axis and passing through the origin O. The axis on which the second grating scale is located serves as the Y-axis of the world coordinate system. Based on the world coordinate system established above, each time the movable stage moves, that is, each time the to-be-processed workpiece moves, the X-axis coordinate is read from the first grating scale and the Y-axis coordinate is read from the second grating scale, and a coordinate (X, Y) represents a physical position of the to-be-processed workpiece. It can be understood that (X, Y) is coordinate data representing the displacement of the to-be-processed workpiece.

[0052] In an embodiment, the processing device includes a first image acquisition apparatus. Based on the hardware limitation of the processing device, it is defaulted that the physical position of the processing tool coincides with the physical position of the center of the field of

view of the first image acquisition apparatus. The first position information of the target predetermined processing line is represented by a first image position of a feature point in a detection image or a first physical position corresponding to the first image position, where the feature point is located on the target predetermined processing line in the detection image that is acquired by the first image acquisition apparatus. The second position information of the processing tool is represented by a second image position of the center of the field of view of the first image acquisition apparatus or a second physical position corresponding to the second image position.

[0053] According to the above technical solution, by using coordinates in an image coordinate system or in a physical coordinate system to represent the first position information of the target predetermined processing line and the second position information of the processing tool, the accuracy and consistency of the first position information and the second position information can be ensured.

[0054] In step S120, a position deviation is determined based on the first position information of the target predetermined processing line and the second position information of the processing tool.

[0055] In an embodiment, a position deviation is determined based on the first position information of the target predetermined processing line and the second position information of the processing tool. The position deviation may be a deviation in the X-axis direction, or a deviation in the Y-axis direction, or may be a relative deviation between the position of the target predetermined processing line and the position of the processing tool.

[0056] In step S130, the position deviation is compared with a target deviation threshold.

[0057] In an embodiment, a user sets the target deviation threshold in advance, to calibrate the position of the target predetermined processing line based on the target position deviation threshold and the calculated position deviation. The target deviation threshold may be equal to any value, such as 0.1 millimeters (mm), 0.2 mm, or 0.3 mm, and the like. In an embodiment of the present disclosure, the target position deviation threshold is equal to 0.2 mm.

[0058] In step S140, in response to the position deviation being less than or equal to the target deviation threshold, a position of the target predetermined processing line is calibrated based on the position deviation, so as to process the to-be-processed workpiece based on the calibrated

position of the target predetermined processing line.

[0059] In an embodiment, in a case that the position deviation is less than or equal to the target deviation threshold, the position of the to-be-processed workpiece is adjusted based on the position deviation to calibrate the position of the target predetermined processing line. For example, in a case that the target position deviation threshold is equal to 0.2 mm and the position deviation is equal to +0.15 mm, the to-be-processed workpiece is moved by 0.15mm in a direction opposite to the deviation to calibrate the position of the target predetermined processing line.

[0060] In an embodiment, the calibrated position of the target predetermined processing line is determined as the position of the target predetermined processing line during actual processing, and the to-be-processed workpiece is processed at the position. In an embodiment, after the position of the target predetermined processing line is calibrated, the calibrated position of the target predetermined processing line may be determined as the position of the target predetermined processing line during actual processing. The processing tool performs processing along the target predetermined processing line at the calibrated position.

[0061] According to the above technical solution, the position deviation is determined based on the first position information of the target predetermined processing line and the second position information of the processing tool. After comparing the position deviation with the target deviation threshold, in response to the position deviation being less than or equal to the target deviation threshold, the position of the target predetermined processing line is calibrated based on the position deviation. The to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line. This solution involves acquiring the first position information of the target predetermined processing line and the second position information of the processing tool, so as to determine whether it is required to calibrate the position of a current target predetermined processing line, and involves calibrating the position of the current target predetermined processing line on determining to calibrate. In this way, the accuracy of a current cleaving position of a cleaving blade is ensured, thereby preventing damage to the to-be-processed workpiece. In addition, an installation requirement for the perpendicularity between an X-axis and a Y-axis in the processing device is reduced, thereby reducing the hardware cost of the processing device.

[0062] In an embodiment, the target predetermined processing line is calibrated in a preset

order. Before the comparing the position deviation with a target deviation threshold, the method further includes: determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, where in a case that the expected spacing falls within any one specific spacing range among at least two spacing ranges, the target deviation threshold is equal to a preset deviation threshold which corresponds to the specific spacing range among at least two preset deviation thresholds. The at least two spacing ranges and the at least two preset deviation thresholds are in one-to-one correspondence, and among the at least two spacing ranges, a spacing range containing greater values corresponds to a greater preset deviation threshold.

[0063] In an embodiment, the target predetermined processing line is calibrated in a preset order. The preset order may refer to a processing order in the processing. FIG. 3 illustrates a schematic diagram of a to-be-processed workpiece according to an embodiment of the present disclosure. As shown in FIG. 3, the to-be-processed workpiece is provided with seven predetermined processing lines extending in a first direction thereon, which are predetermined processing lines L_1, L_2 ... L_7, respectively. The processing may be performed in an order from top to bottom (i.e., in an order from L_1 to L_7), or in an order from bottom to top (i.e., in an order from L_7 to L_1), or in an order from both ends to the middle (for example, in an order from L_1 to L_4 and then from L_7 to L_4), which is not limited in the present disclosure. Users may select any processing order to process the to-be-processed workpiece according to the actual processing scenario. The target deviation threshold may be determined based on an expected spacing H between a current target predetermined processing line and a previous target predetermined processing line.

[0064] The expected spacing H may be equal to an integer multiple of a die spacing h between any two adjacent dicing streets. For the processing performed in an order from L_7 to L_1, if it is required to calibrate the position of each predetermined processing line before processing the to-be-processed workpiece along the predetermined processing line, the expected spacing H is equal to the die spacing h. If it is required to calibrate the position of the current predetermined processing line every two predetermined processing lines, the expected spacing is equal to twice the die spacing (i.e. $H = 2h$). For the processing performed in an order from L_1 to L_4 and then from L_7 to L_4, if it is required to calibrate the position of each predetermined processing line before processing the to-be-processed workpiece along the predetermined processing line, the current target predetermined processing line is L_7 after processing L_4. A target predetermined

processing line immediately preceding the current target predetermined processing line L_7 is L_4, and thus the expected spacing H is equal to three times the die spacing. If it is required to calibrate the position of the current predetermined processing line every two predetermined processing lines, the current target predetermined processing line is L_7 after processing L_3. A target predetermined processing line immediately preceding the current target predetermined processing line L_7 is L_3, and thus the expected spacing H is equal to four times the die spacing. When the expected spacing falls within any specific spacing range among at least two spacing ranges, the target deviation threshold is equal to a preset deviation threshold which corresponds to the specific spacing range among at least two preset deviation thresholds. For example, the spacing ranges are [h, 5h) and [5h, 10h), respectively, and these two spacing ranges correspond preset deviation thresholds respectively.

[0065] The preset deviation corresponding to a spacing range is greater than the preset deviation corresponding to another spacing range when the spacing range is entirely higher than the another spacing range. In an embodiment of the present disclosure, a preset deviation threshold corresponding to a spacing range [h, 5h) is equal to 0.01mm, and a preset deviation threshold corresponding to a spacing range [5h, 10h) is equal to 0.2 mm. If the expected spacing is equal to 5h, the preset deviation threshold corresponding to [5h, 10h) is determined as the target deviation threshold. If the expected spacing is equal to 2h, the preset deviation threshold corresponding to [h, 5h) is determined as the target deviation threshold.

[0066] According to the above technical solution, the target deviation threshold is determined based on an expected spacing between the current target predetermined processing line and the previous target predetermined processing line. The target deviation threshold may be equal to one of at least two preset deviation thresholds that corresponds to a specific spacing range, and a preset deviation corresponding to a spacing range is greater than a preset deviation corresponding to another spacing range when the spacing range is entirely higher than the another spacing range. With this method, a great preset deviation threshold is selected in a case that the expected spacing is large, to avoid an increasing error due to the accumulation of processing times. If a small preset deviation threshold value is still selected for comparison with the position deviation of the current target predetermined line in this case, the calibration may fail. On the contrary, in a case that the expected spacing is small, a small preset deviation threshold is selected, to avoid large calibration amplitude caused by selecting a great preset deviation threshold for comparison with the position deviation of the current target

predetermined line.

[0067] In an embodiment, the at least two preset deviation thresholds include a first preset deviation threshold and a second preset deviation threshold. The first preset deviation threshold is greater than the second preset deviation threshold. The first preset deviation threshold and the second preset deviation threshold are in one-to-one correspondence with two spacing ranges, and a preset spacing threshold is equal to a boundary between the two spacing ranges. The determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, includes: determining, in response to the expected spacing being greater than or equal to the preset spacing threshold, the first preset deviation threshold as the target deviation threshold; and determining, in response to the expected spacing being less than the preset spacing threshold, the second preset deviation threshold as the target deviation threshold.

[0068] In an embodiment, the at least two preset deviation thresholds include the first preset deviation threshold and the second preset deviation threshold. The first preset deviation threshold is greater than the second preset deviation threshold. The first preset deviation threshold and the second preset deviation threshold are in one-to-one correspondence with two spacing ranges. For example, the spacing range [h, 5h) in the above embodiment corresponds to a second preset deviation threshold T_{h2}, and the spacing range [5h, 10h) in the above embodiment corresponds to a first preset deviation threshold T_{h1}. A boundary 5h between the two spacing ranges may represent the preset spacing threshold. In a case that the expected spacing is greater than or equal to the preset spacing threshold, the target deviation threshold is determined to be the first preset deviation threshold T_{h1}. In a case that the expected spacing is less than the preset spacing threshold, the target deviation threshold is determined to be the second preset deviation threshold T_{h2}.

[0069] According to the above technical solution, the boundary between the two spacing ranges is determined as the preset spacing threshold. In a case that the expected spacing is greater than or equal to the preset spacing threshold, the target deviation threshold is determined to be the first preset deviation threshold. Otherwise, the target deviation threshold is determined to be the second preset deviation threshold. In this way, different preset deviation thresholds are determined and applied based on the comparison result between the expected spacing and the preset spacing threshold, so as to ensure the accuracy of the calibration result.

[0070] In an embodiment, the to-be-processed workpiece is a wafer. The preset spacing threshold is equal to a specific multiple of a die spacing of the wafer. The first preset deviation threshold is equal to the specific multiple of a minimum deviation threshold. The die spacing is spacing between two adjacent predetermined processing lines. The minimum deviation threshold is equal to a difference between a position of any first predetermined processing line after the to-be-processed workpiece is moved by one die spacing in a second direction and a position of a second predetermined processing line before the movement. The second predetermined processing line is adjacent to the first predetermined processing line and located on a side facing a movement direction of the to-be-processed workpiece, and the second direction is along a second coordinate axis that is perpendicular to a first coordinate axis corresponding to the first direction in a mechanical coordinate system employed by the processing device.

[0071] In an embodiment, the to-be-processed workpiece is a wafer, and the preset spacing threshold is equal to a specific multiple of a die spacing h of the wafer. For example, in the foregoing embodiment, the preset spacing threshold is 5h, that is, the preset spacing threshold is equal to 5 times the die spacing. The die spacing is spacing between two adjacent predetermined processing lines, that is, a distance between any two adjacent dicing streets in the foregoing embodiment. The first preset deviation threshold may be equal to the specific multiple of a minimum deviation threshold. The minimum deviation threshold is equal to a difference between a position of any first predetermined processing line after the to-be-processed workpiece is moved by one die spacing in a second direction and a position of a second predetermined processing line before the movement. The first direction is a direction along the first coordinate axis (X-axis), and the second direction may be a direction along the second coordinate axis (Y-axis) perpendicular to the first coordinate axis (X-axis). Referring to FIG. 3, if the first predetermined processing line is L_2 and the processing order is from the predetermined processing line L_1 to the predetermined processing line L_7, the second predetermined processing line is L_3. It can be understood that in theory, the X-axis and the Y-axis are perpendicular to each other when the processing device is installed. However, due to installation errors, a non-perpendicularity condition between the X-axis and the Y-axis may occur. Under this condition, the difference between the position of any first predetermined processing line after the movement and the position of the second predetermined processing line before the movement is equal to the difference in a direction of the Y-axis in the real

physical world.

[0072] According to the above technical solution, the preset spacing threshold may be determined based on the die spacing. A first preset deviation threshold is determined based on the minimum deviation threshold. Therefore, the reliability of the determined preset spacing threshold and the first preset deviation threshold is ensured.

[0073] In an embodiment, before the comparing the position deviation with a target deviation threshold, the method may further include: determining the at least two preset deviation thresholds based on first parameter setting information inputted by a user.

[0074] In an embodiment, the processing device further includes an input apparatus and/or an output apparatus. The input apparatus and/or the output apparatus may be communicatively connected to or included in a processing parameter detection apparatus. The input apparatus may include, but is not limited to, one or more of a mouse, a keyboard, a microphone, a touch screen, and the like. The output apparatus may include, but is not limited to, one or more of a display apparatus, a speaker, and the like. The user may input first parameter setting information by using the input apparatus to determine the at least two preset deviation thresholds. In an embodiment of the present disclosure, a display interface of the current display apparatus includes two text input controls. One of the text input controls is used for inputting a parameter corresponding to a first preset deviation threshold, and a second text input control is used for inputting a parameter corresponding to a second preset deviation threshold. The user may input 0.2 into the first text input control by a mouse or a keyboard, which indicates that the first preset deviation threshold is 0.2 mm. Similarly, the user may also input 0.01 into the second text input control by a mouse or a keyboard, which indicates that the second preset deviation threshold is 0.01 mm.

[0075] According to the above technical solution, the user may determine the at least two preset deviation thresholds by inputting the first parameter setting information. In this way, requirements for different users or different application scenarios are met, and interactivity is enhanced.

[0076] In an embodiment, after the comparing the position deviation with a target deviation threshold, the method may further include: outputting alarm information in response to the position deviation being greater than the target deviation threshold.

[0077] In an embodiment, when the position deviation is greater than the target deviation threshold, the output apparatus outputs the alarm information. For example, the output apparatus is a display apparatus, and character information such as "Calibration Failure" may be outputted as the alarm information in a display interface of the display apparatus, to prompt the user that the current position deviation is greater than the target deviation threshold. For another example, the output apparatus is a microphone, and voice information such as "Calibration Failure" may be outputted as the alarm information, to prompt the user that the current position deviation is greater than the target deviation threshold.

[0078] According to the above technical solution, in a case that the position deviation is greater than the target deviation threshold, the alarm information is outputted. This prompts the user to manually calibrate the position of the current predetermined processing line, to ensure smooth processing of the to-be-processed workpiece.

[0079] In an embodiment, before the comparing the position deviation with a target deviation threshold, the method further includes: determining the target deviation threshold based on second parameter setting information inputted by a user.

[0080] In an embodiment, for an implementation of the user inputting the second parameter information, reference may be made to the related description of the user inputting the first parameter information in the foregoing embodiment, which is not repeated herein for the sake of brevity. The target deviation threshold is determined based on the second parameter setting information inputted by the user. The target deviation threshold may be the first preset deviation threshold or the second preset deviation threshold in the above embodiment.

[0081] According to the above technical solution, the user can input the second parameter setting information, so as to directly determine the target deviation threshold, thereby reducing operations by the user and offering better user experience and strong interactivity.

[0082] In an embodiment, before the comparing the position deviation with a target deviation threshold, the method may further include: determining a starting target predetermined processing line and/or a processing line spacing in each of the at least one processing stage based on third parameter setting information inputted by the user, where the processing line spacing is a distance between any two target predetermined processing lines in each processing stage.

[0083] In an embodiment, for an implementation of the user inputting the third parameter information, reference may be made to the related description of the user inputting the first parameter information in the foregoing embodiment, which is not repeated herein for the sake of brevity. Based on the third parameter setting information inputted by the user, a starting target predetermined processing line or a processing line spacing in each of the at least one processing stage may be determined, or a starting target predetermined processing line and a processing line spacing in each of the at least one processing stage may be determined. Referring again to FIG. 3, when the wafer is processed in the order from L_1 to L_7, an invalid dicing street may exist on the wafer. For example, if the dicing street corresponding to the predetermined processing line L_1 is an invalid dicing street, the user may input "2" into the input control corresponding to the starting target predetermined processing line, which indicates that the second predetermined processing line is determined as the starting target predetermined processing line. Similarly, the processing line spacing may also be inputted.

[0084] According to the above technical solution, the user inputs the third parameter setting information, so as to determine the starting target predetermined processing line and/or the processing line spacing in each of the at least one processing stage, thereby reducing operations by the user and offering better user experience and strong interactivity.

[0085] In an embodiment, the calibrating a position of the target predetermined processing line based on the position deviation includes: moving the image acquisition apparatus by a distance according to the position deviation, to calibrate the position of the target predetermined processing line.

[0086] In an embodiment, the image acquisition apparatus is controlled to move a distance according to the position deviation, to calibrate the position of the target predetermined processing line. For example, if the position deviation is equal to +0.15 mm, which indicates that the to-be-processed workpiece is deviated by 0.15 mm in the positive direction of the Y-axis, in this case, the image acquisition apparatus is controlled to move by 0.15 mm in the negative direction of the Y-axis, to calibrate the position of the target predetermined processing line.

[0087] According to the above technical solution, the image acquisition apparatus is controlled to move a distance according to the position deviation, to calibrate the position of the target predetermined processing line without complex calibration operations, improving the

efficiency.

[0088] In an embodiment, before the acquiring first position information of a target predetermined processing line, the method further includes: identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, where the first feature point is a feature point on any predetermined processing line; calibrating, based on the first direction, a third predetermined processing line where the first feature point is located; moving, after the calibration, the center of the field of view of the first image acquisition apparatus to a physical position, where the center of the field of view of the first image acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image; acquiring a second detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus; identifying a second feature point from the second detection image, where the second feature point is a feature point located on any predetermined processing line; moving the center of the field of view of the first image acquisition apparatus by a distance corresponding to an expected spacing, where the expected spacing is between a fourth predetermined processing line where the second feature point is located and a starting target predetermined processing line in a first processing stage among at least one processing stage; and acquiring a third detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus, where the third detection image includes the starting target predetermined processing line in the first processing stage, and performing the process of acquiring first position information of a target predetermined processing line for the starting target predetermined processing line in the first processing stage based on the third detection image.

[0089] In an embodiment, the processing device includes a first image acquisition apparatus. The first detection image is acquired by the first image acquisition apparatus. The first feature point is identified from the first detection image. By performing template matching on the first detection image using a template image, the first feature point in the first detection image is obtained. In an embodiment, the to-be-processed workpiece is a wafer, the template image may include an intersection region of two mutually perpendicular dicing streets on the wafer and a region within a preset range surrounding the intersection region. A matched feature point may be a center point of the intersection region. FIG. 4 illustrates a schematic diagram of a template image according to an embodiment of the present disclosure. As shown in FIG. 4, the template image includes a center point (represented by a black dot) of the dicing street. The center point

is determined as a reference point. In addition, FIG. 4 also shows a cross-shaped white region, and the cross is formed by portions of two mutually perpendicular dicing streets. An intersection region is illustrated by a rectangular box in dotted lines in the middle of the cross. The template image may further include a region (which may be referred to as a predetermined region) located within a preset range surrounding the intersection region, such as four gray sub-regions and a portion of the two dicing streets located outside the intersection region shown in FIG. 4. The preset range is provided such that image features contained in the intersection region and the predetermined region are sufficient for identifying the positions of the intersection region and predetermined region in an image through an image processing algorithm, where the image is acquired by the image acquisition apparatus. As shown in FIG. 4, the image features contained in the intersection region are not distinct and difficult to distinguish, and thus the surrounding predetermined region are incorporated to form sufficiently distinguishable image features, to facilitate determining the positions of the intersection region and the predetermined region. A main object is to determine the position of the intersection region, and consequently, to determine the position of the matched feature point. Based on the position of the matched feature point, the first feature point is identified from the first detection image. A third predetermined processing line where the first feature point is located is calibrated based on a first direction. The first direction may be, for example, a horizontal direction. In an embodiment, a predetermined processing line is calibrated based on an angle between the third predetermined processing line where the first feature point is located and the first direction. For example, if the angle between the predetermined processing line and the first direction is +2 degrees (°) in a clockwise direction, the predetermined processing line may be rotated by 2° in an anticlockwise direction, to calibrate the predetermined processing line. After the calibration is completed, the center of the field of view of the first image acquisition apparatus is moved to a physical position, where the center of the field of view of the first image acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image. Then, a second detection image is acquired by the moved first image acquisition apparatus. Based on the acquired second detection image and the template image, a second feature point may be identified from the second detection image. The second feature point may be a feature point on any predetermined processing line. For example, the second feature point may be a feature point on the predetermined processing line L_3 in the embodiment illustrated in FIG. 3. An expected spacing between the predetermined processing line L_3 and a

starting target predetermined processing line L_1 is 2h, and the center of the field of view of the first image acquisition apparatus may be moved by 2h, such that the starting target predetermined processing line is located within the field of view of the moved first image apparatus. A third detection image including the starting target predetermined processing line is acquired by the moved first image acquisition apparatus.

[0090] According to the above technical solution, by identifying the first feature point from the first detection image acquired by the first image acquisition apparatus, the first feature point is rapidly identified from the first detection image. The third predetermined processing line where the first feature point is located is calibrated based on the first direction. The center of the field of view of the first image acquisition apparatus is moved to a physical position after the calibration, where the center of the field of view of the first image acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image, and the second detection image is acquired. The second feature point is identified from the second detection image. With this method, by calibrating the predetermined processing line, high-precision positioning of the predetermined processing line can be achieved, thereby ensuring the accuracy of the obtained second feature point. The center of the field of view of the first image acquisition apparatus is moved by a distance corresponding to an expected spacing between a fourth predetermined processing line where the second feature point is located and a starting target predetermined processing line in a first processing stage among at least one processing stage, and a third detection image including the starting target predetermined processing line in the first processing stage is acquired by the first image acquisition apparatus after the movement of the first image acquisition apparatus. This ensures that the identified starting target predetermined processing line is located as close to the central region of the image as possible, thereby ensuring the accuracy of the first position information of the target predetermined processing line acquired subsequently.

[0091] In an embodiment, the processing device may further include a second image acquisition apparatus. An image acquisition range of the second image acquisition apparatus is greater than an image acquisition range of the first image acquisition apparatus. Before the identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, the method further includes: identifying a contour of the to-be-processed workpiece from a fourth detection image acquired by the second image acquisition apparatus, where when the second image acquisition apparatus acquires the fourth detection image, a

center of field of view of the second image acquisition apparatus coincides with a center of a carrying apparatus for carrying the to-be-processed workpiece; determining a third image position of a product center of the to-be-processed workpiece in the fourth detection image based on the contour of the to-be-processed workpiece; determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference; moving the carrying apparatus to a position within the field of view of the first image acquisition apparatus to enable a center of the carrying apparatus to coincide with the center of the field of view of the first image acquisition apparatus; adjusting the position of the carrying apparatus based on the physical position difference to enable a physical position of the product center of the to-be-processed workpiece on the carrying apparatus to coincide with the physical position of the center of the field of view of the first image acquisition apparatus; and acquiring, after the adjustment, the first detection image by the first image acquisition apparatus.

[0092] In an embodiment of the present disclosure, the processing device further includes a second image acquisition apparatus. An image acquisition range of the second image acquisition apparatus is greater than the image acquisition range of the first image acquisition apparatus. A contour of the to-be-processed workpiece is identified from the fourth detection image acquired by the second image acquisition apparatus. FIG. 5 illustrates a schematic diagram of a fourth detection image according to an embodiment of the present disclosure. As shown in FIG. 5, a black circular region represents a wafer. A contour of the black circular region is a contour of the wafer. For the fourth detection image, a grayscale threshold is set, and each pixel value in the fourth detection image is compared with the grayscale threshold, to determine a position of the contour of the wafer. The grayscale threshold may be any numerical value, for example, 50, 100, 150, and the like. Referring to FIG. 5, a dark region may represent a region where a pixel with a grayscale value less than 50 is located. Thus, a region where the wafer is located and the contour of the wafer are obtained. When the second image acquisition apparatus acquires the fourth detection image, the center of the field of view of the second image acquisition apparatus coincides with the center of a carrying apparatus for carrying a to-be-processed workpiece. In an embodiment of the present disclosure, a wafer serving as a to-be-processed workpiece is generally arranged at an iron ring. The product center of the wafer

may not coincide with the center of the iron ring due to misaligned wafer arrangement or an incomplete wafer. Due to hardware limitations of the processing device, when the iron ring is placed on the carrying apparatus, it may be defaulted that the center of the iron ring coincides with the center of the carrying apparatus. Therefore, the product center of the wafer does not necessarily coincide with the center of the carrying apparatus. An image position of the center of the field of view of the second image acquisition apparatus may be represented by (x_M, y_M). Based on a contour of the to-be-processed workpiece, a third image position of the product center in the fourth detection image may be determined by calculating an average value of the sum of pixel values for each row of pixels located within the contour of the workpiece as a first average value and an average value of the sum of pixel values for each column of pixels located within the contour of the workpiece as a second average value. The third image position may be represented by (x_{C1}, y_{C1}). Based on the third image position (x_{C1}, y_{C1}) and the second image position (x_M, y_M) of the center of the field of view of the second image acquisition apparatus, an image position difference between the image positions (x_{C1}, y_{C1}) and (x_M, y_M) is calculated. The difference between the x-coordinates is expressed as $\Delta x_1=x_{C1}-x_M$, and the difference between the y-coordinates is expressed as $\Delta y_1=y_{C1}-y_M$. A one-to-one conversion relationship exists between the image position of any object described herein and the physical position of the object in the world coordinate system. For example, based on an image position (x', y'), a physical position (X', Y'), corresponding to the image position, in the world coordinate system is obtained via the conversion relationship. Based on the obtained image position differences Δx_1 and Δy_1, physical position differences δX_1 and δY_1 corresponding to the image position differences Δx_1 and Δy_1 are obtained via the above conversion relationship. The carrying apparatus is moved to a position within the field of view of the first image acquisition apparatus, such that the center of the moved carrying apparatus coincides with the center of the field of view of the first image acquisition apparatus. Based on the calculated physical position differences δX_1 and δY_1, the position of the carrying apparatus is adjusted. The operation of moving the carrying apparatus may be performed manually by the user, or automatically by a processing control system. For example, the carrying apparatus may be moved by controlling a robotic arm, or the carrying apparatus may be directly controlled to move. The processing control system may be a processing device for processing the to-be-processed workpiece or other control system communicatively connected to the processing device, such as a host computer system or the like. A physical position of the product center of the to-be-processed

workpiece on the adjusted carrying apparatus coincides with a physical position of the center of the field of view of the first image acquisition apparatus. A first detection image is acquired by the adjusted first image acquisition apparatus.

[0093] According to the above technical solution, based on the image position difference between the third image position and the second image position of the center of the field of view of the second image acquisition apparatus and the conversion relationship between the image position and the physical position, the physical position difference corresponding to the image position difference is determined. The carrying apparatus is moved according to the physical position difference after the carrying apparatus is moved to a position within the field of view of the first image acquisition apparatus, such that the physical position of the product center of the to-be-processed workpiece coincides with the physical position of the center of the field of view of the first image acquisition apparatus. After the movement, the first detection image is acquired by the first image acquisition apparatus. With this method, the physical position where the product center of the to-be-processed workpiece coincides the center of the field of view of the first image acquisition apparatus is rapidly determined based on the conversion relationship and in coordination with the movement of the carrying apparatus. This solution is implemented with a simple algorithm and the physical position of the coincidence is determined accurately.

[0094] In an embodiment, before the determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference, the method further includes: acquiring multiple fifth detection images, where the multiple fifth detection images of the to-be-processed workpiece are acquired by the first image acquisition apparatus when the to-be-processed workpiece is located at multiple fourth physical positions, the quantity of the multiple fifth detection images is greater than or equal to 3, and the multiple fourth physical positions are different from each other; for each fifth detection image of the multiple fifth detection images, determining an image position of an identification feature in the fifth detection image based on a template image, where the template image includes the identification feature on the to-be-processed workpiece; and determining the conversion relationship based on the image positions of the identification feature in the multiple fifth detection images and the multiple fourth physical positions.

[0095] In an embodiment, the quantity of the multiple fifth detection images is greater than or equal to 3. By way of example and not limitation, the quantity of the multiple fifth detection images is greater than or equal to 3 and less than or equal to 9. For example, nine fifth detection images are acquired. The nine fifth detection images of the to-be-processed workpiece may be acquired by the image acquisition apparatus when the to-be-processed workpiece is located at nine different fourth physical positions, respectively. The nine different fourth physical positions may be denoted as K_1, K_2, ..., and K_9 respectively and may be any positions.

[0096] For each fifth detection image of the nine fifth detection images, an image position of an identification feature in the fifth detection image may be determined based on an acquired template image. The identification feature may be any recognizable feature on the to-be-processed workpiece, which may be a feature point on the predetermined processing line described herein, or another form of feature. In an embodiment, the identification feature may be inherent feature points on the to-be-processed workpiece, such as features on certain shapes or structures. In an embodiment, the identification feature may also be a feature that is additionally marked on the to-be-processed workpiece manually or by the processing device, such as some easily recognizable symbol, pattern and the like. The identification feature may be of any shape, for example, circular, cross-shaped, star-shaped, and the like. The determining an image position of an identification feature in the fifth detection image based on a template image may be performed by: identifying an identification feature that matches the identification feature in the template image from the fifth detection image, and determining the image position of the identification feature in the fifth detection image as the image position of the identification feature in the fifth detection image.

[0097] Based on image positions F_1, F_2, ...,F_9 of the identification feature in the nine fifth detection images and nine corresponding fourth physical positions K_1, K_2, ...,K_9, a mapping relationship between coordinates of the image positions and coordinates of the physical positions may be established as $(X_K, Y_K) = f(w)(x_F, y_F)$. (X_K, Y_K) represents the fourth physical position, and (x_F, y_F) represents the image position. The f(w) matrix is calculated based on the determined nine coordinate points, and then a conversion relationship between each image position and the corresponding fourth physical position is determined. Based on the conversion relationship, a conversion relationship between any image position and a physical position corresponding to the image position is determined.

[0098] According to the above technical solution, a conversion relationship is determined based on the image positions of the identification feature in the multiple fifth detection images and the multiple fourth physical positions of the identification feature. With the technical solution, the conversion relationship can be determined based on multiple image positions and multiple fourth physical positions. The technical solution features a simple algorithm and straightforward implementation.

[0099] In an embodiment, the calibrating, based on the first direction, a third predetermined processing line where the first feature point is located, includes: determining the first feature point as a reference position point, and sequentially determining multiple groups of position points based on the reference position point, where each group of the multiple groups of position points includes a first position point and a second position point that are located on different sides of the reference position point, a spacing between the first position point and the second position point in the multiple groups of position points gradually increases along the first direction across the groups, and different position points among the reference position point and the multiple groups of position points correspond to different feature points on the third predetermined processing line; calculating, each time after one group of the multiple groups of position points is determined, an angle of a connecting line relative to the first direction, where the connecting line is between the first position point and the second position point in the group of position points, and performing a calibration operation which includes: determining an adjustment angle based on the angle of the connecting line in a case that the angle of the connecting line is greater than a preset angle threshold, and adjusting a position of the to-be-processed workpiece according to the adjustment angle to calibrate a position of the third predetermined machining line on the to-be-processed workpiece; and stopping the calibration operation in a case that the angle of the connecting line is less than or equal to the preset angle threshold, where for the multiple groups of position points, after a current group of the multiple groups of position points is determined and the calibration operation for the current group is performed, a next group of position points is determined, and along the first direction, a spacing between the first position point and the second position point in the next group of position points is greater than a spacing between the first position point and the second position point in the current group of position points.

[0100] In an embodiment, the first feature point is determined as the reference position point, and multiple groups of position points are sequentially determined based on the reference

position point. Among the reference position point and the multiple groups of position points, different position points correspond to different feature points on the third predetermined processing line. A position point corresponding to any feature point may be an image position point of the feature point in the image coordinate system, or may be a physical position point of the feature point in the world coordinate system.

[0101] In an embodiment, the multiple groups of position points are determined based on the first feature point as the reference position point. For example, a first group of position points B_1B_2 may include a first position point B_1 and a second position point B_2. The first position point B_1 and the second position point B_2 may be located on different sides of the reference position point. Similarly, multiple groups of position points C_1C_2, D_1D_2, and the like may be sequentially determined, and each group of position points may include a first position point and a second position point. A spacing between the first position point and the second position point in the multiple groups of position points gradually increases along the first direction (horizontal direction) across the groups. That is, a spacing between the two position points D_1 and D_2 is greater than a spacing between the two position points C_1 and C_2. Different position points among the reference position point and the multiple groups of position points correspond to different feature points lying on the third predetermined processing line.

[0102] Each time after a group of position points is determined, the following operations may be performed to calibrate the position of the third predetermined processing line. The user may pre-configure a preset angle threshold for determining whether the third predetermined processing line is to be calibrated. The preset angle threshold may be any angle greater than 0. In an embodiment, and not by way of limitation, the preset angle threshold may be in a range of [0.001, 0.2] degrees, such as 0.1 degrees, 0.03 degrees, 0.006 degrees, 0.002 degrees, or the like. Calibrating the position of the third predetermined processing line may include the following calibration operation. In a case that the angle of a connecting line between the first position point B_1 and the second position point B_2 is 0.7 degrees, which is greater than the preset angle threshold of 0.002 degrees, the wafer may be rotated by an angle towards a direction opposite to an inclination direction of the connecting line between the first position point B1 and the second position point B2, such that the connecting line aligns with the horizontal direction. Then, for a second group of position points C_1C_2, specifically for a first position point C_1 and a second position point C_2 in the second group of position points C_1C_2, it is determined whether an angle of a connecting line between the first position point C_1 and the second position

point C_2 is greater than the preset angle threshold of 0.002 degrees in a similar manner as described above. If the angle of the connecting line between the first position point C_1 and the second position point C_2 is greater than the preset angle threshold of 0.002 degrees, a calibration operation is performed. After sequentially performing the above calibration operation, the calibration is stopped when the angle of the connecting line between the first position point and the second position point among the position points is less than or equal to the preset angle threshold value of 0.002 degrees. It should be noted that a spacing between two position points (e.g., C_1 and C_2) included in the next group of position points is greater than a spacing between two position points (e.g., B1 and B2) included in the current group of position points.

[0103] According to the above technical solution, multiple groups of position points are determined, and the position of the to-be-processed workpiece is adjusted based on an angle of a connecting line, relative to a predetermined reference direction, between two position points in each group of position points, to calibrate the position of the third predetermined processing line. With the multiple groups of position points, a high-precision positioning of the third predetermined processing line on the to-be-processed workpiece can be achieved over a wide range.

[0104] According to a second aspect of the present disclosure, a processing method is further provided. The processing method may be applied to a processing device. The processing device may include a processing tool. The processing tool is configured to process a to-be-processed workpiece along a predetermined processing line. The to-be-processed workpiece may be provided with at least one predetermined processing line extending in a first direction thereon. The processing method may include a first processing operation 610. FIG. 6 illustrates a flowchart of the first processing operation 610 according to an embodiment of the present disclosure. As shown in FIG. 6, the first processing operation 610 includes the following steps S611 and S612.

[0105] In step S611, a position of a target predetermined processing line during actual processing is determined by using the above method for calibrating the position of the predetermined processing line.

[0106] In an embodiment, those skilled in the art can understand the specific implementations and beneficial effects of the above step S611 by reading the related description of the method for calibrating the position of the predetermined processing line described above, which is not

repeated herein for the sake of brevity.

[0107] In step S612, the processing tool is controlled to perform processing at the position of the target predetermined processing line.

[0108] In an embodiment, after the position of the target predetermined processing line during actual processing is determined, it is defaulted that the position of the processing tool substantially aligns with the position of the target predetermined processing line. The processing tool is controlled to perform processing at the position of the target predetermined processing line.

[0109] According to the above technical solution, the position of the target predetermined processing line during actual processing is determined, and then the processing tool is controlled to perform processing at the position of the target predetermined processing line. This can ensure the processing accuracy and avoid damage to the to-be-processed workpiece.

[0110] In an embodiment, processing is performed along the at least one predetermined processing line in a preset order, and the first processing operation is performed when processing is performed along any one of the target predetermined processing line.

[0111] In an embodiment, the implementation in which the at least one predetermined processing line is sequentially processed in a preset order has been described in detail in the foregoing embodiment, and will not be repeated herein for the sake of brevity.

[0112] In an embodiment, the processing method further includes: performing, when processing is performed along any one non-target predetermined processing line other than the target predetermined processing line, a second processing operation, which includes: determining a position of the non-target predetermined processing line based on a position of a previous predetermined processing line in a previous processing operation; and controlling the processing tool to perform processing at the position of the non-target predetermined processing line.

[0113] In an embodiment, the position of the non-target predetermined processing line in a current processing operation is determined based on the position of the previous predetermined processing line in the previous processing operation. Referring again to FIG. 3, when the processing is performed in an order from a predetermined processing line L1 to a predetermined processing line L7, if processing is performed along the predetermined processing line L1, a

predetermined processing line L2 is determined to be next. When the processing is performed at a position of the predetermined processing line L2, the processing tool may be directly controlled to perform processing at the position of the predetermined processing line L2 without calibrating the position of the predetermined processing line L2.

[0114] According to the above technical solution, the position of the non-target predetermined processing line is determined based on the position of the previous predetermined processing line in the previous processing operation, and the processing tool is controlled to perform processing at the position of the non-target predetermined processing line. In this way, not all the predetermined processing lines are to be calibrated, improving the processing efficiency.

[0115] According to a third aspect of the present disclosure, an apparatus for calibrating a position of a predetermined processing line is provided. The apparatus for calibrating the position of the predetermined processing line may be applied to a processing device. The processing device includes a processing tool for processing a to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction thereon. FIG. 7 illustrates a schematic block diagram of an apparatus 700 for calibrating a position of a predetermined processing line according to an embodiment of the present disclosure. As shown in FIG. 7, the apparatus 700 for calibrating the position of the predetermined processing line includes an acquisition module 710, a first determination module 720, a comparison module 730, a calibration module 740, and a second determination module 750.

[0116] The acquisition module 710 is configured to acquire first position information of a target predetermined processing line. The target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line.

[0117] The first determination module 720 is configured to determine a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool.

[0118] The comparison module 730 is configured to compare the position deviation with a target deviation threshold.

[0119] The calibration module 740 is configured to calibrate a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold. The to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

[0120] Those skilled in the art can understand the specific implementations and beneficial effects of the apparatus for calibrating the position of the predetermined processing line described above by reading the related description of the method for calibrating the position of the predetermined processing line described above, which is not repeated herein for the sake of brevity.

[0121] According to a fourth aspect of the present disclosure, a processing apparatus is further provided. The processing apparatus may be applied to a processing device. The processing device includes a processing tool, and the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line. The to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction thereon. FIG. 8 illustrates a schematic block diagram of a processing apparatus 800 according to an embodiment of the present disclosure. As shown in FIG. 8, the processing apparatus 800 includes an execution module 810. The execution module 810 includes a determination sub-module 811 and a control sub-module 812.

[0122] The determination sub-module 811 is configured to determine a position of a target predetermined processing line during actual processing by using the apparatus for calibrating the position of the predetermined processing line described above.

[0123] The control sub-module 812 is configured to control the processing tool to perform processing at the position of the target predetermined processing line.

[0124] Those skilled in the art can understand the specific implementations and beneficial effects of the processing apparatus described above by reading the related description of the processing method described above, which is not repeated herein for the sake of brevity.

[0125] According to a fifth aspect of the present disclosure, an electronic device is further provided. FIG. 9 illustrates a schematic block diagram of an electronic device according to an embodiment of the present disclosure. As shown in FIG. 9, the electronic device 900 includes

a processor 910 and a memory 920. The memory 920 stores a computer program instruction, and the computer program instruction, when executed by the processor 910, performs the method for calibrating the position of the predetermined processing line described above and/or the processing method described above.

[0126] According to a sixth aspect of the present disclosure, a storage medium storing a computer program/instruction is further provided. The storage medium may include, for example, a storage component of a tablet computer, a hard disk of a personal computer, an erasable programmable read-only memory (EPROM), a portable read-only memory (CD-ROM), a USB memory, or any combination of the storage media described above. The storage medium may be any combination of one or more computer-readable storage media. The computer program/instruction, when executed by the processor, performs the method for calibrating the position of the predetermined processing line and/or the processing method described above.

[0127] Those skilled in the art can understand the specific implementations of the electronic device and the storage medium described above by reading the related description of the method for calibrating the position of the predetermined processing line and/or the processing method described above, which is not repeated herein for the sake of brevity.

[0128] Embodiments:

[0129] Embodiment 1

A method for calibrating a position of a predetermined processing line, applied to a processing device, is provided, where the processing device includes a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the method includes:

acquiring first position information of a target predetermined processing line, where the target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line;

determining a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool;

comparing the position deviation with a target deviation threshold; and

calibrating a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold, where the to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

[0130] Embodiment 2

The method according to embodiment 1 is provided, where the target predetermined processing line is calibrated in a preset order, and

before the comparing the position deviation with a target deviation threshold, the method further includes:

determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, where

in a case that the expected spacing falls within any one specific spacing range among at least two spacing ranges, the target deviation threshold is equal to a preset deviation threshold which corresponds to the specific spacing range among at least two preset deviation thresholds, where the at least two spacing ranges and the at least two preset deviation thresholds are in one-to-one correspondence, and among the at least two spacing ranges, a spacing range containing greater values corresponds to a greater preset deviation threshold.

[0131] Embodiment 3

The method according to embodiment 1 or 2 is provided, where the at least two preset deviation thresholds comprise a first preset deviation threshold and a second preset deviation threshold, the first preset deviation threshold is greater than the second preset deviation threshold, the first preset deviation threshold and the second preset deviation threshold are in one-to-one correspondence with the two spacing ranges, and a preset spacing threshold is equal to a boundary between the two spacing ranges,

the determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, includes:

determining, in response to the expected spacing being greater than or equal to the preset spacing threshold, the first preset deviation threshold as the target deviation threshold; and

determining, in response to the expected spacing being less than the preset spacing threshold, the second preset deviation threshold as the target deviation threshold.

[0132] Embodiment 4

The method according to any one of embodiments 1 to 3 is provided, where the to-be-processed workpiece is a wafer, the preset spacing threshold is equal to a specific multiple of a die spacing of the wafer, the first preset deviation threshold is equal to the specific multiple of a minimum deviation threshold,

the die spacing is spacing between two adjacent predetermined processing lines, the minimum deviation threshold is equal to a difference between a position of any first predetermined processing line after the to-be-processed workpiece is moved by one die spacing in a second direction and a position of a second predetermined processing line before the movement, the second predetermined processing line is adjacent to the first predetermined processing line and located on a side facing a movement direction of the to-be-processed workpiece, and the second direction is along a second coordinate axis that is perpendicular to a first coordinate axis corresponding to the first direction in a mechanical coordinate system employed by the processing device.

[0133] Embodiment 5

The method according to any one of embodiments 1 to 4 is provided, where before the comparing the position deviation with a target deviation threshold, the method further includes:

determining the at least two preset deviation thresholds based on first parameter setting information inputted by a user.

[0134] Embodiment 6

The method according to any one of embodiments 1 to 5 is provided, where after the comparing the position deviation with a target deviation threshold, the method further includes:

outputting alarm information in response to the position deviation being greater than the target deviation threshold.

[0135] Embodiment 7

The method according to any one of embodiments 1 to 6 is provided, where before the comparing the position deviation with a target deviation threshold, the method further includes:

determining the target deviation threshold based on second parameter setting information inputted by a user.

[0136] Embodiment 8

The method according to any one of embodiments 1 to 7 is provided, where the processing device includes a first image acquisition apparatus, a physical position of the processing tool remains aligned with a physical position of a center of field of view of the first image acquisition apparatus;

the first position information of the target predetermined processing line is represented by a first image position of a feature point in a detection image or a first physical position corresponding to the first image position, the feature point is located on the target predetermined processing line in the detection image that is acquired by the first image acquisition apparatus, and the second position information of the processing tool is represented by a second image position of the center of the field of view of the first image acquisition apparatus or a second physical position corresponding to the second image position.

[0137] Embodiment 9

The method according to any one of embodiments 1 to 8 is provided, where the calibrating a position of the target predetermined processing line based on the position deviation includes:

moving the image acquisition apparatus by a distance according to the position deviation, to calibrate the position of the target predetermined processing line.

[0138] Embodiment 10

The method according to any one of embodiments 1 to 9 is provided, where before the acquiring first position information of a target predetermined processing line, the method further includes:

identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, where the first feature point is a feature point on any one of the at least one predetermined processing line;

calibrating, based on the first direction, a third predetermined processing line where the first feature point is located;

moving, after the calibration, the center of the field of view of the first image acquisition

apparatus to a physical position, where the center of the field of view of the first image acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image;

acquiring a second detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus;

identifying a second feature point from the second detection image, where the second feature point is a feature point located on any one of the at least one predetermined processing line;

moving the center of the field of view of the first image acquisition apparatus by a distance corresponding to an expected spacing, where the expected spacing is between a fourth predetermined processing line where the second feature point is located and a starting target predetermined processing line in a first processing stage among at least one processing stage; and

acquiring a third detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus, where the third detection image includes the starting target predetermined processing line in the first processing stage, and performing the process of acquiring first position information of a target predetermined processing line for the starting target predetermined processing line in the first processing stage based on the third detection image.

[0139] Embodiment 11

The method according to any one of embodiments 1 to 10 is provided, where the processing device further includes a second image acquisition apparatus, an image acquisition range of the second image acquisition apparatus is greater than an image acquisition range of the first image acquisition apparatus, and before the identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, the method further includes:

identifying a contour of the to-be-processed workpiece from a fourth detection image acquired by the second image acquisition apparatus, where when the second image acquisition apparatus acquires the fourth detection image, a center of field of view of the second image acquisition apparatus coincides with a center of a carrying apparatus for carrying the to-be-processed workpiece;

determining a third image position of a product center of the to-be-processed workpiece in the fourth detection image based on the contour of the to-be-processed workpiece;

determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference;

moving the carrying apparatus to a position within the field of view of the first image acquisition apparatus to enable a center of the carrying apparatus to coincide with the center of the field of view of the first image acquisition apparatus;

adjusting the position of the carrying apparatus based on the physical position difference to enable a physical position of the product center of the to-be-processed workpiece on the carrying apparatus to coincide with the physical position of the center of the field of view of the first image acquisition apparatus; and

acquiring, after the adjustment, the first detection image by the first image acquisition apparatus.

[0140] Embodiment 12

The method according to any one of embodiments 1 to 11 is provided, where before the determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference, the method further includes:

acquiring multiple fifth detection images, where the plurality of fifth detection images of the to-be-processed workpiece are acquired by the first image acquisition apparatus when the to-be-processed workpiece is located at multiple fourth physical positions, the quantity of the multiple fifth detection images is greater than or equal to 3, and the multiple fourth physical positions are different from each other;

for each fifth detection image of the multiple fifth detection images, determining an image position of an identification feature in the fifth detection image based on a template image, where the template image includes the identification feature on the to-be-processed workpiece;

and

determining the conversion relationship based on the image positions of the identification feature in the multiple fifth detection images and the multiple fourth physical positions.

[0141] Embodiment 13

The method according to any one of embodiments 1 to 12 is provided, where the calibrating, based on the first direction, a third predetermined processing line where the first feature point is located, includes:

determining the first feature point as a reference position point, and sequentially determining multiple groups of position points based on the reference position point, where each group of the plurality groups of position points includes a first position point and a second position point that are located on different sides of the reference position point, a spacing between the first position point and the second position point in the multiple groups of position points gradually increases along the first direction across the groups, and different position points among the reference position point and the multiple groups of position points correspond to different feature points on the third predetermined processing line;

calculating, each time after one group of the multiple groups of position points is determined, an angle of a connecting line relative to the first direction, where the connecting line is between the first position point and the second position point in the group of position points, and performing a calibration operation which includes:

determining an adjustment angle based on the angle of the connecting line in a case that the angle of the connecting line is greater than a preset angle threshold, and adjusting a position of the to-be-processed workpiece according to the adjustment angle to calibrate a position of the third predetermined processing line on the to-be-processed workpiece; and

stopping the calibration operation in a case that the angle of the connecting line is less than or equal to the preset angle threshold, where

for the multiple groups of position points, after a current group of the multiple groups of position points is determined and the calibration operation for the current group is performed, a next group of position points is determined, and along the first direction, a spacing between the first position point and the second position point in the next group of position points is greater than a spacing between the first position point and the second position point in the

current group of position points.

[0142] Embodiment 14

A processing method, applied to a processing device, is provided, where the processing device includes a processing tool, the processing tool is configured to process a to-be-processed workpiece along a predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the processing method includes:

performing a first processing operation, which includes:

determining a position of a target predetermined processing line during actual processing by using the method for calibrating the position of the predetermined processing line according to any one of embodiments 1 to 13; and

controlling the processing tool to perform processing at the position of the target predetermined processing line.

[0143] Embodiment 15

The processing method according to embodiment 14 is provided, where processing is performed along the at least one predetermined processing line in a preset order, and the first processing operation is performed when processing is performed along any one of the at least one target predetermined processing line.

[0144] Embodiment 16

The processing method according to embodiment 14 or 15 is provided, further comprising:

performing, when processing is performed along any one non-target predetermined processing line other than the target predetermined processing line, a second processing operation, which includes:

determining a position of the non-target predetermined processing line based on a position of a previous predetermined processing line in a previous processing operation; and

controlling the processing tool to perform processing at the position of the non-target predetermined processing line.

[0145] Embodiment 17

An apparatus for calibrating a position of a predetermined processing line, applied to a processing device, is provided, where the processing device includes a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the apparatus includes:

an acquisition module, configured to acquire first position information of a target predetermined processing line, where the target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line;

a first determination module, configured to determine a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool;

a comparison module, configured to compare the position deviation with a target deviation threshold; and

a calibration module, configured to calibrate a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold, where the to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

[0146] Embodiment 18

A processing apparatus, applied to a processing device, is provided, where the processing device includes a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the processing apparatus includes an execution module, where the execution module includes a determination sub-module and a control sub-module,

the determination sub-module, configured to determine a position of a target predetermined processing line during actual processing by using the apparatus for calibrating the position of the predetermined processing line according to embodiment 17; and

the control sub-module, configured to control the processing tool to perform processing at the position of the target predetermined processing line.

[0147] Embodiment 19

An electronic device, including a processor and a memory, is provided, where the memory stores a computer program instruction, and the computer program instruction, when executed by the processor, performs the method for calibrating the position of the predetermined processing line according to any one of embodiments 1 to 13 and/or the processing method according to any one of embodiments 14 to 16.

[0148] Embodiment 20

A storage medium, storing a computer program/instruction is provided, where the computer program/instruction, when executed, performs the method for calibrating the position of the predetermined processing line according to any one of embodiments 1 to 13 and/or the processing method according to any one of embodiments 14 to 16.

[0149] Although the example embodiments have been described herein with reference to the drawings, it should be understood that the above example embodiments are merely exemplary and are not intended to limit the scope of the present disclosure. Various changes and modifications may be made by those skilled in the art without departing from the scope and spirit of the present disclosure. All such changes and modifications are deemed to fall into the scope of the claims of the present disclosure.

[0150] Those skilled in the art may realize that, the units and algorithm steps of each example described in conjunction with embodiments herein may be implemented by electronic hardware, or a combination of computer software and electronic hardware. Whether these functions are performed in hardware or software depends on the specific application and design constraints of the technical solutions. Those skilled in the art may use different methods to implement the described functions for each specific application, but such implementation should not be regarded as beyond the scope of the present disclosure.

[0151] It should be understood that the devices and methods disclosed in the embodiments of the present disclosure may be implemented in other manners. For example, the device embodiments described hereinabove are only schematic. For example, the division of the units is only based on logical functions, and there may be other division ways in actual implementation, such as multiple units or components may be combined or integrated into another device, or some features may be neglected or not executed.

[0152] In the specification provided herein, numerous specific details are described. However, it can be understood that the embodiments of the present disclosure may be practiced without these specific details. In some instances, well-known methods, structures, and techniques are not shown in detail to avoid obscuring understanding of this specification.

[0153] Similarly, it should be understood that in order to simplify the present disclosure and facilitate understanding one or more of the various aspects of the application, in the description of the exemplary embodiments of the present disclosure, the various features of the present disclosure are sometimes grouped together into a single embodiment, figure, or description thereof. However, the method according to the present disclosure should not be interpreted as reflecting the following intention: the claimed application requires more features than those explicitly stated in each claim. More specifically, as reflected in the corresponding claims, the inventive point lies in that the corresponding technical problem can be solved with features fewer than all the features in a single disclosed embodiment. Therefore, the claims following the detailed embodiments are hereby expressly incorporated into the detailed embodiments, where each claim itself serves as an independent embodiment of the present disclosure.

[0154] It can be understood by those skilled in the art that, except for mutually exclusive features, all features disclosed in this specification (including the appended claims, abstract, and drawings) and all processes or units of any method or device disclosed in this specification may be combined in any way. Unless otherwise explicitly stated, each of the features disclosed in this specification (including the appended claims, abstract, and drawings) may be replaced by an alternative feature that provides the same, equivalent, or similar purpose.

[0155] In addition, it may be understood by those skilled in the art that, although some embodiments described herein include certain features included in other embodiments instead of other features, the combination of features of different embodiments is meant to be within the scope of the present disclosure and form different embodiments. For example, in the claims, any one of the claimed embodiments may be used in any combination.

[0156] The various component embodiments of the present disclosure may be implemented in hardware, or in software modules running on one or more processors, or in a combination thereof. It may be understood by those skilled in the art that a microprocessor or a digital signal processor (DSP) may be adopted in practice to realize some or all of the functions of some of the modules of the apparatus for calibrating the position of the predetermined processing line

and/or the processing apparatus according to the embodiments of the present disclosure. The present disclosure may alternatively be implemented as a device program (such as a computer program and a computer program product) for performing part or all of the methods described herein. Such a program implementing the present disclosure may be stored on a computer-readable medium, or may be in the form of one or more signals. Such a signal may be downloaded from an Internet website, or provided on a carrier signal, or provided in any other form.

[0157] It should be noted that the above embodiments illustrate rather than limit the present disclosure, and alternative embodiments may be designed by those skilled in the art without departing from the scope of the claims. In the claims, any reference numerals located between parentheses shall not be construed as a limitation on the claims. The word "comprising (including)" does not exclude the presence of elements or steps not listed in the claims. The word "a" or "an" preceding an element does not exclude the presence of multiple such elements. The present disclosure may be implemented by means of hardware including several different elements and by means of a suitably programmed computer. In a unit claim listing several devices, some of these devices may be embodied by a same hardware item. The use of the words "first", "second", and "third", etc. does not indicate any order. These words may be interpreted as names.

[0158] Described above are only specific embodiments of the present disclosure or explanation for the specific embodiments of the present disclosure, and the protection scope of the present disclosure is not limited thereto. Any changes or alternations that can be easily envisaged by those skilled in the art within the technical scope disclosed in the present disclosure shall fall within the protection scope of the present disclosure. Therefore, the protection scope of the present disclosure shall be in accordance with the protection scope of the claims.

CLAIMS

1. A method for calibrating a position of a predetermined processing line, applied to a processing device, wherein the processing device comprises a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the method comprises:

acquiring first position information of a target predetermined processing line, wherein the target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line;

determining a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool;

comparing the position deviation with a target deviation threshold; and

calibrating a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold, wherein the to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

2. The method according to claim 1, wherein the target predetermined processing line is calibrated in a preset order, and

before the comparing the position deviation with a target deviation threshold, the method further comprises:

determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, wherein

in a case that the expected spacing falls within any one specific spacing range among at least two spacing ranges, the target deviation threshold is equal to a preset deviation threshold which corresponds to the specific spacing range among at least two preset deviation thresholds, wherein the at least two spacing ranges and the at least two preset deviation thresholds are in one-to-one correspondence, and among the at least two spacing ranges, a spacing range containing greater values corresponds to a greater preset deviation threshold.

3. The method according to claim 2, wherein the at least two preset deviation thresholds comprise a first preset deviation threshold and a second preset deviation threshold, the first preset deviation threshold is greater than the second preset deviation threshold, the first preset deviation threshold and the second preset deviation threshold are in one-to-one correspondence with the two spacing ranges, and a preset spacing threshold is equal to a boundary between the two spacing ranges,

the determining the target deviation threshold based on an expected spacing between a current target predetermined processing line and a previous target predetermined processing line, comprises:

determining, in response to the expected spacing being greater than or equal to the preset spacing threshold, the first preset deviation threshold as the target deviation threshold; and

determining, in response to the expected spacing being less than the preset spacing threshold, the second preset deviation threshold as the target deviation threshold.

4. The method according to claim 3, wherein the to-be-processed workpiece is a wafer, the preset spacing threshold is equal to a specific multiple of a die spacing of the wafer, the first preset deviation threshold is equal to the specific multiple of a minimum deviation threshold,

the die spacing is spacing between two adjacent predetermined processing lines, the minimum deviation threshold is equal to a difference between a position of any first predetermined processing line after the to-be-processed workpiece is moved by one die spacing in a second direction and a position of a second predetermined processing line before the movement, the second predetermined processing line is adjacent to the first predetermined processing line and located on a side facing a movement direction of the to-be-processed workpiece, and the second direction is along a second coordinate axis that is perpendicular to a first coordinate axis corresponding to the first direction in a mechanical coordinate system employed by the processing device.

5. The method according to claim 2, wherein before the comparing the position deviation with a target deviation threshold, the method further comprises:

determining the at least two preset deviation thresholds based on first parameter setting information inputted by a user.

6. The method according to claim 1, wherein after the comparing the position deviation with a target deviation threshold, the method further comprises:

outputting alarm information in response to the position deviation being greater than the target deviation threshold.

7. The method according to claim 1, wherein before the comparing the position deviation with a target deviation threshold, the method further comprises:

determining the target deviation threshold based on second parameter setting information inputted by a user.

8. The method according to any one of claims 1 to 7, wherein the processing device comprises a first image acquisition apparatus, a physical position of the processing tool remains aligned with a physical position of a center of field of view of the first image acquisition apparatus;

the first position information of the target predetermined processing line is represented by a first image position of a feature point in a detection image or a first physical position corresponding to the first image position, the feature point is located on the target predetermined processing line in the detection image that is acquired by the first image acquisition apparatus, and the second position information of the processing tool is represented by a second image position of the center of the field of view of the first image acquisition apparatus or a second physical position corresponding to the second image position.

9. The method according to claim 8, wherein the calibrating a position of the target predetermined processing line based on the position deviation comprises:

moving the image acquisition apparatus by a distance according to the position deviation, to calibrate the position of the target predetermined processing line.

10. The method according to claim 8, wherein before the acquiring first position information of a target predetermined processing line, the method further comprises:

identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, wherein the first feature point is a feature point on any one of the at least one predetermined processing line;

calibrating, based on the first direction, a third predetermined processing line where the first feature point is located;

moving, after the calibration, the center of the field of view of the first image acquisition apparatus to a physical position, wherein the center of the field of view of the first image

acquisition apparatus is located at the physical position when the first image acquisition apparatus acquires the first detection image;

acquiring a second detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus;

identifying a second feature point from the second detection image, wherein the second feature point is a feature point located on any one of the at least one predetermined processing line;

moving the center of the field of view of the first image acquisition apparatus by a distance corresponding to an expected spacing, wherein the expected spacing is between a fourth predetermined processing line where the second feature point is located and a starting target predetermined processing line in a first processing stage among at least one processing stage; and

acquiring a third detection image by the first image acquisition apparatus after the movement of the first image acquisition apparatus, wherein the third detection image comprises the starting target predetermined processing line in the first processing stage, and performing the process of acquiring first position information of a target predetermined processing line for the starting target predetermined processing line in the first processing stage based on the third detection image.

11. The method according to claim 10, wherein the processing device further comprises a second image acquisition apparatus, an image acquisition range of the second image acquisition apparatus is greater than an image acquisition range of the first image acquisition apparatus, and before the identifying a first feature point from a first detection image acquired by the first image acquisition apparatus, the method further comprises:

identifying a contour of the to-be-processed workpiece from a fourth detection image acquired by the second image acquisition apparatus, wherein when the second image acquisition apparatus acquires the fourth detection image, a center of field of view of the second image acquisition apparatus coincides with a center of a carrying apparatus for carrying the to-be-processed workpiece;

determining a third image position of a product center of the to-be-processed workpiece in the fourth detection image based on the contour of the to-be-processed workpiece;

determining, based on an image position difference between a second image position of

the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference;

moving the carrying apparatus to a position within the field of view of the first image acquisition apparatus to enable a center of the carrying apparatus to coincide with the center of the field of view of the first image acquisition apparatus;

adjusting the position of the carrying apparatus based on the physical position difference to enable a physical position of the product center of the to-be-processed workpiece on the carrying apparatus to coincide with the physical position of the center of the field of view of the first image acquisition apparatus; and

acquiring, after the adjustment, the first detection image by the first image acquisition apparatus.

12. The method according to claim 11, wherein before the determining, based on an image position difference between a second image position of the center of the field of view of the second image acquisition apparatus and the third image position and a conversion relationship between an image position and a physical position, a physical position difference corresponding to the image position difference, the method further comprises:

acquiring a plurality of fifth detection images, wherein the plurality of fifth detection images of the to-be-processed workpiece are acquired by the first image acquisition apparatus when the to-be-processed workpiece is located at a plurality of fourth physical positions, the quantity of the plurality of fifth detection images is greater than or equal to 3, and the plurality of fourth physical positions are different from each other;

for each fifth detection image of the plurality of fifth detection images, determining an image position of an identification feature in the fifth detection image based on a template image, wherein the template image comprises the identification feature on the to-be-processed workpiece; and

determining the conversion relationship based on the image positions of the identification feature in the plurality of fifth detection images and the plurality of fourth physical positions.

13. The method according to claim 10, wherein the calibrating, based on the first direction, a third predetermined processing line where the first feature point is located, comprises:

determining the first feature point as a reference position point, and sequentially determining a plurality of groups of position points based on the reference position point, wherein each group of the plurality groups of position points comprises a first position point and a second position point that are located on different sides of the reference position point, a spacing between the first position point and the second position point in the plurality of groups of position points gradually increases along the first direction across the groups, and different position points among the reference position point and the plurality of groups of position points correspond to different feature points on the third predetermined processing line;

calculating, each time after one group of the plurality of groups of position points is determined, an angle of a connecting line relative to the first direction, where the connecting line is between the first position point and the second position point in the group of position points, and performing a calibration operation which comprises:

determining an adjustment angle based on the angle of the connecting line in a case that the angle of the connecting line is greater than a preset angle threshold, and adjusting a position of the to-be-processed workpiece according to the adjustment angle to calibrate a position of the third predetermined processing line on the to-be-processed workpiece; and

stopping the calibration operation in a case that the angle of the connecting line is less than or equal to the preset angle threshold, wherein

for the plurality of groups of position points, after a current group of the plurality of groups of position points is determined and the calibration operation for the current group is performed, a next group of position points is determined, and along the first direction, a spacing between the first position point and the second position point in the next group of position points is greater than a spacing between the first position point and the second position point in the current group of position points.

14. A processing method, applied to a processing device, wherein the processing device comprises a processing tool, the processing tool is configured to process a to-be-processed workpiece along a predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the processing method comprises:

performing a first processing operation, which comprises:

determining a position of a target predetermined processing line during actual processing

by using the method for calibrating the position of the predetermined processing line according to any one of claims 1 to 13; and

controlling the processing tool to perform processing at the position of the target predetermined processing line.

15. The processing method according to claim 14, wherein processing is performed along the at least one predetermined processing line in a preset order, and the first processing operation is performed when processing is performed along any one of the at least one target predetermined processing line.

16. The processing method according to claim 15, further comprising:

performing, when processing is performed along any one non-target predetermined processing line other than the target predetermined processing line, a second processing operation, which comprises:

determining a position of the non-target predetermined processing line based on a position of a previous predetermined processing line in a previous processing operation; and

controlling the processing tool to perform processing at the position of the non-target predetermined processing line.

17. An apparatus for calibrating a position of a predetermined processing line, applied to a processing device, wherein the processing device comprises a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the apparatus comprises:

an acquisition module, configured to acquire first position information of a target predetermined processing line, wherein the target predetermined processing line is a predetermined processing line to be calibrated among the at least one predetermined processing line;

a first determination module, configured to determine a position deviation based on the first position information of the target predetermined processing line and second position information of the processing tool;

a comparison module, configured to compare the position deviation with a target deviation threshold; and

a calibration module, configured to calibrate a position of the target predetermined processing line based on the position deviation in response to the position deviation being less than or equal to the target deviation threshold, wherein the to-be-processed workpiece is processed based on the calibrated position of the target predetermined processing line.

18. A processing apparatus, applied to a processing device, wherein the processing device comprises a processing tool, the processing tool is configured to process a to-be-processed workpiece along the predetermined processing line, the to-be-processed workpiece is provided with at least one predetermined processing line extending in a first direction, and the processing apparatus comprises an execution module, wherein the execution module comprises a determination sub-module and a control sub-module,

the determination sub-module, configured to determine a position of a target predetermined processing line during actual processing by using the apparatus for calibrating the position of the predetermined processing line according to claim 17; and

the control sub-module, configured to control the processing tool to perform processing at the position of the target predetermined processing line.

19. An electronic device, comprising a processor and a memory, wherein the memory stores a computer program instruction, and the computer program instruction, when executed by the processor, performs the method for calibrating the position of the predetermined processing line according to any one of claims 1 to 13 and/or the processing method according to any one of claims 14 to 16.

20. A storage medium, storing a computer program/instruction, wherein the computer program/instruction, when executed, performs the method for calibrating the position of the predetermined processing line according to any one of claims 1 to 13 and/or the processing method according to any one of claims 14 to 16.