United States Patent Application Publication	20250264325
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	Aoki; Tatsuya et al.

METHOD FOR PROCESSING WORKPIECE AND MEASUREMENT SYSTEM

Abstract

A method for processing a workpiece, includes, a preparation step of providing a resist film with an opening on a processing surface of the workpiece, a processing step of removing a processing portion of the workpiece exposed by the opening while protecting a protection portion of the workpiece covered by the resist film provided on the workpiece, a measuring step of measuring an overall height from the processing portion of the workpiece to an upper surface of the resist film after the processing step, and a calculating step of calculating a processing amount of the workpiece based on the overall height measured and a thickness of the resist film after the processing step.

Inventors: **Aoki; Tatsuya (Nagoya-shi, JP), Kawamoto; Akihiro (Nagoya-shi, JP), Takeuchi; Takumi (Nagoya-shi, JP), Morita; Hidenori (Nagoya-shi, JP), Ishii; Norimasa (Nagoya-shi, JP)**

Applicant: **SINTOKOGIO, LTD.** (Nagoya-shi, JP)

Family ID: **1000008493742**

Assignee: **SINTOKOGIO, LTD. (Nagoya-shi, JP)**

Appl. No.: **19/050421**

Filed: **February 11, 2025**

Foreign Application Priority Data

JP	2024-021344	Feb. 15, 2024

Publication Classification

Int. Cl.: **G01B11/06** (20060101); **B24C1/08** (20060101)

U.S. Cl.:

CPC **G01B11/0625** (20130101); **B24C1/086** (20130101);

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on Japanese Patent Application No. 2024-021344 filed with Japan Patent Office on Feb. 15, 2024, the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD

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

BACKGROUND

[0003] Japanese laid-open application publication No. 2006-065000 discloses a method for processing a workpiece. In this method, a resist film is attached to the workpiece, a pattern is formed on the resist film, the entire workpiece is subjected to sandblasting, and finally, the resist film is removed with an alkaline stripping solution.

SUMMARY

[0004] From the perspective of quality control, it is necessary to confirm whether the workpiece has been processed to the designed shape before removing the resist film. For example, after sandblasting, it is conceivable to temporarily remove the resist film manually to measure the amount of processing. When the processing amount is insufficient, the resist film is reattached, and sandblasting is performed again. This ensures the quality of the workpiece. However, the process of removing and reattaching the resist film requires skilled techniques, is time-consuming, and hinders automation. The present disclosure provides a technology that can calculate the processing amount without removing the resist film.

[0005] A method for processing a workpiece according to one aspect of the present disclosure includes a preparation step, a processing step, a measuring step, and a calculating step. The preparation step includes providing a resist film with an opening on a processing surface of the workpiece. The processing step includes removing a processing portion of the workpiece exposed by the opening while protecting a protection portion of the workpiece covered by the resist film provided on the workpiece. The measuring step includes measuring an overall height from the processing portion of the workpiece to an upper surface of the resist film after the processing step. The calculating step includes calculating a processing amount of the workpiece based on the overall height measured and a thickness of the resist film after the processing step.

[0006] A measurement system according to another aspect of the present disclosure includes a measuring device and a control unit. The measuring device measures an overall height from a processing portion of a workpiece exposed by an opening to an upper surface of a resist film covering a protection portion of the workpiece. The control unit is connected to the measuring device and calculates a processing amount of the workpiece. The control unit causes the measuring device to measure the overall height from the processing portion of the workpiece to the upper surface of the resist film after processing in which the processing portion of the workpiece is removed while protecting the protection portion of the workpiece, and calculates the processing amount of the workpiece based on the overall height measured and a thickness of the resist film after the processing in which the processing portion of the workpiece is removed.

[0007] According to the present disclosure, it is possible to calculate the processing amount without removing the resist film.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a diagram illustrating an example of a processing system to which a method for processing a workpiece according to an embodiment is applied.

[0009] FIG. **2** is a flowchart illustrating a method for processing a workpiece according to an embodiment.

[0010] FIGS. **3**A to **3**E are diagrams illustrating an example of a workpiece in each step.

[0011] FIG. **4** is a diagram illustrating dimensions of the workpiece.

DETAILED DESCRIPTION

[0012] Embodiments of the present disclosure will be described in detail with reference to the drawings. In the description of the drawings, the same elements are designated with the same reference signs, and redundant descriptions will be omitted. The dimensional ratios in the drawings do not necessarily match those in the description. The terms “upper,” “lower,” “left,” and “right” are based on the illustrated state and are for convenience.

[Example of Processing System]

[0013] FIG. **1** is a diagram illustrating an example of a processing system to which a method for processing a workpiece according to an embodiment is applied. The processing system **1** shown in FIG. **1** is composed of a group of devices for processing a workpiece. The workpiece is, for example, a plate-like member. Specific examples of the workpiece include an electrostatic chuck for holding a substrate, a glass substrate, a ceramic substrate, and/or a silicon substrate. The processing system **1** performs processing to remove the surface of the workpiece. Specific examples of the processing include forming protrusions on the workpiece, forming holes, and/or forming grooves. The processing method is not particularly limited as long as it can remove the surface of the workpiece. Specific examples of the processing method include sandblasting and/or etching. Hereinafter, a case where the processing system **1** forms protrusions on a plate-like workpiece by sandblasting to manufacture an electrostatic chuck will be described as an example.

[0014] The processing system **1** includes a laminating device **11**, an exposure device **12**, a developing device **13**, a blasting device **14**, a measurement system **15**, and a stripping and cleaning device **16**.

[0015] The laminating device **11** is a device for attaching a resist film to the upper surface of the workpiece. The resist film is made of a material resistant to the abrasive grains of the sandblasting. The resist film is formed of a resin as an example. The laminating device **11** includes a supply unit for supplying the resist film and a roller for crimping the supplied resist film to the workpiece. The workpiece processed by the laminating device **11** is conveyed to the exposure device **12**.

[0016] The exposure device **12** is a device for transferring a pattern to the resist film. The exposure device includes a light source that emits light of a specific wavelength such as ultraviolet light and a mask having a pattern to be transferred to the resist film. The workpiece processed by the exposure device **12** is conveyed to the developing device **13**.

[0017] The developing device **13** is a device for chemically processing the exposed resist film to form a pattern. The developing device **13** includes a nozzle for injecting developing solution and a spin coater for rotating the workpiece. The workpiece processed by the developing device **13** is conveyed to the blasting device **14**.

[0018] The blasting device **14** is a device for processing the surface by injecting abrasive grains onto the surface of the workpiece at high pressure. The blasting device **14** includes a compressor for supplying compressed air, a hopper for storing abrasive grains, a nozzle connected to the compressor and the hopper for injecting the abrasive grains, a stage for supporting the workpiece, a chamber for accommodating the nozzle and the stage, and an abrasive grain recovery mechanism. The blasting device **14** performs processing according to the set processing conditions. The

processing conditions may include the injection amount, processing time (injection time), and/or injection speed. The workpiece processed by the blasting device **14** is once conveyed to the measurement system **15**.

[0019] The measurement system **15** is a system for calculating the processing amount of the workpiece. The measurement system **15** includes a measuring device **150** and a control unit **151**.

[0020] The measuring device **150** is a device for measuring the overall height from the processing portion of the workpiece to the upper surface of the resist film. The measuring device **150** is a 3D (three-dimensional) sensor capable of measuring film thickness. Specific examples of the measuring device **150** include a white light interferometer and/or a laser microscope. The white light interferometer irradiates the workpiece with white light and analyzes the interference pattern of the reflected light to measure the overall height from the processing portion of the workpiece to the upper surface of the resist film. The laser microscope irradiates the workpiece with laser light and analyzes the intensity or phase change of the reflected light to measure the overall height from the processing portion of the workpiece to the upper surface of the resist film.

[0021] The control unit **151** is connected to the measuring device **150** and calculates the processing amount of the workpiece. The control unit **151** is configured as a computer system including, for example, a processor such as a CPU (Central Processing Unit), a memory such as RAM (Random Access Memory) and ROM (Read Only Memory), input/output devices such as a touch panel, a mouse, a keyboard, and a display, and communication devices such as a network card. The control unit **151** realizes the functions described later by operating each hardware based on a program stored in the memory or the like.

[0022] The control unit **151** is configured to operate the measuring device **150**. The control unit **151** calculates the processing amount of the workpiece based on the measurement result of the measuring device **150**. The method for calculating the processing amount of the workpiece will be described later. The control unit **151** may feed back the measurement result to the blasting device **14**. For example, the control unit **151** transmits a signal to the blasting device **14** to change the processing conditions of the blasting device **14** based on the measurement result.

[0023] The measurement system **15** may include a spectroscopic film thickness meter in addition to the measuring device **150**. The 3D sensor, which is the measuring device **150**, may not be able to measure the film thickness of the resist film depending on the transmittance of the resist film. The spectroscopic film thickness meter has a light source that emits light of a predetermined wavelength and can measure the thickness of the resist film based on the intensity of the reflected light from the surface and the back surface of the resist film and the refractive index of the resist film. The workpiece measured by the measurement system **15** is conveyed to the blasting device **14**. The workpiece measured by the measurement system **15** may be conveyed to the stripping and cleaning device **16**.

[0024] The stripping and cleaning device **16** is a device for stripping and cleaning the resist film from the workpiece. The stripping and cleaning device **16** includes a tank for storing the stripping solution and a nozzle for spraying the stripping solution. The workpiece is finished as a product by the stripping and cleaning device **16**.

[0025] As described above, the processing system **1** shown in FIG. **1** processes the workpiece in sequence. The workpiece may be conveyed between the devices by a robot or by an operator. By adopting robot conveyance, the entire process can be automated.

[Example of Method for Processing Workpiece]

[0026] FIG. **2** is a flowchart illustrating a method for processing a workpiece according to an embodiment. The processing method M**1** shown in FIG. **2** is executed by the processing system **1**. In the description of the processing method, reference is made to FIGS. **3**A to **3**E and FIG. **4**. FIGS. **3**A to **3**E are diagrams illustrating an example of a workpiece in each step. FIG. **4** is a diagram illustrating dimensions of the workpiece.

[0027] As shown in FIG. **2**, first, in step S**10** (an example of the preparation step), a workpiece

masked with a resist film is prepared. The workpiece masked with the resist film is the workpiece just before the sandblasting. FIGS. **3**A to **3**C illustrate the workpiece prepared in step S**10**.

[0028] First, as shown in FIG. **3**A, the resist film **20** is supplied from the film supply unit of the laminating device **11**, and the resist film **20** is crimped to the processing surface **100** of the workpiece **10** by the roller. Next, as shown in FIG. **3**B, light of a specific wavelength such as ultraviolet light is projected onto the resist film **20** from the light source of the exposure device **12** through the mask. The exposed resist film **20** chemically changes to become the resist film **20**A in which a soluble region **200** and an insoluble region **201** are formed. Next, as shown in FIG. **3**C, the developing solution is supplied onto the exposed resist film **20**A from the nozzle of the developing device **13**. As a result, the resist film **20**A becomes the resist film **20**B in which the soluble region **200** is dissolved to form the opening **202** and the insoluble region **201** remains. The processing surface **100** of the workpiece **10** has a processing portion **10***a* exposed by the opening **202** and a protection portion **10***b* covered with the resist film **20**B. The workpiece shown in FIG. **3**C is the workpiece masked with the resist film and is the workpiece just before the processing step.

[0029] Subsequently, in step S**12**, the workpiece is set on the stage of the blasting device **14**. Subsequently, in step S**14** (processing step), the processing portion **10***a* of the workpiece **10** is removed while protecting the protection portion **10***b* of the workpiece **10** with the resist film **20**B. As a more specific example, abrasive grains are injected toward the workpiece **10** from the nozzle of the blasting device **14**. As a result, as shown in FIG. **3**D, the workpiece **10** becomes the workpiece **10**A in which the processing portion **10***a* of the workpiece **10** is removed (cut), and the resist film **20**B becomes the resist film **20**C with the upper surface worn.

[0030] As shown in FIG. **4**, before the processing step, the thickness F**1** of the resist film **20**B provided on the workpiece is the same as the overall height H**1** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**B. In the processing step, when the processing portion **10***a* of the workpiece **10** is removed, the upper surface of the resist film **20**B is also worn to some extent. After the processing step, the sum of the thickness F**2** of the resist film **20**C and the wear amount DF of the resist film is the same as the thickness F**1** of the resist film **20**B (or the overall height H**1**), and the sum of the thickness F**2** of the resist film **20**C and the processing amount DP is the same as the overall height H**2** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**C.

[0031] Subsequently, in step S**16**, the workpiece **10**A provided with the resist film **20**C is conveyed from the blasting device **14** to the measuring device **150**. In step S**18**, the measuring device **150** measures the overall height H**2** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**C.

[0032] Subsequently, in step S**20**, the control unit **151** calculates the thickness F**2** of the resist film **20**C. Then, in step S**22** (calculating step), the control unit **151** calculates the processing amount DP based on the thickness F**2** of the resist film **20**C. The following two methods exist.

[0033] The first method is a method of calculating the processing amount DP by subtracting the thickness F**2** of the resist film **20**C from the overall height H**2** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**C. The thickness F**2** of the resist film **20**C is measured by a spectroscopic film thickness meter separately included in the measuring device **150**, for example. As a specific example, the thickness of the resist film **20**C is measured based on the intensity of the reflected light from the surface and the back surface of the resist film **20**C and the refractive index of the resist film **20**C. Since the thickness F**2** of the resist film **20**C is directly measured, the accurate processing amount DP can be calculated compared to the case where the thickness F**2** of the resist film **20**C is calculated or estimated.

[0034] The second method is a method of calculating the processing amount DP by calculating the wear amount DF, calculating the thickness F**2** of the resist film **20**C from the wear amount DF, and subtracting the thickness F**2** of the resist film **20**C from the overall height H**2** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**C.

[0035] First, before the processing step, the measuring device **150** measures the overall height H**1** (thickness F**1** of the resist film **20**B) from the processing portion **10***a* of the workpiece **10** to the upper surface of the resist film **20**B (pre-measuring step). That is, the pre-measuring step is executed in step S**10** (preparation step).

[0036] Next, the control unit **151** calculates the wear amount DF. The storage unit of the control unit **151** stores the wear amount of the resist film **20** per unit injection amount in advance. The control unit **151** calculates the wear amount DF by multiplying the injection amount of the abrasive grains in step S**14** (processing step) by the wear amount of the resist film **20** per unit injection amount. Then, the control unit **151** calculates the thickness F**2** of the resist film **20**C by subtracting the wear amount DF from the overall height H**1** (thickness F**1** of the resist film **20**B) from the processing portion **10***a* of the workpiece **10** to the upper surface of the resist film **20**B. Then, the control unit **151** calculates the processing amount DP by subtracting the thickness F**2** of the resist film **20**C from the overall height H**2** from the processing portion **10***a* of the workpiece to the upper surface **20***a* of the resist film **20**C. According to the second method, even if the thickness F**2** of the resist film **20**C cannot be directly measured due to the relationship between the refractive index and the transmittance, the processing amount DP can be calculated.

[0037] When the processing amount DP is calculated, in step S**24**, the control unit **151** determines whether the processing amount DP is within the target range. The target range is set to include the target processing amount, for example. When it is determined that the processing amount DP is not within the target range (step S**24**: NO), the control unit **151** changes the processing conditions of the next processing step in step S**26** (feedback step). By feeding back the measurement result to the processing conditions, the workpiece is processed to the designed shape. When it is determined that the processing amount DP is within the target range (step S**24**: YES), the flowchart shown in FIG. **2** ends.

[0038] When the flowchart shown in FIG. **2** ends, a stripping and cleaning step (not shown) is executed. FIG. **3**E is a diagram illustrating an example of a workpiece in the stripping and cleaning step. In the stripping and cleaning step, the stripping solution is sprayed onto the entire workpiece **10**A from the nozzle of the stripping and cleaning device **16**. As a result, the resist film **20**C is stripped off, and the workpiece **10**A is obtained as a product.

Summary of Embodiment

[0039] In the processing method M**1** and the measurement system **15**, the workpiece **10** is prepared, and the processing portion **10***a* of the workpiece **10** is removed using the resist film **20**B. Thereafter, the overall height H**2** from the processing portion **10***a* of the workpiece **10**A to the upper surface **20***a* of the resist film **20**C is measured. Next, the processing amount of the workpiece **10**A is calculated based on the measured overall height H**2** and the thickness F**2** of the resist film **20**C after the processing step. In the processing method M**1** and the measurement system **15**, the processing amount is calculated without removing the resist film **20**C. Therefore, it is not necessary to remove or reattach the resist film **20**C to measure the processing amount, which eliminates the need for skilled techniques and reduces manpower and time.

[0040] As described above, various exemplary embodiments have been described, but the present disclosure is not limited to the above-described exemplary embodiments, and various omissions, substitutions, and changes may be made. For example, the measurement system **15** may be integrated with the blasting device **14**. As an example, the measuring device **150** may be disposed inside the chamber of the blasting device **14**. Even in such a configuration, the same effects as those of the processing method M**1** and the measurement system **15** can be obtained. Also, the refractive index of the resist film **20** may be unknown. In this case, the thickness F**1** of the resist film **20**B may be measured by the 3D sensor or the spectroscopic film thickness meter, and the overall height H**1** may be measured by the 3D sensor, and the refractive index of the resist film **20** may be derived by dividing the thickness F**1** of the resist film **20**B by the overall height H**1**. The

processing method M**1** and the measurement system **15** may calculate the processing amount of the workpiece **10**A using the derived refractive index of the resist film **20**.

Claims

1. A method for processing a workpiece, comprising: a preparation step of providing a resist film with an opening on a processing surface of the workpiece; a processing step of removing a processing portion of the workpiece exposed by the opening while protecting a protection portion of the workpiece covered by the resist film provided on the workpiece; a measuring step of measuring an overall height from the processing portion of the workpiece to an upper surface of the resist film after the processing step; and a calculating step of calculating a processing amount of the workpiece based on the overall height measured and a thickness of the resist film after the processing step.

2. The method for processing the workpiece according to claim 1, wherein in the calculating step, the thickness of the resist film after the processing step is measured based on an intensity of reflected light from a surface and a back surface of the resist film and a refractive index of the resist film.

3. The method for processing the workpiece according to claim 1, wherein the preparation step includes a pre-measuring step of measuring the overall height from the processing portion of the workpiece to the upper surface of the resist film before the processing step as a thickness of the resist film before the processing step; the processing step includes injecting abrasive grains onto the workpiece; and in the calculating step, a wear amount of the resist film in the processing step is calculated based on an injection amount of the abrasive grains and a wear amount of the resist film per unit injection amount, and the thickness of the resist film after the processing step is calculated based on the thickness of the resist film before the processing step and the wear amount of the resist film.

4. The method for processing the workpiece according to claim 1, further comprising a feedback step of changing processing conditions of next processing step based on the processing amount of the workpiece calculated in the calculating step and a target processing amount.

5. A measurement system comprising: a measuring device for measuring an overall height from a processing portion of a workpiece exposed by an opening to an upper surface of a resist film covering a protection portion of the workpiece; and a control unit connected to the measuring device for calculating a processing amount of the workpiece, wherein the control unit causes the measuring device to measure the overall height from the processing portion of the workpiece to the upper surface of the resist film after processing in which the processing portion of the workpiece is removed while protecting the protection portion of the workpiece, and calculates the processing amount of the workpiece based on the overall height measured and a thickness of the resist film after the processing in which the processing portion of the workpiece is removed.