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PROCESSING DEVICE AND PROCESSING METHOD

Abstract

A processing device for processing a workpiece includes: a holding table that holds the workpiece; a processing unit that performs processing on the workpiece held on the holding table; an abnormality detection unit that detects an abnormality of the workpiece; and a control unit that controls at least the processing unit and the abnormality detection unit. The control unit includes: a registration unit that registers first reference information serving as a reference for determining that the workpiece before processing is normal; and a comparison unit that compares the first reference information registered in the registration unit with first detection information obtained by detecting the workpiece by the abnormality detection unit before the workpiece is processed by the processing unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2024-020532 filed in Japan on Feb. 14, 2024.

BACKGROUND

[0002] The present disclosure relates to a processing device and a processing method for processing a workpiece.

[0003] A plurality of devices are formed on a front surface of a thin plate-shaped wafer and then the wafer is divided into individual devices, so that device chips to be mounted on electronic devices can be formed. For dividing a workpiece such as a wafer, for example, a processing device is used, such as a cutting device capable of cutting the workpiece with an annular cutting blade or a laser processing device that irradiates the workpiece with a laser beam to process the workpiece. In the processing device, the workpiece is processed under predetermined processing conditions in order to obtain a predetermined processing result.

[0004] However, the workpiece may not be appropriately processed by the processing device due to a defect of the processing device or the like. Then, when manufacturing is performed in a state where a scratch is generated on the workpiece or the chip or in a state where contamination (waste) adheres to the workpiece or the chip, the obtained chip may become a defective product.

[0005] Therefore, in order to confirm that the processing of the workpiece has been appropriately performed, the workpiece processed by the processing device is imaged and inspected by a camera unit (see, for example, JP 2021-32588 A).

[0006] However, when a scratch or contamination is found in the workpiece during the inspection as described in JP 2021-32588 A, the cause is not limited to a processing defect of the processing device, and may be a scratch already formed on the workpiece or contamination adhering to the workpiece before processing. In such a case, there is a problem that it takes time to specify the cause.

[0007] Therefore, concerning a processing device for processing a workpiece, there is a need for specifying whether an abnormality of a front surface of a workpiece is caused by a defect of the processing device.

SUMMARY

[0008] A processing device according the present disclosure is a device for processing a workpiece. The processing device includes: a holding table that holds the workpiece; a processing unit that performs processing on the workpiece held on the holding table; an abnormality detection unit that detects an abnormality of the workpiece; and a control unit that controls at least the processing unit and the abnormality detection unit. The control unit includes: a registration unit that registers first reference information serving as a reference for determining that the workpiece before processing is normal; and a comparison unit that compares the first reference information registered in the registration unit with first detection information obtained by detecting the workpiece by the abnormality detection unit before the workpiece is processed by the processing unit.

[0009] A processing method according to the present disclosure is a method for processing a workpiece. The processing method includes: holding the workpiece on a holding table; performing processing on the workpiece held on the holding table by a processing unit; detecting an abnormality of the workpiece before performing the processing; and before performing the processing and after detecting the abnormality of the workpiece, comparing reference information

registered for determining that the workpiece before processing is normal with detection information obtained by newly detecting the workpiece in detecting the abnormality.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a perspective view illustrating a configuration example of a processing device according to a first embodiment;

[0011] FIG. **2** is a diagram illustrating an example of a first reference image registered in a registration unit of a control unit of the processing device illustrated in FIG. **1**;

[0012] FIG. **3** is a diagram illustrating an example of a second reference image registered in the registration unit of the control unit of the processing device illustrated in FIG. **1**;

[0013] FIG. **4** is a flowchart illustrating a part of a flow of a processing method according to the first embodiment;

[0014] FIG. **5** is a flowchart illustrating the other part of the flow of the processing method according to the first embodiment;

[0015] FIG. **6** is a diagram illustrating an example of a first comparison image generated in a first imaging step of the processing method illustrated in FIG. **4**;

[0016] FIG. **7** is a diagram illustrating an example of a second comparison image generated in a second imaging step of the processing method illustrated in FIG. **5**;

[0017] FIG. **8** is a diagram illustrating an example of a first reference image registered in a registration unit of a control unit of the processing device according to the second embodiment;

[0018] FIG. **9** is a diagram illustrating another example of a first reference image registered in the registration unit of the control unit of the processing device according to the second embodiment;

[0019] FIG. **10** is a diagram illustrating an example of a second reference image registered in the registration unit of the control unit of the processing device according to the second embodiment;

[0020] FIG. **11** is a diagram illustrating another example of a second reference image registered in the registration unit of the control unit of the processing device according to the second embodiment;

[0021] FIG. **12** is a diagram illustrating an example of a first comparison image generated in a first imaging step according to the second embodiment;

[0022] FIG. **13** is a diagram illustrating an example of a second comparison image generated in a second imaging step of the processing method according to the second embodiment; and

[0023] FIG. **14** is a perspective view illustrating a modification of the processing device illustrated in FIG. **1**.

DETAILED DESCRIPTION

[0024] Embodiments of the present disclosure will be described in detail with reference to the drawings. The present invention is not limited by the contents described in the following embodiments. In addition, the components described below include those that can be easily conceived by those skilled in the art and those that are substantially the same. Furthermore, the configurations described below can be appropriately combined. In addition, various omissions, substitutions, or changes can be made to the configurations without departing from the gist of the present invention.

First Embodiment

[0025] A processing device according to a first embodiment of the present invention will be described with reference to the drawings. FIG. **1** is a perspective view illustrating a configuration example of the processing device according to the first embodiment. FIG. **2** is a diagram illustrating an example of a first reference image registered in a registration unit of a control unit of the processing device illustrated in FIG. **1**. FIG. **3** is a diagram illustrating an example of a second

reference image registered in the registration unit of the control unit of the processing device illustrated in FIG. **1**.

Workpiece

[0026] A processing device **1** according to the first embodiment is a cutting device that performs cutting processing (corresponding to processing) on a workpiece **200**. In the first embodiment, the workpiece **200** is a disk-shaped semiconductor wafer using silicon, sapphire, gallium nitride, gallium arsenide, or the like as a base material, or a wafer such as an optical device wafer.

[0027] As illustrated in FIG. **2**, in the workpiece **200**, devices **204** are formed in regions divided in a lattice shape along a plurality of planned division lines **203** having the lattice shape on a front surface **201**. The device **204** is, for example, an integrated circuit such as an integrated circuit (IC) or a large scale integration (LSI), or an image sensor such as a charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS), or a memory (semiconductor storage device).

[0028] In the first embodiment, a central portion of a tape **210** having a larger diameter than the workpiece **200** is attached to a back surface **205** on a back side of the front surface **201** of the workpiece **200**. An annular frame **209** is attached to an outer edge of the tape **210**. The workpiece **200** is supported in an opening inside the frame **209**.

Processing Device

[0029] The processing device **1** illustrated in FIG. **1** is a cutting device that holds the workpiece **200** on a holding table **10**, performs cutting processing on the planned division lines **203** of the workpiece **200** with a cutting blade (not illustrated) to form cut grooves **206** along the planned division lines **203**, and divides the workpiece **200** into individual devices **204**. As illustrated in FIG. **1**, the processing device **1** includes a holding table **10** (corresponding to a suction table) that sucks and holds the workpiece **200** on a holding surface **11**, a cutting unit **20** that performs cutting processing on the workpiece **200** held by the holding table **10** with the cutting blade, a camera **30** serving as an abnormality detection unit that detects an abnormality of the workpiece **200**, an alignment camera **40** that captures an image of the workpiece **200** held on the holding table **10**, and a control unit **100**.

[0030] In addition, the processing device **1** includes a moving unit (not illustrated) that moves the cutting unit **20** relative to the workpiece **200** held by the holding table **10**. The moving unit includes an X-axis moving unit that feeds the holding table **10** for processing in an X-axis direction parallel to a horizontal direction, a Y-axis moving unit that feeds the cutting unit **20** for indexing in a Y-axis direction parallel to the horizontal direction and orthogonal to the X-axis direction, a Z-axis moving unit that feeds the cutting unit **20** for cutting in a Z-axis direction parallel to a vertical direction orthogonal to both the X-axis direction and the Y-axis direction, and a rotary moving unit that rotates the holding table **10** about an axis parallel to the Z-axis direction.

[0031] The X-axis moving unit relatively feeds the holding table **10** and the cutting unit **20** for processing along the X-axis direction by moving the holding table **10** in the X-axis direction, which is a feeding direction for processing. The Y-axis moving unit relatively feeds the holding table **10** and the cutting unit **20** for indexing along the Y-axis direction by moving the cutting unit **20** in the Y-axis direction, which is a feeding direction for indexing. The Z-axis moving unit relatively feeds the holding table **10** and the cutting unit **20** for cutting along the Z-axis direction by moving the cutting unit **20** in the Z-axis direction, which is a feeding direction for cutting.

[0032] Each of the X-axis moving unit, the Y-axis moving unit, and the Z-axis moving unit includes a known ball screw provided to be rotatable about an axis thereof, a known motor that rotates the ball screw about the axis, and a known guide rail that supports the holding table **10** or the cutting unit **20** in a movable manner in the X-axis direction, the Y-axis direction, or the Z-axis direction. The rotary moving unit includes a motor that rotates the holding table **10** about the axis.

[0033] The holding table **10** has a disk shape. The holding surface **11** that holds the workpiece **200** is formed of porous ceramic or the like. The holding table **10** is provided to be movable in the X-axis direction by the X-axis moving unit between a processing region below the cutting unit **20** and

a loading/unloading region that is separated from below the cutting unit **20** to load/unload the workpiece **200**, and is provided to be rotatable about the axis parallel to the Z-axis direction by the rotary moving unit.

[0034] The holding surface **11** is connected to a suction source (not illustrated) and is sucked by the suction source, so that the holding table **10** sucks and holds the workpiece **200** placed on the holding surface **11**. In the first embodiment, the holding table **10** sucks and holds the back surface **205** side of the workpiece **200**. The holding table **10** has a plurality of clamp portions **12** that clamps the frame **209** on an outer periphery of the holding surface **11**.

[0035] The cutting unit **20** is a processing unit that performs cutting processing on the workpiece **200** held by the holding table **10**. The cutting unit **20** is provided to be movable in the Y-axis direction by the Y-axis moving unit and movable in the Z-axis direction by the Z-axis moving unit with respect to the workpiece **200** held on the holding table **10**.

[0036] The cutting unit **20** is provided on a gate-shaped support frame erected from a device body **2** via the Y-axis moving unit, the Z-axis moving unit, and so on. The cutting unit **20** is configured to locate the cutting blade at any position on the holding surface **11** of the holding table **10** by the Y-axis moving unit and the Z-axis moving unit.

[0037] The cutting unit **20** includes: a cutting blade that performs cutting processing on the workpiece **200**; a spindle housing provided to be movable in the Y-axis direction and the Z-axis direction by the Y-axis moving unit and the Z-axis moving unit; a spindle provided to be rotatable about an axis thereof in the spindle housing; and a spindle motor (not illustrated) that rotates the spindle about the axis.

[0038] The cutting blade is an ultrathin cutting grindstone having a substantially ring shape, and performs cutting processing on the workpiece **200** along the planned division lines **203** of the workpiece **200** held by the holding table **10**. In the first embodiment, the cutting blade includes an annular cutting edge that performs cutting processing on the workpiece **200**, and an annular base that supports the cutting edge at an outer edge thereof and is detachably attached to the spindle.

[0039] The cutting edge is made of abrasive grains such as diamond or cubic boron nitride (CBN) and a bonding material such as metal or resin, and is formed to have a predetermined thickness. In the present invention, the cutting blade may be a so-called washer blade including only the cutting edge.

[0040] The spindle housing is supported to be movable in the Z-axis direction by the Z-axis moving unit, and movable in the Y-axis direction by the Y-axis moving unit via the Z-axis moving unit. The spindle housing houses a portion excluding a tip portion of the spindle, the spindle motor (not illustrated), and so on, and supports the spindle to be rotatable about the axis.

[0041] The spindle fixes the cutting blade to a tip thereof. The spindle is rotated by the spindle motor (not illustrated), and the tip portion of the spindle protrudes beyond a tip surface of the spindle housing. The tip portion of the spindle is formed to be gradually thinner toward the tip, and the cutting blade is fixed to the tip.

[0042] The axes of the spindle and the cutting blade of the cutting unit **20** are set parallel to the Y-axis direction.

[0043] In the first embodiment, the alignment camera **40** is fixed to a fixed frame **4** provided on the device body **2**, and is disposed between the loading/unloading region and the processing region. The alignment camera **40** includes an imaging element that captures an image of a region to be divided of the workpiece **200** before cutting processing held on the holding table **10**, that is, a part of the front surface **201** of the workpiece **200**. The imaging element is, for example, a charge-coupled device (CCD) imaging element or a complementary MOS (CMOS) imaging element. The alignment camera **40** captures an image of the workpiece **200** held on the holding table **10**, obtains an image for performing alignment to align the workpiece **200** and the cutting blade, and outputs the obtained image to the control unit **100**.

[0044] Note that, in the first embodiment, in the image captured and obtained by the alignment

camera **40**, intensities of light received by respective pixels of the imaging element are defined by grayscales at plural stages (for example, 256 stages). That is, the image captured and acquired by the alignment camera **40** is an image showing intensities of light at stages corresponding to the intensities of light received by the pixels, that is, a grayscale image having shades of gray.

[0045] The processing device **1** includes an X-axis direction position detection unit (not illustrated) for detecting a position of the holding table **10** in the X-axis direction, a Y-axis direction position detection unit (not illustrated) for detecting a position of the cutting unit **20** in the Y-axis direction, and a Z-axis direction position detection unit for detecting a position of the cutting unit **20** in the Z-axis direction. Each of the X-axis direction position detection unit and the Y-axis direction position detection unit may include a linear scale parallel to the X-axis direction or the Y-axis direction and a reading head. The Z-axis direction position detection unit detects the position of the cutting unit **20** in the Z-axis direction based on a pulse of the motor. The X-axis direction position detection unit, the Y-axis direction position detection unit, and the Z-axis direction position detection unit output the positions of the holding table **10** in the X-axis direction and the cutting unit **20** in the Y-axis direction and the Z-axis direction to the control unit **100**. In the first embodiment, the positions of the components of the processing device **1** in the X-axis direction, the Y-axis direction, and the Z-axis direction are determined based on predetermined reference positions (not illustrated). The reference position in the Z-axis direction is a position of the cutting unit **20** where a lower end of the cutting edge of the cutting blade is located on the same plane as the holding surface **11**.

[0046] The processing device **1** includes: a cassette table **50** on which a cassette **51** containing the workpiece **200** before and after cutting processing is placed and which moves the cassette **51** in the Z-axis direction; a conveyance unit **60** which conveys the workpiece **200** between the cassette **51** and the holding table **10**; and a cleaning unit **70** which cleans the workpiece **200** after cutting processing.

[0047] The conveyance unit **60** conveys the workpiece **200** from the cassette **51** placed on the cassette table **50** to the holding table **10** and the cleaning unit **70** in this order. The conveyance unit **60** includes: a pair of guide rails **61** on which the workpiece **200** taken out of the cassette **51** before cutting processing and the workpiece **200** accommodated in the cassette **51** after cutting processing are placed; a loading/unloading unit **62** that takes out the workpiece **200** before cutting processing from the cassette **51** and places the workpiece **200** on the guide rails **61**, and accommodates the workpiece **200** after cutting processing on the guide rails **61** in the cassette **51**; a first conveyance unit **63** that conveys the workpiece **200** before cutting processing on the guide rails **61** to the holding table **10** in the loading/unloading region and conveys the workpiece **200** after cleaning from the cleaning unit **70** onto the guide rails **61**; and a second conveyance unit **64** that conveys the workpiece **200** after cutting processing from the holding table **10** in the loading/unloading region to the cleaning unit **70**.

[0048] The guide rails **61** and the holding table **10** in the loading/unloading region constitute a conveyance path of the workpiece **200** conveyed from the cassette **51** to the holding table **10** by the conveyance unit **60**.

[0049] The camera **30** detects an abnormality of the workpiece **200**. The camera **30** images the workpiece **200**. In the first embodiment, the camera **30** is disposed above the guide rails **61** in the Z-axis direction, and is provided on the conveyance path of the workpiece **200**. The camera **30** includes an imaging element that captures an image of the entire front surface **201** of the workpiece **200** placed on the guide rails **61** before cutting processing. The imaging element is, for example, a charge-coupled device (CCD) imaging element or a complementary MOS (CMOS) imaging element. The camera **30** captures an image of the workpiece **200** placed on the guide rails **61** and outputs the obtained image to the control unit **100**.

[0050] Note that, in the first embodiment, in the image captured and obtained by the camera **30**, intensities of light received by respective pixels of the imaging element are defined by grayscales at plural stages (for example, 256 stages). That is, the image captured and acquired by the camera **30**

is an image showing intensities of light at stages corresponding to the intensities of light received by the pixels, that is, a grayscale image having shades of gray.

[0051] The control unit **100** controls each component of the processing device **1** to cause the processing device **1** to perform a cutting processing operation on the workpiece **200**. That is, the control unit **100** controls at least the holding table **10**, the cutting unit **20**, the cleaning unit **70**, and the camera **30**. Note that the control unit **100** is a computer including an arithmetic processing device including a microprocessor such as a central processing unit (CPU), a storage device including a memory such as a read only memory (ROM) or a random access memory (RAM), and an input/output interface device. The arithmetic processing device of the control unit **100** performs arithmetic processing according to a computer program stored in the storage device, and outputs a control signal for controlling the processing device **1** to each component of the processing device **1** via the input/output interface device.

[0052] The processing device **1** is connected to a display unit including a liquid crystal display device that displays a state of a processing operation, an image, and so on, an input unit used when an operator registers processing conditions and the like, and a notification unit **80**. The display unit, the input unit, and the notification unit **80** are connected to the control unit **100**. The input unit includes at least one of a touch panel provided on the display unit or an external input device such as a keyboard. The notification unit **80** emits at least one of sound or light to notify the operator. In the first embodiment, the function of the notification unit **80** is implemented by a screen displayed on the display unit, a warning light that emits light or the like, transmission of information to a mobile terminal held by the operator, or the like.

[0053] In addition, the control unit **100** includes a processing control unit **101**, a registration unit **102**, and a comparison unit **103**. The processing control unit **101** controls each component of the processing device **1** to cause the processing device **1** to perform a cutting processing operation on the workpiece **200**.

[0054] The registration unit **102** registers a first reference image **111** illustrated in FIG. **2** and a second reference image **112** illustrated in FIG. **3**. The first reference image **111** is an image serving as a reference for determining that the workpiece **200** before cutting processing is normal, and the first reference image **111** is an image obtained by capturing an image of the entire front surface **201** of the workpiece **200** that is normal before the cutting processing with the camera **30**. The normal workpiece **200** refers to a workpiece **200** that has no foreign matter such as contamination attached to the front surface **201** and has no scratch on the front surface **201**.

[0055] The second reference image **112** is an image serving as a reference for determining that the workpiece **200** is normal after cutting processing, and the second reference image **112** is an image obtained by capturing an image of the entire front surface **201** of the workpiece **200** that is normal after the cutting processing with the camera **30**.

[0056] The comparison unit **103** compares a first comparison image **121** (illustrated in FIG. **6** as an example) with the first reference image **111** registered in the registration unit **102**. The first comparison image **121** is first detection information obtained by capturing an image of the workpiece **200** with the camera **30** before the workpiece **200** is subjected to cutting processing by the cutting unit **20**. The comparison unit **103** also compares a second comparison image **122** (illustrated in FIG. **7** as an example) with the second reference image **112** registered in the registration unit **102**. The second comparison image **122** is second detection information obtained by capturing an image of the workpiece **200** with the camera **30** after the workpiece **200** is subjected to cutting processing by the cutting unit **20** and cleaning by the cleaning unit **70**.

[0057] Note that the function of the registration unit **102** is implemented by the storage device described above. The functions of the processing control unit **101** and the comparison unit **103** are implemented by the arithmetic processing device performing arithmetic processing according to the computer program stored in the storage device.

Processing Method

[0058] Next, a processing method according to the first embodiment will be described. FIG. **4** is a flowchart illustrating a part of a flow of the processing method according to the first embodiment. FIG. **5** is a flowchart illustrating the other part of the flow of the processing method according to the first embodiment. FIG. **6** is a diagram illustrating an example of a first comparison image generated in a first imaging step of the processing method illustrated in FIG. **4**. FIG. **7** is a diagram illustrating an example of a second comparison image generated in a second imaging step of the processing method illustrated in FIG. **5**.

[0059] The processing method according to the first embodiment is a method in which the processing device **1** performs cutting processing on the planned division lines **203** of the workpiece **200** with the cutting blade to form cutting grooves **206** along division-planned lines **203**, and divides the workpiece **200** into individual devices **204**. The processing method according to the first embodiment is also a processing operation of the processing device **1** having the above-described configuration.

[0060] As illustrated in FIGS. **4** and **5**, the processing method according to the first embodiment includes a first imaging step **1003**, which is an abnormality detection step, a first comparison step **1004**, a holding step **1010**, a processing step **1011**, a second imaging step **1013**, and a second comparison step **1014**. In the processing method according to the first embodiment, in a reference image registration step **1001**, processing conditions are registered in the control unit **100** by the operator or the like, and the cassette **51** containing the workpiece **200** before cutting processing is placed on the cassette table **50**. The processing conditions include a first reference image **111** serving as first reference information and a second reference image **112** serving as second reference information. In the processing method according to the first embodiment, when the control unit **100** of the processing device **1** receives a processing operation start instruction from the operator, a processing operation of the processing device **1** is started (step **1002**).

[0061] In the processing method according to the first embodiment, when the processing operation is started, the processing device **1** rotates the spindle about the axis at a rotation speed determined by the processing conditions, and performs the first imaging step **1003**. The first imaging step **1003** is an abnormality detection step in which the camera **30** images the workpiece **200** to detect an abnormality of the workpiece **200** before the processing step **1011**.

[0062] In the first imaging step **1003**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to take out the workpiece **200** from the cassette **51** and place the workpiece **200** on the guide rails **61** before cutting processing. In the first imaging step **1003**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the camera **30** to image the workpiece **200** placed on the guide rails **61**, thereby obtaining a second comparison image **122** illustrated in FIG. **6** as an example. Then, the process proceeds to the first comparison step **1004**.

[0063] The first comparison step **1004** is a step of, before the processing step **1011** and after the first imaging step **1003**, comparing the first reference image **111** registered in the registration unit **102** for determining that the workpiece **200** before cutting processing is normal with the first comparison image **121** newly obtained by imaging the target workpiece **200** before cutting processing in the first imaging step **1003**. In the first comparison step **1004**, in the processing device **1**, the comparison unit **103** of the control unit **100** performs template matching (pattern matching) between the first reference image **111** and the first comparison image **121**. As the template matching, for example, known SAD, SSD, NCC, ZNCC, or the like can be used, and these are basically algorithms that look at and determine differences between pixel values in various methods. The comparison unit **103** of the control unit **100** performs pattern matching between the first reference image **111** and the first comparison image **121**, and determines whether an abnormality has occurred in the workpiece **200** placed on the guide rails **61** before being subjected to cutting processing based on whether similarity therebetween is equal to or higher than a predetermined value.

[0064] In the first comparison step **1004**, in the processing device **1**, when the similarity is lower than the predetermined value, the comparison unit **103** of the control unit **100** determines that an abnormality has occurred in the workpiece **200** placed on the guide rails **61** before cutting processing (Yes). Then, the process proceeds to the notification step **1005**. Since the first comparison image **121** illustrated in FIG. **6** includes two abnormal portions **207**, it is determined in the first comparison step **1004** that an abnormality has occurred in the workpiece **200** before cutting processing. The abnormal portion **207** is a portion where a foreign matter is attached onto the front surface **201** of the workpiece **200** or a portion where the front surface **201** of the workpiece **200** is damaged.

[0065] The notification step **1005** is a step in which the notification unit **80** notifies the operator that an abnormality has occurred in the target workpiece **200** before cutting processing. In the notification step **1005**, in the processing device **1**, the processing control unit **101** of the control unit **100** operates the notification unit **80** to notify the operator. In this way, in the notification step **1005**, when it is determined that there is an abnormality in the workpiece **200** based on the comparison between the first reference image **111** and the first comparison image **121** by the comparison unit **103**, the control unit **100** causes the notification unit **80** to notify that the abnormality has occurred.

[0066] After the notification step **1005**, in the processing device **1**, the processing control unit **101** of the control unit **100** determines whether to perform cleaning on the workpiece **200** placed on the guide rails **61** before cutting processing (step **1006**). In the first embodiment, when cleaning has not yet been performed on the workpiece **200** placed on the guide rails **61** before cutting processing, it is determined that cleaning is to be performed on the workpiece **200** placed on the guide rails **61** before cutting processing (step **1006**: Yes). Then, the process proceeds to a pre-input cleaning step **1007**.

[0067] The pre-input cleaning step **1007** is a step in which the cleaning unit **70** cleans the workpiece **200** before cutting processing when an abnormality occurs in the workpiece **200** placed on the guide rails **61** before cutting processing in the immediately preceding first comparison step **1004**. In the pre-input cleaning step **1007**, the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to convey the workpiece **200** placed on the guide rails **61** before cutting processing to the cleaning unit **70**, the cleaning unit **70** cleans the workpiece **200** before cutting processing, and thereafter the workpiece **200** before cutting processing is placed back on the guide rails **61**. Then, the process returns to the first imaging step **1003**. In this way, in the pre-input cleaning step **1007**, when it is determined that there is an abnormality in the workpiece **200** based on the comparison between the first reference image **111** and the first comparison image **121** by the comparison unit **103**, the workpiece **200** is cleaned by the cleaning unit **70**.

[0068] In the first comparison step **1004**, in the processing device **1**, if the similarity is equal to or higher than the predetermined value, when it is determined that no abnormality has occurred in the workpiece **200** placed on the guide rails **61** before cutting processing (No), or when cleaning has been performed on the workpiece **200** placed on the guide rails **61** before cutting processing in the first embodiment, the comparison unit **103** of the control unit **100** determines not to perform cleaning on the workpiece **200** placed on the guide rails **61** before cutting processing (step **1006**: No). Then, the process proceeds to the holding step **1010**.

[0069] The holding step **1010** is a step in which the holding table **10** holds the workpiece **200**. In the holding step **1010**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the moving unit to locate the holding table **10** in the loading/unloading region, and causes the conveyance unit **60** to place the workpiece **200** before cutting processing placed on the guide rails **61** onto the holding surface **11** of the holding table **10**. In the holding step **1010**, the processing device **1** causes the processing control unit **101** of the control unit **100** to suck and hold the back surface **205** of the workpiece **200** onto the holding surface **11** of the holding table **10** and causes the clamp portions **12** to clamp the frame **209**. Then, the process proceeds to the processing

step **1011**.

[0070] The processing step **1011** is a step in which the cutting unit **20** performs cutting processing on the workpiece **200** held on the holding table **10**. In the processing step **1011**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the moving unit to move the holding table **10** toward the processing region, the alignment camera **40** captures an image of the workpiece **200**, and alignment is performed based on the image captured and obtained by the alignment camera **40**.

[0071] In the processing step **1011**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the moving unit, the cutting unit **20**, and so on to cause the cutting edge of the cutting blade to cut into the workpiece **200** until reaching the tape **210** while relatively moving the cutting edge of the cutting blade rotating about the axis of the cutting unit **20** along the planned division lines **203** of the workpiece **200** held on the holding table **10**, thereby performing cutting processing on all the planned division lines **203** of the workpiece **200**. In the processing step **1011**, in the processing device **1**, when cutting processing is performed on all the planned division lines **203** of the workpiece **200**, the process proceeds to the cleaning step **1012**.

[0072] The cleaning step **1012** is a step in which the cleaning unit **70** cleans the workpiece **200** subjected to cutting processing in the processing step **1011**. In the cleaning step **1012**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the moving unit to move the holding table **10** to the loading/unloading region so that the cutting unit is spaced away from the workpiece **200** held on the holding table **10**. In the cleaning step **1012**, in the processing device **1**, the processing control unit **101** of the control unit **100** stops the sucking and holding of the workpiece **200** onto the holding table **10**, and releases the clamping of the frame **209** by the clamp portions **12**.

[0073] In the cleaning step **1012**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to convey the workpiece **200** placed on the holding surface **11** of the holding table **10** in the loading/unloading region after cutting processing to the cleaning unit **70**, and the cleaning unit **70** cleans the workpiece **200** after cutting processing. Then, the process proceeds to the second imaging step **1013**. The second imaging step **1013** is a step in which the camera **30** images the workpiece **200** after the processing step **1011**.

[0074] In the second imaging step **1013**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to place the workpiece **200** subjected to cutting processing on the guide rails **61** from the cleaning unit **70**. In the second imaging step **1013**, in the processing device **1**, the processing control unit **101** of the control unit **100** controls the camera **30** to image the workpiece **200** placed on the guide rails **61**, thereby obtaining a second comparison image **122** illustrated in FIG. **7** as an example. Then, the process proceeds to the second comparison step **1014**.

[0075] The second comparison step **1014** is a step of, after the processing step **1011**, comparing the second reference image **112** registered in the registration unit **102** for determining that the workpiece **200** after cutting processing is normal with the second comparison image **122** newly obtained by imaging the target workpiece **200** after cutting processing in the second imaging step **1013**. In the second comparison step **1014**, in the processing device **1**, the comparison unit **103** of the control unit **100** performs pattern matching such as normalized correlation between the second reference image **112** and the second comparison image **122**, and determines whether an abnormality has occurred in the workpiece **200** placed on the guide rails **61** after cutting processing based on whether similarity therebetween is equal to or higher than the predetermined value.

[0076] In the second comparison step **1014**, in the processing device **1**, when the similarity is lower than the predetermined value, the comparison unit **103** of the control unit **100** determines that an abnormality has occurred in the workpiece **200** placed on the guide rails **61** after cutting processing (Yes). Then, the process proceeds to the notification step **1015**. Since the second comparison image **122** illustrated in FIG. **7** includes two abnormal portions **207**, it is determined in the second

comparison step **1014** that an abnormality has occurred in the workpiece **200** after cutting processing.

[0077] The notification step **1015** is a step in which the notification unit **80** notifies the operator that an abnormality has occurred in the target workpiece **200** after cutting processing. In the notification step **1015**, in the processing device **1**, the processing control unit **101** of the control unit **100** operates the notification unit **80** to notify the operator. In this way, in the notification step **1015**, when it is determined that there is an abnormality in the workpiece **200** based on the comparison between the second reference image **112** and the second comparison image **122** by the comparison unit **103**, the control unit **100** causes the notification unit **80** to notify that the abnormality has occurred.

[0078] After the notification step **1015**, in the processing device **1**, the processing control unit **101** of the control unit **100** determines whether to perform cleaning on the workpiece **200** placed on the guide rails **61** after cutting processing (step **1016**). In the first embodiment, when cleaning has not yet been performed on the workpiece **200** placed on the guide rails **61** after cutting processing after the cleaning step, it is determined that cleaning is to be performed on the workpiece **200** placed on the guide rails **61** after cutting processing (step **1016**: Yes), and the process proceeds to the re-cleaning step **1017**.

[0079] The re-cleaning step **1017** is a step in which the cleaning unit **70** cleans the workpiece **200** after cutting processing when an abnormality occurs in the workpiece **200** placed on the guide rails **61** after cutting processing in the immediately preceding second comparison step **1014**. In the re-cleaning step **1017**, the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to convey the workpiece **200** placed on the guide rails **61** after cutting processing to the cleaning unit **70**, the cleaning unit **70** cleans the workpiece **200** after cutting processing, and thereafter the workpiece **200** after cutting processing is placed back on the guide rails **61**. Then, the process returns to the second imaging step **1013**. In this way, in the re-cleaning step **1017**, when it is determined that there is an abnormality in the workpiece **200** based on the comparison between the second reference image **112** and the second comparison image **122** by the comparison unit **103**, the workpiece **200** is cleaned by the cleaning unit **70**.

[0080] In the second comparison step **1014**, in the processing device **1**, if the similarity is equal to or higher than the predetermined value, when it is determined that no abnormality has occurred in the workpiece **200** placed on the guide rails **61** after cutting processing (No), or when cleaning has been performed on the workpiece **200** placed on the guide rails **61** after cutting processing after the cleaning step **1012** in the first embodiment, the comparison unit **103** of the control unit **100** determines not to perform cleaning on the workpiece **200** placed on the guide rails **61** after cutting processing (step **1016**: No), and the processing control unit **101** of the control unit **100** controls the conveyance unit **60** to accommodate the workpiece **200** after cutting processing in the cassette **51**. The processing device **1** sequentially performs cutting processing on the workpieces **200** in the cassette **51**, and terminates the processing operation when the cutting processing is completed on the workpieces **200** in the cassette **51**.

[0081] As described above, the processing device **1** according to the first embodiment includes: a control unit **100** including the registration unit **102** that registers a first reference image **111** for determining the workpiece **200** before cutting processing to be normal in advance; and a comparison unit **103** that compares the first reference image **111** registered in the registration unit **102** with a first comparison image **121** newly obtained by imaging the workpiece **200** with the camera **30** before the workpiece **200** is subjected to cutting processing by the cutting unit **20**.

[0082] Therefore, the processing device **1** and the processing method according to the first embodiment is capable of determining whether there is an abnormality in the front surface **201** of the workpiece **200** before being subjected to cutting processing by the cutting unit **20**.

[0083] As a result, the processing device **1** and the processing method according to the first embodiment have an effect in that it is possible to specify whether the abnormality of the

workpiece **200** has been caused by a defect of the processing device **1**.

Second Embodiment

[0084] A processing device and a processing method according to a second embodiment will be described with reference to the drawings. FIG. **8** is a diagram illustrating an example of a first reference image registered in a registration unit of a control unit of the processing device according to the second embodiment. FIG. **9** is a diagram illustrating another example of a first reference image registered in the registration unit of the control unit of the processing device according to the second embodiment. FIG. **10** is a diagram illustrating an example of a second reference image registered in the registration unit of the control unit of the processing device according to the second embodiment. FIG. **11** is a diagram illustrating another example of a second reference image registered in the registration unit of the control unit of the processing device according to the second embodiment. FIG. **12** is a diagram illustrating an example of a first comparison image generated in a first imaging step according to the second embodiment. FIG. **13** is a diagram illustrating an example of a second comparison image generated in a second imaging step of the processing method according to the second embodiment. In FIGS. **8**, **9**, **10**, **11**, **12**, and **13**, the same parts as those in the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0085] The processing device **1** according to the second embodiment is the same as that according to the first embodiment, except that first reference images **111-1** and **111-2** that are reference information illustrated in FIGS. **8** and **9** and second reference images **112-1** and **112-2** that are reference information illustrated in FIGS. **10** and **11**, which are registered in the registration unit **102**, are different, and the alignment camera **40**, which is an abnormality detection unit, images the front surface **201** of the workpiece **200** held on the holding surface **11** of the holding table **10** to detect abnormalities in the workpiece **200** in the imaging steps **1003** and **1013**.

[0086] In the second embodiment, the first reference images **111-1** and **111-2** are images of partial region between which similarity is equal to or higher than a threshold, among a plurality of images of partial regions obtained by imaging at least two partial regions in the front surface **201** of the workpiece **200** determined to be normal before cutting processing with the alignment camera **40**. In the second embodiment, the first reference images **111-1** and **111-2** are two images of partial regions having the highest similarity when pattern matching is performed on a plurality of images of partial regions obtained by imaging at least two partial regions in the front surface **201** of the workpiece **200** determined to be normal before cutting processing with the alignment camera **40**.

[0087] In the second embodiment, the second reference images **112-1** and **112-2** are images of partial regions between which similarity is more equal to or higher than a threshold, among a plurality of images of partial regions obtained by imaging at least two partial regions in the front surface **201** of the workpiece **200** determined to be normal after cutting processing with the alignment camera **40**. In the second embodiment, the second reference images **112-1** and **112-2** are two images of partial regions having the highest similarity when pattern matching such as normalized correlation is performed on a plurality of images of partial regions obtained by imaging at least two partial regions in the front surface **201** of the workpiece **200** determined to be normal after cutting processing with the alignment camera **40**.

[0088] In the processing method according to the second embodiment, in the first imaging step **1003**, the alignment camera **40** images a partial region in the front surface **201** of the target workpiece **200** before cutting processing, thereby obtaining a first comparison image **121-2** illustrated in FIG. **12** as an example. In the processing method according to the second embodiment, in the second imaging step **1013**, the alignment camera **40** images a partial region in the front surface **201** of the target workpiece **200** after cutting processing, thereby obtaining a second comparison image **122-2** illustrated in FIG. **13** as an example.

[0089] In the processing method according to the second embodiment, in the first comparison step **1004**, when the similarity between both the first reference images **111-1** and **111-2** and the first

comparison image **121-2** is equal to or higher than the predetermined value, the comparison unit **103** of the control unit **100** determines that no abnormality has occurred in the workpiece **200** held on the holding table **10** before cutting processing (No). In the processing method according to the second embodiment, in the first comparison step **1004**, when the similarity between at least one of the first reference images **111-1** and **111-2** and the first comparison image **121-2** is lower than the predetermined value, the comparison unit **103** of the control unit **100** determines that an abnormality has occurred in the workpiece **200** held on the holding table **10** before cutting processing (Yes).

[0090] In the processing method according to the second embodiment, in the second comparison step **1014**, when the similarity between both the second reference images **112-1** and **112-2** and the second comparison image **122-2** is equal to or higher than the predetermined value, the comparison unit **103** of the control unit **100** determines that no abnormality has occurred in the workpiece **200** held on the holding table **10** after cutting processing (No). In the processing method according to the second embodiment, in the second comparison step **1014**, when the similarity between at least one of the second reference images **112-1** and **112-2** and the second comparison image **122-2** is lower than the predetermined value, the comparison unit **103** of the control unit **100** determines that an abnormality has occurred in the workpiece **200** held on the holding table **10** after cutting processing (Yes).

[0091] Since each of the first comparison image **121-2** illustrated in FIG. **12** and the second comparison image **122-2** illustrated in FIG. **13** includes one abnormal portion **207**, it is determined in the first and second comparison steps **1004** and **1014** that an abnormality has occurred in the workpiece **200** before and after cutting processing. As such, the first comparison image **121-2** and the second comparison image **122-2** are images of a partial region obtained by imaging the partial region of the front surface **201** of the target workpiece **200** before and after cutting processing.

[0092] The processing device **1** according to the second embodiment includes a control unit **100** including: a registration unit **102** that registers the first reference images **111-1** and **111-2**; and a comparison unit **103** that compares the first reference images **111-1** and **111-2** with the first comparison image **121-2** newly obtained by imaging the workpiece **200** with the camera **30** before the workpiece **200** is subjected to cutting processing by the cutting unit **20**. Thus, the processing device **1** according to the second embodiment has an effect in that it is possible to determine whether there is an abnormality in the front surface **201** of the workpiece **200** before being subjected to cutting processing by the cutting unit **20**, and it is possible to specify whether the abnormality of the workpiece **200** is caused by a defect of the processing device **1** as in the first embodiment.

[0093] Note that the present invention is not limited to the above-described embodiment. That is, various modifications can be made without departing from the gist of the present invention. In the present invention, as illustrated in FIG. **14**, the camera **30** may be disposed above the holding surface **11** of the holding table **10** in the loading/unloading region in the Z-axis direction and provided on the conveyance path of the workpiece **200**. FIG. **14** is a perspective view illustrating a modification of the processing device illustrated in FIG. **1**, and the same parts as those in the first embodiment are denoted by the same reference numerals, and description thereof is omitted.

[0094] Further, in the present invention, the alignment camera **40** may image a plurality of areas of the front surface **201** of the workpiece **200** held on the holding surface **11** of the holding table **10** to generate reference images **111** and **112** and comparison images **121** and **122** for the entire front surface **201** of the workpiece **200**.

[0095] Further, in the present invention, in the processing device **1**, at least one of the first reference image (**111**; **111-1**, **111-2**) and the second reference image (**112**; **112-1**, **112-2**) may be the first comparison image (**121**; **121-2**) or the second comparison image (**122**; **122-2**) obtained in the previous imaging step **1003** or **1013**. In this case, the first comparison image (**121**; **121-2**) and the second comparison image (**122**; **122-2**) determined that no abnormality has occurred in the

previous comparison steps **1004** and **1014** are updated to the first reference image (**111**; **111-1**, **111-2**) or the second reference image (**112**; **112-1**, **112-2**).
[0096] Further, in the present invention, the processing device **1** is not limited to the cutting device that performs cutting processing on the workpiece **200**, and may be any of various processing devices such as a laser processing device that performs laser processing on the workpiece **200**, a grinding device that performs grinding processing on the workpiece **200**, or a polishing device that performs polishing processing on the workpiece **200**.
[0097] In the present invention, the abnormality detection unit may be a particle counter that detects particles of the workpiece **200** or a thickness detection sensor that measures the thickness of the workpiece **200**. In this case, reference information is a reference threshold (number) or a reference thickness, and detection information is a number or a thickness.
[0098] In addition, in the present invention, in a case where the abnormality detection unit is the camera **30**, an image may be captured while applying oblique illumination with narrowed-down light at an LED-UV wavelength to the workpiece **200**. Note that, the narrowing-down of the light means that strong light is generated in one direction, like polarion light, making it easier to find a small object. The use of the UV wavelength leads to emission of light of fluorescent substances, thereby forming an LED-UV light source, which has a spectral output with a narrow UV wavelength (short wavelength), making the light more likely to scatter. The short wavelength are suitable when light is applied to a minute object such as dust or foreign matter and reflected.
[0099] In the present invention, the pre-input cleaning step **1007** and the re-cleaning step **1017** may be modified to be performed under a cleaning condition having a stronger cleaning power as compared with the cleaning condition of the cleaning step **1012** after cutting processing is performed on the workpiece **200**. For example, the cleaning unit **70** that supplies pure water at a high pressure (0.2 MPa (gauge pressure) or more and 0.5 MPa (gauge pressure) or less) to perform cleaning may supply the high-pressure pure water for 60 seconds to perform cleaning under the cleaning condition for the cleaning step **1012**, and the cleaning condition for the pre-input cleaning step **1007** and the re-cleaning step **1017** may be changed to a cleaning condition that extends the cleaning time to 120 seconds, which is twice as long as the cleaning condition after cutting processing.
[0100] The present invention has an effect in that it is possible to specify whether or not an abnormality of a workpiece is caused by a defect of a processing device.
[0101] Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

Claims

1. A processing device for processing a workpiece, the processing device comprising: a holding table that holds the workpiece; a processing unit that performs processing on the workpiece held on the holding table; an abnormality detection unit that detects an abnormality of the workpiece; and a control unit that controls at least the processing unit and the abnormality detection unit, wherein the control unit includes: a registration unit that registers first reference information serving as a reference for determining that the workpiece before processing is normal; and a comparison unit that compares the first reference information registered in the registration unit with first detection information obtained by detecting the workpiece by the abnormality detection unit before the workpiece is processed by the processing unit.
2. The processing device according to claim 1, wherein the registration unit of the control unit registers second reference information serving as a reference for determining that the workpiece after processing is normal; the comparison unit of the control unit compares the second reference

information registered in the registration unit with second detection information obtained by detecting the workpiece by the abnormality detection unit after the workpiece is processed by the processing unit.

3. The processing device according to claim 1, further comprising a notification unit, wherein when it is determined that there is an abnormality in the workpiece based on the comparison by the comparison unit, the control unit causes the notification unit to notify that the abnormality has occurred.

4. The processing device according to claim 1, further comprising a cleaning unit that cleans the workpiece, wherein when it is determined that there is an abnormality in the workpiece based on the comparison by the comparison unit, the control unit causes the cleaning unit to clean the workpiece.

5. The processing device according to claim 1, further comprising: a cassette table on which a cassette containing the workpiece is placed; and a conveyance unit that conveys the workpiece from the cassette placed on the cassette table to the holding table, wherein the abnormality detection unit is disposed on a conveyance path along which the workpiece is conveyed from the cassette to the holding table by the conveyance unit.

6. The processing device according to claim 2, wherein at least one of the first reference information and the second reference information is previous first detection information or previous second detection information obtained by previous detection by the abnormality detection unit.

7. The processing device according to claim 1, wherein the abnormality detection unit is a camera that images the workpiece, the first reference information is images of partial regions between which similarity is equal to or higher than a threshold, among a plurality of images of partial regions obtained by imaging at least two partial regions in the workpiece using the camera, and the first detection information is an image of a partial region obtained by imaging the partial region of the workpiece with the camera.

8. A processing method for processing a workpiece, the processing method comprising: holding the workpiece on a holding table; performing processing on the workpiece held on the holding table by a processing unit; detecting an abnormality of the workpiece before performing the processing; and before performing the processing and after detecting the abnormality of the workpiece, comparing reference information registered for determining that the workpiece before processing is normal with detection information obtained by newly detecting the workpiece in detecting the abnormality.