(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 139 400 A1

# (12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**08.03.2017 Bulletin 2017/10**

(51) Int Cl.:
***H01J 49/00*** *(2006.01)* ***H01J 49/14*** *(2006.01)*
***H01J 49/16*** *(2006.01)*

(21) Application number: **16185874.1**

(22) Date of filing: **26.08.2016**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**
Designated Validation States:
**MA MD**

(30) Priority: **04.09.2015 JP 2015174997**

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## (54) POSITION CORRECTION SAMPLE, MASS SPECTROMETRY DEVICE, AND MASS SPECTROMETRY METHOD

(57) According to an embodiment, a position correction sample (20) is used to correct an irradiation position of an ion beam with respect to a sample platform where an analysis object is disposed in mass spectrometry. The position correction sample (20) comprises a stacked body (LB1). The stacked body includes a first layer (201), a second layer (202), and a third layer (203). The first layer includes a first material. The second layer is provided on the first layer. The second layer includes a second material. The third layer is provided on the second layer. The third layer includes a third material.

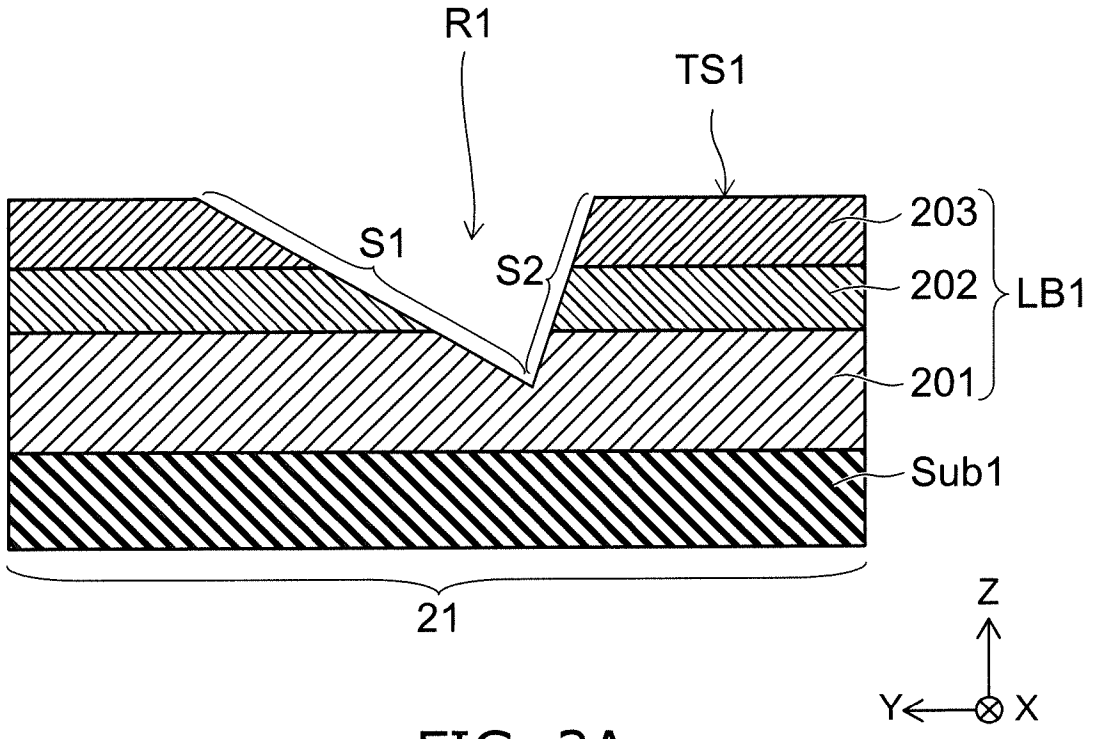


FIG. 3A

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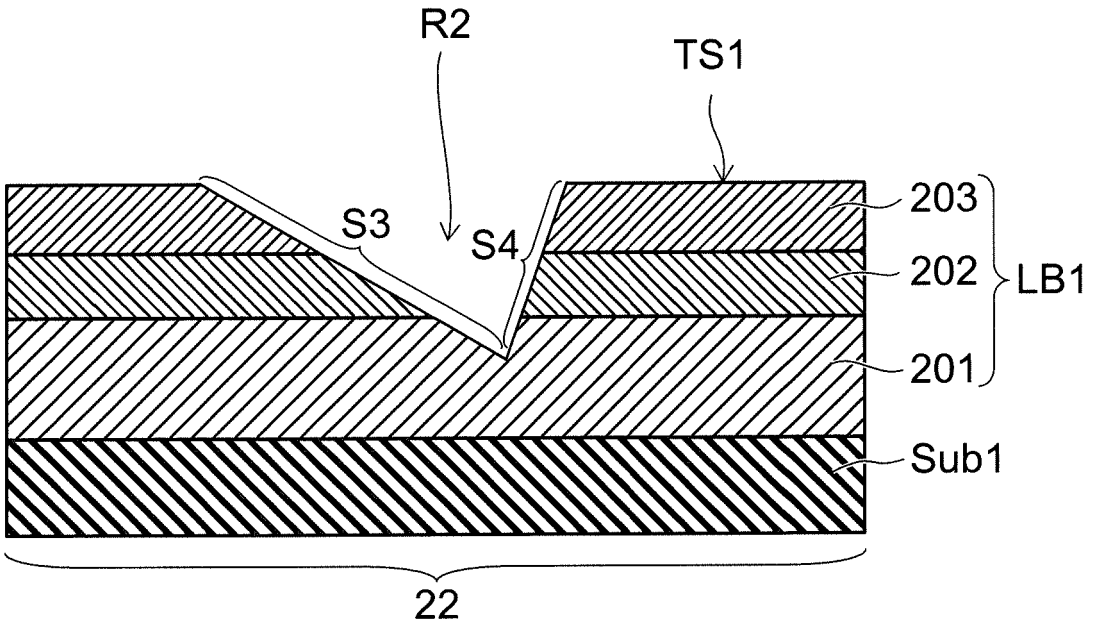
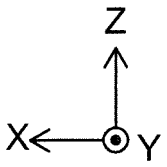



FIG. 3B



## Description

### FIELD

**[0001]** Embodiments described herein generally relate to a position correction sample, a mass spectrometry device, and a mass spectrometry method.

### BACKGROUND

**[0002]** A neutral mass spectrometer (laser SNMS device) that uses laser light performs mass spectrometry by sputtering a sample by irradiating an ion beam on the sample surface, and by producing post-ions by irradiating laser light on the sputtered particles. The laser SNMS device has good quantitativeness and high sensitivity compared to a secondary ion mass spectrometer (SIMS device) that analyzes the secondary ions emitted initially as ions by the sputtering. Therefore, it is also possible to analyze a micro region of the sample.

**[0003]** On the other hand, the position of the sample platform where the sample is disposed may fluctuate due to heat, vibrations, etc., occurring in the analysis. When the position of the sample platform fluctuates, the irradiation position of the ion beam with respect to the sample platform also fluctuates undesirably. Although the fluctuation amount of the position of the sample platform is very small, the fluctuation of the position may be problematic when analyzing a micro region of the sample using the laser SNMS device.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0004]**

FIG. 1 is a schematic view showing the mass spectrometry device according to an embodiment;
FIG. 2 is a plan view showing a sample to be analyzed and a position correction sample disposed on a sample platform;
FIGS. 3A and 3B are cross-sectional views showing the position correction sample;
FIG. 4 is a flowchart showing a mass spectrometry method according to the embodiment;
FIG. 5 is a plan view showing another example of the sample to be analyzed and the position correction sample disposed on the sample platform; and
FIGS. 6A and 6B are cross-sectional views showing the position correction samples.

### DETAILED DESCRIPTION

**[0005]** According to an embodiment, a position correction sample is used to correct an irradiation position of an ion beam with respect to a sample platform where an analysis object is disposed in mass spectrometry. The position correction sample comprises a stacked body. The stacked body includes a first layer, a second layer, and a third layer. The first layer includes a first material. The second layer is provided on the first layer. The second layer includes a second material. The third layer is provided on the second layer. The third layer includes a third material.

**[0006]** Embodiments of the invention will now be described with reference to the drawings. The drawings are schematic or conceptual; and the relationships between the thicknesses and widths of portions, the proportions of sizes between portions, etc., are not necessarily the same as the actual values thereof. The dimensions and/or the proportions may be illustrated differently between the drawings, even in the case where the same portion is illustrated. In the drawings and the specification of the application, components similar to those described thereinabove are marked with like reference numerals, and a detailed description is omitted as appropriate.

**[0007]** A mass spectrometry device according to the embodiment will now be described using FIG. 1.

**[0008]** FIG. 1 is a schematic view showing the mass spectrometry device 10 according to the embodiment.

**[0009]** As shown in FIG. 1, the mass spectrometry device 10 according to the embodiment includes a sample platform 11, an ion beam source 12, a laser light source 14, a controller 15, and a mass spectrometry unit 16.

**[0010]** A sample that is used as an analysis object is disposed on the sample platform 11. The sample platform 11 includes a position adjustment mechanism 11a for adjusting the position of the sample platform 11. The sample platform 11 is disposed inside a chamber that is depressurizable.

**[0011]** The ion beam source 12 irradiates an ion beam toward the sample disposed on the sample platform 11. The sample disposed on the sample platform 11 is sputtered by the ion beam irradiated from the ion beam source 12; and particles such as atoms, molecules, etc., that originate in the sample scatter. The ion beam source 12 is, for example, a focused ion beam (FIB) device. The ion beam source 12 includes a deflection electrode 12a and can change the irradiation position of the ion beam toward the sample platform 11 by controlling the voltage value applied to the deflection electrode 12a.

**[0012]** The laser light source 14 irradiates laser light into a region above the sample platform 11. The particles that are sputtered from the sample are post-ionized by the laser light. It is desirable for the laser light source 14 to irradiate the laser light to be parallel to the front surface of the sample platform 11 at the vicinity of the sample platform 11 to efficiently post-ionize the particles.

**[0013]** The controller 15 is connected to the sample platform 11, the ion beam source 12, the laser light source 14, and the mass spectrometry unit 16 and controls the operations of each constituent included in the mass spectrometry device 10.

**[0014]** The mass spectrometry unit 16 performs mass spectrometry of the particles post-ionized by the laser light. For example, various mass spectrometry devices such as a magnetic sector mass spectrometer, a time-of-flight mass spectrometer, a quadrupole mass spectrometer, etc., may be used as the mass spectrometry unit 16. The mass spectrometry unit 16 includes an attracting electrode 16a for attracting the post-ionized particles into the interior of the mass spectrometry unit 16. A voltage is applied to the attracting electrode 16a to attract the post-ionized particles into the interior of the mass spectrometry unit 16.

**[0015]** The position correction sample according to the embodiment will now be described using FIG. 2 and FIGS. 3A and 3B. Here, an XYZ orthogonal coordinate system is used in the description. Two mutually-orthogonal directions parallel to the front surface of the sample platform 11 are taken as an X-direction and a Y-direction; and a direction perpendicular to these directions is taken as a Z-direction.

**[0016]** FIG. 2 is a plan view showing a sample to be analyzed and a position correction sample disposed on the sample platform 11.

**[0017]** FIGS. 3A and 3B are cross-sectional views showing the position correction sample. Specifically, FIG. 3A is a Y-Z cross-sectional view of the position correction sample 20; and FIG. 3B is an X-Z cross-sectional view of the position correction sample 20.

**[0018]** As shown in FIG. 2, on the sample platform 11, the position correction sample 20 is disposed in addition to a sample 13 which is the object of the analysis. The sample platform 11 includes a first fixing unit 111 and a second fixing unit 112 for fixing the samples. The sample 13 is fixed to the sample platform 11 by the first fixing unit 111; and the position correction sample 20 is fixed to the sample platform 11 by the second fixing unit 112.

**[0019]** In the example shown in FIG. 2, the first fixing unit 111 and the second fixing unit 112 fix the sample 13 and the position correction sample 20 by mechanical chucks. However, this is not limited to the example; and the first fixing unit 111 and the second fixing unit 112 may fix the sample 13 and the position correction sample 20 by electrostatic chucks.

**[0020]** The position of the sample 13 and the position of the position correction sample 20 on the sample platform 11 are not limited to the example shown in FIG. 2 and are arbitrary.

**[0021]** The position correction sample 20 includes a first portion 21 and a second portion 22. The first portion 21 and the second portion 22 are separated from each other. The position of the first portion 21 and the position of the second portion 22 in the position correction sample 20 are arbitrary.

**[0022]** As shown in FIG. 3A and FIG. 3B, the position correction sample 20 includes a first substrate Sub1, and a first stacked body LB1 provided on the first substrate Sub1.

**[0023]** The first stacked body LB1 includes a first layer 201, a second layer 202, and a third layer 203. The second layer 202 is provided on the first layer 201; and the third layer 203 is provided on the second layer 202. The first to third layers 201 to 203 are stacked in the Z-direction. For example, the thickness in the Z-direction of the second layer 202 is equal to the thickness in the Z-direction of the third layer 203.

**[0024]** The first layer 201 includes a first material. The second layer 202 includes a second material. The third layer 203 includes a third material.

**[0025]** The first stacked body LB1 has a first recess R1 in the first portion 21, and a second recess R2 in the second portion 22. The first stacked body LB1 has a first surface S1 and a second surface S2 in the first portion 21, and a third surface S3 and a fourth surface S4 in the second portion 22.

**[0026]** As shown in FIG. 3A, the first surface S1 and the second surface S2 each include a portion of the first layer 201 exposed in the first recess R1, a portion of the second layer 202 exposed in the first recess R1, and a portion of the third layer 203 exposed in the first recess R1.

**[0027]** Similarly, as shown in FIG. 3B, the third surface S3 and the fourth surface S4 each include a portion of the first layer 201 exposed in the second recess R2, a portion of the second layer 202 exposed in the second recess R2, and a portion of the third layer 203 exposed in the second recess R2.

**[0028]** The angles between an upper surface TS1 of the third layer 203 and each of the first to fourth surfaces S1 to S4 are obtuse angles. The angle between the upper surface TS1 and the first surface S1 is larger than the angle between the upper surface TS1 and the second surface S2. Similarly, the angle between the upper surface TS1 and the third surface S3 is larger than the angle between the upper surface TS1 and the fourth surface S4.

**[0029]** While the first surface S1 and the second surface S2 are parallel to planes made by tilting the X-Z plane in the Y-direction, the third surface S3 and the fourth surface S4 are parallel to planes made by tilting the Y-Z plane in the X-direction.

**[0030]** It is unnecessary for the first to fourth surfaces S1 to S4 to be completely flat. The first to fourth surfaces S1 to S4 may include an unevenness occurring when forming the surfaces, an unevenness made by irradiating the ion beam on the surfaces, etc.

**[0031]** The first material, the second material, and the third material are mutually-different materials.

**[0032]** For example, the first to third materials include mutually-different elements. Or, the first to third materials include mutually-different compounds.

**[0033]** The first to third materials may include a common element. However, in such a case, for example, the concentration of the element in the first layer 201, the concentration of the element in the second layer 202, and the concentration of the element in the third layer 203 are different from each other.

**[0034]** The first to third materials may include a common element; and mutually-different elements may be added to the first to third materials.

**[0035]** Or, the first to third materials may include a common compound; and the composition of the compound may be different between the first to third layers 201 to 203.

**[0036]** A case is described in the example shown in FIG. 2 and FIGS. 3A and 3B where the first stacked body LB1 includes three layers. The invention according to the embodiment is not limited to the example; and, for example, the first stacked body LB1 may include another layer other than the first to third layers 201 to 203.

**[0037]** In such a case, the first to fourth surfaces S1 to S4 include portions of the other layer exposed in the first recess R1 and the second recess R2 in addition to the exposed portions of the first to third layers 201 to 203.

**[0038]** A mass spectrometry method according to the embodiment will now be described.

**[0039]** FIG. 4 is a flowchart showing the mass spectrometry method according to the embodiment.

**[0040]** First, the sample 13 and the position correction sample 20 are disposed on the sample platform 11 prior to starting the mass spectrometry.

**[0041]** Then, in step 401, the controller 15 causes an ion beam to be irradiated from the ion beam source 12 toward the first portion 21 of the position correction sample 20. A portion of the position correction sample 20 is removed by the irradiation of the ion beam.

**[0042]** In step 401, the first surface S1 and the second surface S2 are formed in the first portion 21 by irradiating the ion beam on the upper surface TS1 of the third layer 203 so that the ion beam is incident at an angle of less than 45 degrees. For example, the incident angle of the ion beam on the upper surface TS1 can be adjusted by changing the tilt of the sample platform 11.

**[0043]** Then, in step 402, the controller 15 causes an ion beam to be irradiated from the ion beam source 12 toward the second portion 22 of the position correction sample 20. Similarly to step 401, the third surface S3 and the fourth surface S4 are formed in the second portion 22 by this step.

**[0044]** Then, in step 403, each condition for implementing the mass spectrometry according to the embodiment is set. Specifically, first, the setting is performed for the position of the portion of the sample 13 where the measurement is to be performed. Continuing, the voltage value of the deflection electrode 12a for irradiating the ion beam on the portion of the first surface S1 where the second layer 202 is exposed is determined. Continuing, the voltage value of the deflection electrode 12a for irradiating the ion beam on the portion of the third surface S3 where the second layer 202 is exposed is determined.

**[0045]** In step 403, the setting order of each condition is modifiable as appropriate.

**[0046]** Then, in step 404, the controller 15 causes an ion beam to be irradiated from the ion beam source 12 toward the sample 13. Simultaneously, the controller 15 causes laser light to be irradiated from the laser light source 14 toward a region above the sample 13 and causes the mass spectrometry unit 16 to execute mass spectrometry of the post-ionized particles. The mass spectrometry of the particles originating in the sample 13 is performed by this step.

**[0047]** After the mass spectrometry of the sample 13 is performed for a prescribed amount of time, the controller 15 causes an ion beam to be irradiated from the ion beam source 12 toward the first portion 21 of the position correction sample 20 in step 405. Specifically, the controller 15 sets the voltage value of the deflection electrode 12a to the value obtained in step 403 so that the ion beam is irradiated on the portion of the first surface S1 where the second layer 202 is exposed. In step 405, similarly to step 404, the laser light source 14 and the mass spectrometry unit 16 are operated so that mass spectrometry of the particles sputtered in the first portion 21 can be performed.

**[0048]** As described above, the first surface S1 includes a portion of the first layer 201, a portion of the second layer 202, and a portion of the third layer 203. The voltage value of the deflection electrode 12a set in step 403 is set so that the ion beam is irradiated on the second layer 202. Therefore, in the case where the fluctuation amount in the Y-direction of the sample platform 11 is sufficiently small with respect to the width of the exposed portion of the second layer 202, the ion beam is irradiated on the second layer 202; and the second material included in the second layer 202 is detected by the mass spectrometry unit 16.

**[0049]** On the other hand, in the case where the fluctuation amount in the Y-direction of the sample platform 11 is large, a material included in a layer other than the second layer 202 is detected by the mass spectrometry unit 16. For example, in the case where the sample platform 11 fluctuates in the -Y direction, the first material that is included in the

first layer 201 is detected by the mass spectrometry unit 16.

**[0050]** The controller 15 calculates the fluctuation amount in the Y-direction of the sample platform 11 from the result of the mass spectrometry when irradiating the ion beam on the first portion 21, the thicknesses of the first to third layers 201 to 203, the tilt of the first surface S1 with respect to the upper surface TS1, etc.

**[0051]** Or, there are also cases where the ion beam is irradiated on the boundary portion between the layers according to the fluctuation amount of the sample platform 11. In such a case, the irradiation position of the ion beam can be determined from the proportion of each material included in each layer; and the fluctuation amount in the Y-direction of the sample platform 11 can be calculated.

**[0052]** Then, in step 406, the controller 15 causes an ion beam to be irradiated from the ion beam source 12 toward the second portion 22 of the position correction sample 20. Specifically, the controller 15 sets the voltage value of the deflection electrode 12a to the value obtained in step 403 so that the ion beam is irradiated on the portion of the third surface S3 where the second layer 202 is exposed. In step 406, similarly to step 405, the laser light source 14 and the mass spectrometry unit 16 are operated so that the particles sputtered in the second portion 22 can be analyzed.

**[0053]** Similarly to step 405, the controller 15 calculates the fluctuation amount in the X-direction of the sample platform 11 based on the material detected when irradiating the ion beam on the second portion 22.

**[0054]** Then, in step 407, the controller 15 corrects the irradiation position of the ion beam with respect to the sample platform 11 to correct the calculated fluctuation amount in the X-direction and the calculated fluctuation amount in the Y-direction.

**[0055]** Specifically, the controller 15 moves the position of the sample platform 11 by the calculated fluctuation amount by driving the position adjustment mechanism 11a.

**[0056]** Or, the controller 15 may correct the irradiation position of the ion beam to cancel the calculated fluctuation amount by adjusting the voltage applied to the deflection electrode 12a of the ion beam source 12.

**[0057]** By the steps recited above, the irradiation position of the ion beam with respect to the sample platform 11 can be corrected.

**[0058]** After step 407, the irradiation position of the ion beam with respect to the sample 13 is corrected again by performing mass spectrometry of the sample 13; and as a result, it is possible to increase the precision of the mass spectrometry.

**[0059]** In the mass spectrometry method according to the embodiment described above, it is also possible to execute steps 405 and 406 by interchanging the order.

**[0060]** It is also possible to omit steps 401 and 402 by disposing, on the sample platform 11, the position correction sample 20 in which the first recess R1 and the second recess R2 are made beforehand.

**[0061]** The various conditions obtained in step 403 may be preset prior to starting the mass spectrometry method described above. In such a case, step 403 may be omitted.

**[0062]** In steps 405 and 406, it is desirable for the energy of the ion beam irradiated on the position correction sample 20 to be smaller than the energy of the ion beam irradiated on the sample 13. The sputtering of the position correction sample 20 can be suppressed by reducing the energy of the ion beam irradiated on the position correction sample 20. By suppressing the sputtering of the position correction sample 20, the depositing of the particles sputtered from the position correction sample 20 on the sample 13 can be suppressed; and it is possible to use the position correction sample 20 over a longer period of time.

**[0063]** For example, the energy of the ion beam can be reduced by reducing the acceleration energy of the ions or reducing the density of the ions accelerated toward the position correction sample 20. Both the acceleration energy of the ions and the density of the ions accelerating toward the position correction sample 20 may be reduced.

**[0064]** In steps 401 and 402, it is desirable for the acceleration energy of the ions to be small when forming the first to fourth surfaces S1 to S4 in the position correction sample 20. For example, the acceleration energy of the ions in steps 401 and 402 is smaller than the acceleration energy of the ions in step 404.

**[0065]** By setting the acceleration energy of the ions to be small in steps 401 and 402, the depositing of removed particles on the first to fourth surfaces S1 to S4 can be suppressed when forming the surfaces.

**[0066]** According to the position correction sample, the mass spectrometry device, and the mass spectrometry method according to the embodiment described above, even in the case where fluctuation of the position of the sample platform 11 of the mass spectrometry device 10 occurs, it is possible to correct the irradiation position of the ion beam with respect to the sample platform 11 with high precision. By using the position correction sample 20 according to the embodiment, the irradiation position of the ion beam with respect to the sample platform 11 can be corrected partway through the mass spectrometry.

**[0067]** To determine the fluctuation amount in the Y-direction and the fluctuation amount in the X-direction of the sample platform 11 with higher precision, it is desirable for the third material to be a conductor and for the third layer 203 to be conductive. This is because, by the third layer 203 being conductive, charging of the front surface of the position correction sample 20 can be suppressed; and the change of the path of the ion beam due to the charge can be suppressed.

**[0068]** When the ion beam is irradiated on the position correction sample 20, it is desirable for the difference between the first ionization energies of the first material, the second material, and the third material to be small to efficiently post-ionize the sputtered particles. Specifically, it is desirable for the ionization energy E of the first to third materials to satisfy the following Formula (1), where the wavelength of the laser light irradiated from the laser light source 14 is $\lambda$, the width at half maximum of the distribution of the wavelength is $\Delta\lambda$, Planck's constant is *h,* and the first to third materials are ionized by the energy of *n* photons.

$$\frac{nh}{\lambda - \Delta\lambda} \geq E \geq \frac{nh}{\lambda + \Delta\lambda} \qquad (1)$$

**[0069]** Similarly, to efficiently post-ionize the sputtered particles when the ion beam is irradiated on the position correction sample 20, in the case where the ionization energy of one of the first material, the second material, or the third material is about an integer multiple of the photon energy, it is desirable for the ionization energies of the other materials also to be about integer multiples of the photon energy.

**[0070]** Specifically, the case is considered where the ionization energy E of one of the first to third materials satisfies the following Formula (2), where the wavelength of the laser light irradiated from the laser light source 14 is $\lambda$, the width at half maximum of the distribution of the wavelength is $\Delta\lambda$, and Planck's constant is *h.* It is desirable for the ionization energies E of the other materials to satisfy the following Formula (3). Here, it is unnecessary for *m* in Formula (3) to be common between the other materials; and it is sufficient for the other ionization energies to be about integer multiples of the photon energy.

$$\frac{nh}{\lambda - \Delta\lambda} \geq E \geq \frac{nh}{\lambda + \Delta\lambda} \quad (n \text{ being an integer}) \qquad (2)$$

$$\frac{mh}{\lambda - \Delta\lambda} \geq E \geq \frac{mh}{\lambda + \Delta\lambda} \quad (m \text{ being an integer}) \qquad (3)$$

**[0071]** It is desirable for the diameter of the ion beam irradiated on the position correction sample 20 to be narrower than the width of the exposed portion of the second layer 202 positioned between the first layer 201 and the third layer 203. Specifically, it is desirable for the following Formula (4) to be satisfied, where the diameter of the ion beam is $\phi$, the thickness in the Z-direction of the second layer 202 is *d*, and the angle between the first surface S1 and the upper surface TS1 is $\theta$.

$$\frac{d}{\sin(180 - \theta)} > \phi \qquad (4)$$

**[0072]** To determine the fluctuation amount in the Y-direction and the fluctuation amount in the X-direction of the sample platform 11 with higher precision in the case where the first to third materials include a common compound, it is desirable for the composition of the compound to change continuously from the first material to the third material.

**[0073]** For example, in the case where the first to third materials include a compound of silicon and a p-type impurity or an n-type impurity, it is desirable for the concentration of the impurity in the first layer 201 to be higher than the concentration of the impurity in the second layer 202 and for the concentration of the impurity in the second layer 202 to be higher than the concentration of the impurity in the third layer 203.

**[0074]** Or, it is desirable for the concentration of the impurity in the first layer 201 to be lower than the concentration of the impurity in the second layer 202 and for the concentration of the impurity in the second layer 202 to be lower than the concentration of the impurity in the third layer 203.

**[0075]** The precision of the correction can be increased by increasing the number of layers of the first stacked body LB1 and by setting the thicknesses in the Z-direction of the layers to be thin.

**[0076]** It is desirable for the length in the Y-direction of the first surface S1 and the length in the X-direction of the third surface S3 to be greater than the average fluctuation amount in the X-direction and the Y-direction of the sample platform 11.

Modification

**[0077]** FIG. 5 is a plan view showing another example of the sample to be analyzed and the position correction sample disposed on the sample platform 11.

**[0078]** FIGS. 6A and 6B are cross-sectional views showing the position correction samples. Specifically, FIG. 6A is an X-Z cross-sectional view of a first position correction sample 31; and FIG. 6B is a Y-Z cross-sectional view of a second position correction sample 32.

**[0079]** In the example shown in FIG. 2 and FIGS. 3A and 3B, the first portion 21 for correcting the position in the X-direction and the second portion 22 for correcting the position in the Y-direction are provided in one position correction sample 20.

**[0080]** Conversely, in the modification as shown in FIG. 5, the first position correction sample 31 that functions as the first portion 21 and the second position correction sample 32 that functions as the second portion 22 are disposed in the sample platform 11.

**[0081]** The sample platform 11 includes a third fixing unit 113 in addition to the first fixing unit 111 and the second fixing unit 112. The sample 13 is fixed by the first fixing unit 111. The first position correction sample 31 is fixed by the second fixing unit 112. The second position correction sample 32 is fixed by the third fixing unit 113.

**[0082]** A configuration similar to that of the position correction sample 20 is employable as the configuration of the first position correction sample 31. In other words, as shown in FIG. 6A, the first position correction sample 31 includes, for example, the first substrate Sub1, and the first stacked body LB1 provided on the first substrate Sub1.

**[0083]** The first stacked body LB1 includes a first layer 311, a second layer 312, and a third layer 313. The first layer 311 includes the first material. The second layer 312 includes the second material. The third layer 313 includes the third material. The first stacked body LB1 has the first surface S1 and the second surface S2.

**[0084]** As shown in FIG. 6B, the second position correction sample 32 includes a second substrate Sub2, and a second stacked body LB2 provided on the second substrate Sub2. The second stacked body LB2 includes a fourth layer 324, a fifth layer 325, and a sixth layer 326.

**[0085]** The fifth layer 325 is provided on the fourth layer 324; and the sixth layer 326 is provided on the fifth layer 325. The fourth to sixth layers 324 to 326 are stacked in the Z-direction. For example, the thickness in the Z-direction of the fifth layer 325 is equal to the thickness in the Z-direction of the sixth layer 326. The fourth layer 324 includes a fourth material. The fifth layer 325 includes a fifth material. The sixth layer 326 includes a sixth material.

**[0086]** The third surface S3 and the fourth surface S4 each include a portion of the fourth layer 324 exposed in the second recess R2, a portion of the fifth layer 325 exposed in the second recess R2, and a portion of the sixth layer 326 exposed in the second recess R2.

**[0087]** The angle between an upper surface TS2 of the sixth layer 326 and each of the third surface S3 and the fourth surface S4 are obtuse angles. The angle between the upper surface TS2 and the third surface S3 is larger than the angle between the upper surface TS2 and the fourth surface S4. While the first surface S1 and the second surface S2 are parallel to planes made by tilting the Y-Z plane in the X-direction, the third surface S3 and the fourth surface S4 are parallel to planes made by tilting the X-Z plane in the Y-direction.

**[0088]** The fourth material, the fifth material, and the sixth material are mutually-different materials.

**[0089]** For example, the fourth to sixth materials include mutually-different elements. Or, the fourth to sixth materials include mutually-different compounds.

**[0090]** The fourth to sixth materials may include a common element. However, in such a case, for example, the concentration of the element in the fourth layer 324, the concentration of the element in the fifth layer 325, and the concentration of the element in the sixth layer 326 are different from each other.

**[0091]** The fourth to sixth materials may include a common element; and mutually-different elements may be added to the fourth to sixth materials.

**[0092]** Or, the fourth to sixth materials may include a common compound; and the composition of the compound may be different between the fourth to sixth layers 324 to 326.

**[0093]** One of the first to third materials may be the same as one of the fourth to sixth materials. For example, the first material and the fourth material may be the same; the second material and the fifth material may be the same; and the third material and the sixth material may be the same.

**[0094]** In the case where the mass spectrometry method and the position correction sample according to the modification are used as well, it is possible to correct the irradiation position of the ion beam with respect to the sample platform similarly to the flowchart shown in FIG. 4.

**[0095]** In other words, the fluctuation amount in the Y-direction of the sample platform 11 can be determined by irradiating the ion beam on the first position correction sample 31 and by performing mass spectrometry. The fluctuation amount in the X-direction of the sample platform 11 can be calculated by irradiating the ion beam on the second position correction sample 32 and by performing mass spectrometry.

**[0096]** While certain embodiments have been described, these embodiments have been presented by way of example

only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

## Claims

1. A position correction sample (20) used to correct an irradiation position of an ion beam with respect to a sample platform where an analysis object is disposed in mass spectrometry, the position correction sample comprising a stacked body (LB1),
the stacked body including:

    a first layer (201) including a first material,
    a second layer (202) provided on the first layer, the second layer including a second material, and
    a third layer (203) provided on the second layer, the third layer including a third material.

2. The sample (20) according to claim 1, wherein the stacked body has a first recess (R1) reaching the first layer (201) from the third layer (203).

3. The sample (20) according to claim 2, wherein
the stacked body (LB1) has a first surface (S1), the first surface including a portion exposed via the first recess (R1) of the first layer (201), a portion exposed via the first recess of the second layer (202), and a portion exposed via the first recess of the third layer (203), and
an angle between the first surface (S1) and an upper surface (TS1) of the third layer is an obtuse angle.

4. The sample (20) according to claim 3, wherein
the stacked body has a second surface (S2), the second surface including one other portion exposed via the first recess (R1) of the first layer (201), one other portion exposed via the first recess of the second layer (202), and one other portion exposed via the first recess of the third layer (203),
an angle between the second surface (S2) and the upper surface (TS1) is an obtuse angle, and
the angle between the first surface (S1) and the upper surface (TS1) is larger than the angle between the second surface (S2) and the upper surface (TS1).

5. The sample (20) according to claim 3 or 4, wherein
the stacked body (LB1) has a second recess (R2) separated from the first recess (R1), the second recess reaching the first layer (201) from the third layer (203), and
the stacked body has a third surface (S3), the third surface including a portion exposed via the second recess (R2) of the first layer (201), a portion exposed via the second recess of the second layer (202), and a portion exposed via the second recess of the third layer (203).

6. The sample (20) according to claim 5, wherein
the first layer (201), the second layer (202), and the third layer (203) are stacked along a first direction (Z), and
the first surface (S1) is parallel to a plane made by tilting, toward a third direction (Y), a plane including the first direction (Z) and a second direction (X), the second direction being perpendicular to the first direction, the third direction being perpendicular to the first direction and the second direction.

7. The sample (20) according to claim 6, wherein
the third surface (S3) is parallel to a plane made by tilting, toward the second direction (X), a plane including the first direction (Z) and the third direction (Y).

8. The sample (20) according to any one of claims 1 to 7, wherein
the first layer (201), the second layer (202), and the third layer (203) are stacked along a first direction (Z), and
a thickness of the second layer (202) in the first direction is equal to a thickness of the third layer (203) in the first direction.

9. A mass spectrometry device (10), comprising:

a sample platform (11) including a fixing unit (111,112) fixing the position correction sample according to any one of claims 1 to 8;
an ion beam source (12) irradiating an ion beam toward the sample;
a laser light source (14) irradiating laser light toward a region above the sample platform; and
a mass spectrometry unit (16) analyzing ionized particles.

**10.** A mass spectrometry method, comprising:

irradiating an ion beam on a first sample (13), using laser light to ionize first particles originating in the first sample, and performing mass spectrometry of the ionized first particles; and
irradiating an ion beam on the position correction sample (20) according to any one of claims 1 to 8, using laser light to ionize second particles originating in the position correction sample, performing mass spectrometry of the ionized second particles, and correcting an irradiation position of the ion beam with respect to the first sample based on a mass spectrometry result of the second particles.

**11.** The method according to claim 10, wherein mass spectrometry of the ionized first particles is performed again after the correcting of the irradiation position of the ion beam with respect to the sample platform.

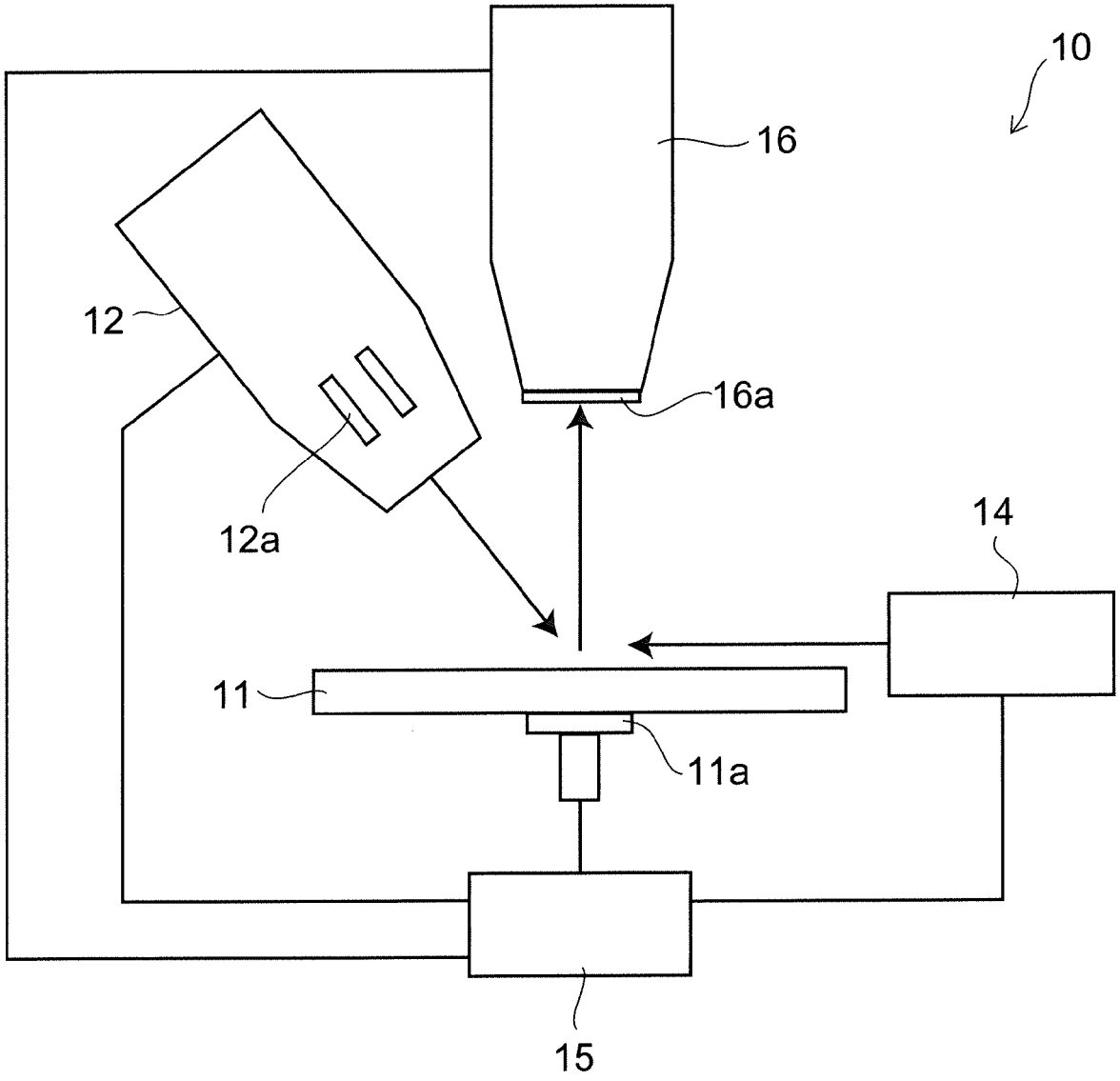



FIG. 1

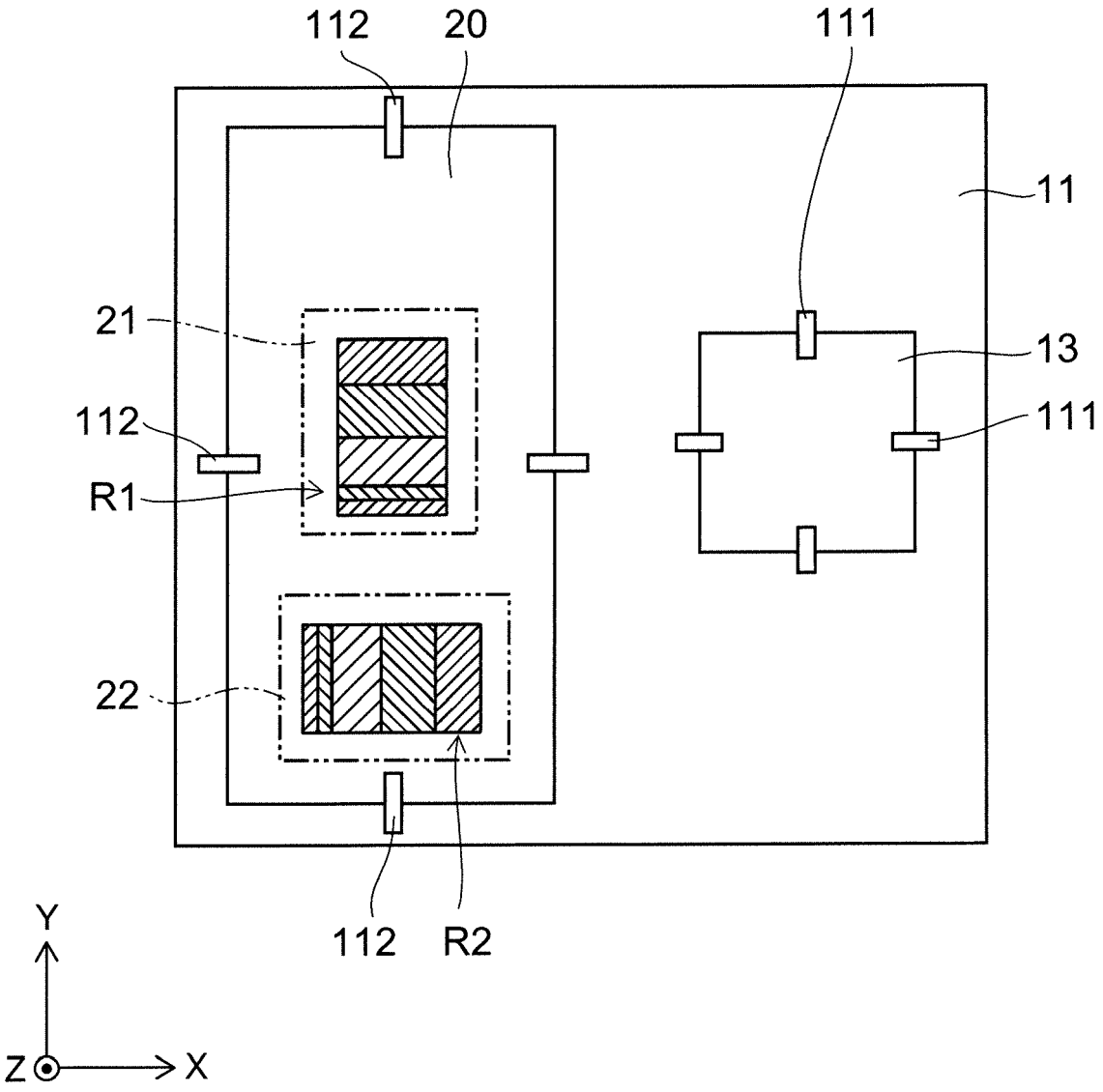



FIG. 2

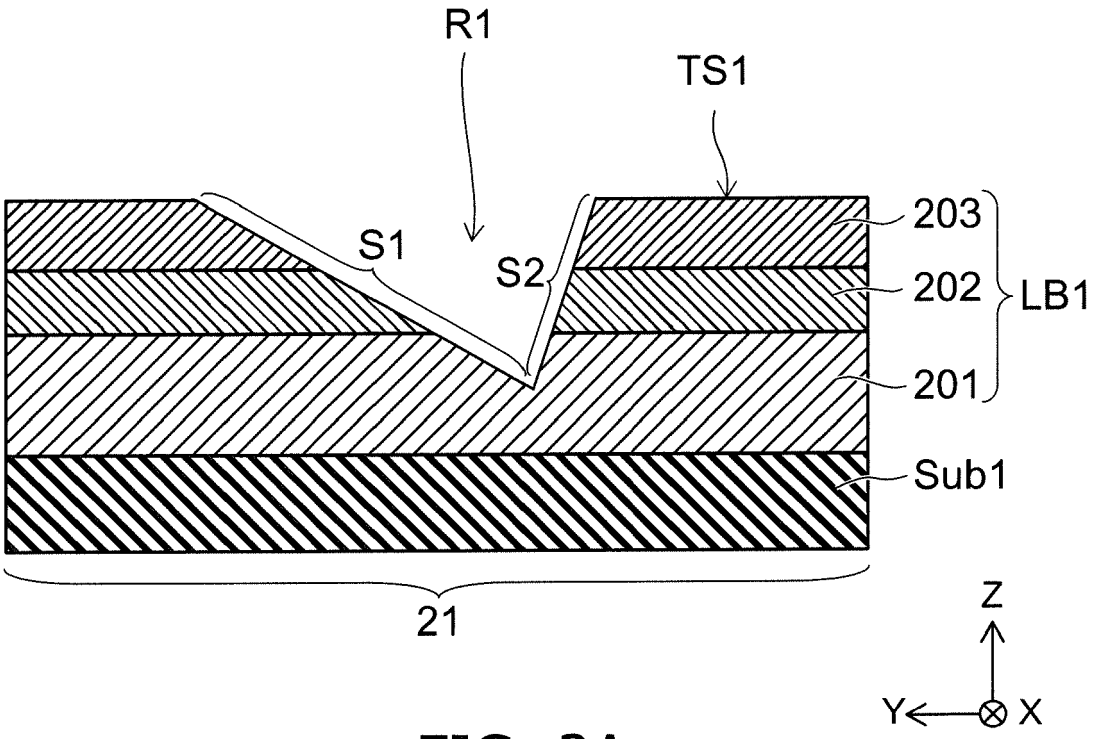

R1
TS1
S1
S2
203
202
LB1
201
Sub1
21
Z
Y
X

FIG. 3A

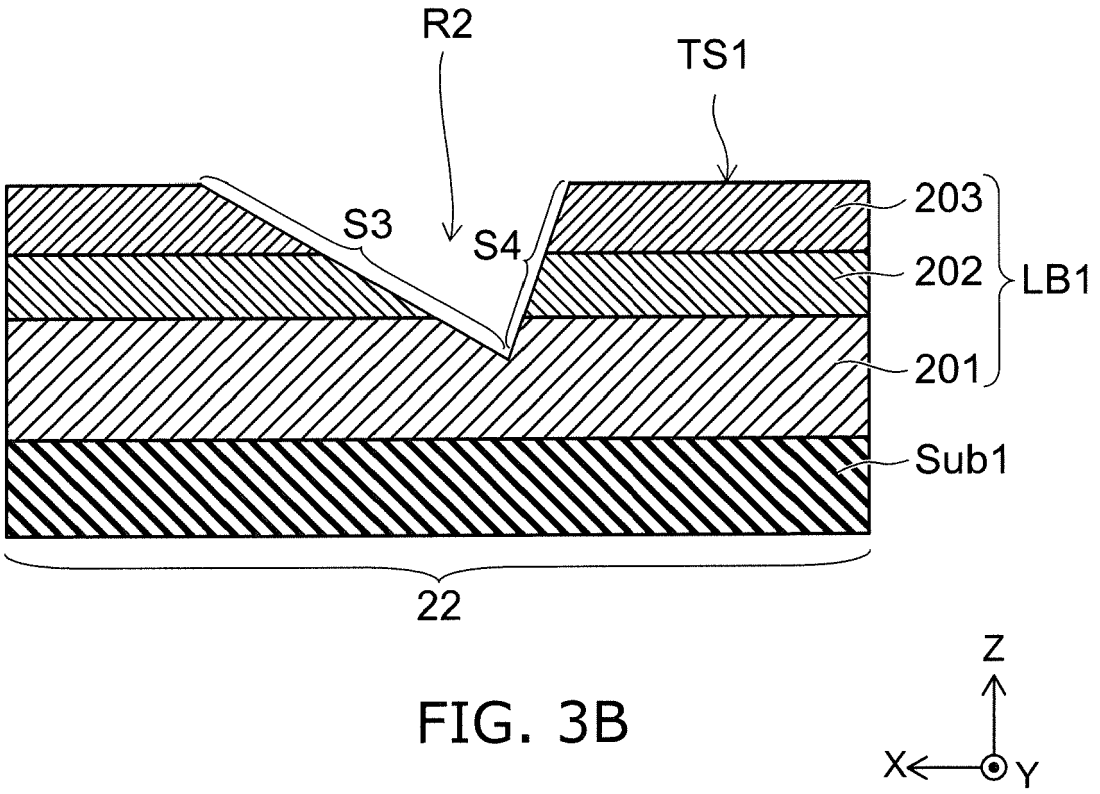

R2
TS1
S3
S4
203
202
LB1
201
Sub1
22
Z
X
Y

FIG. 3B

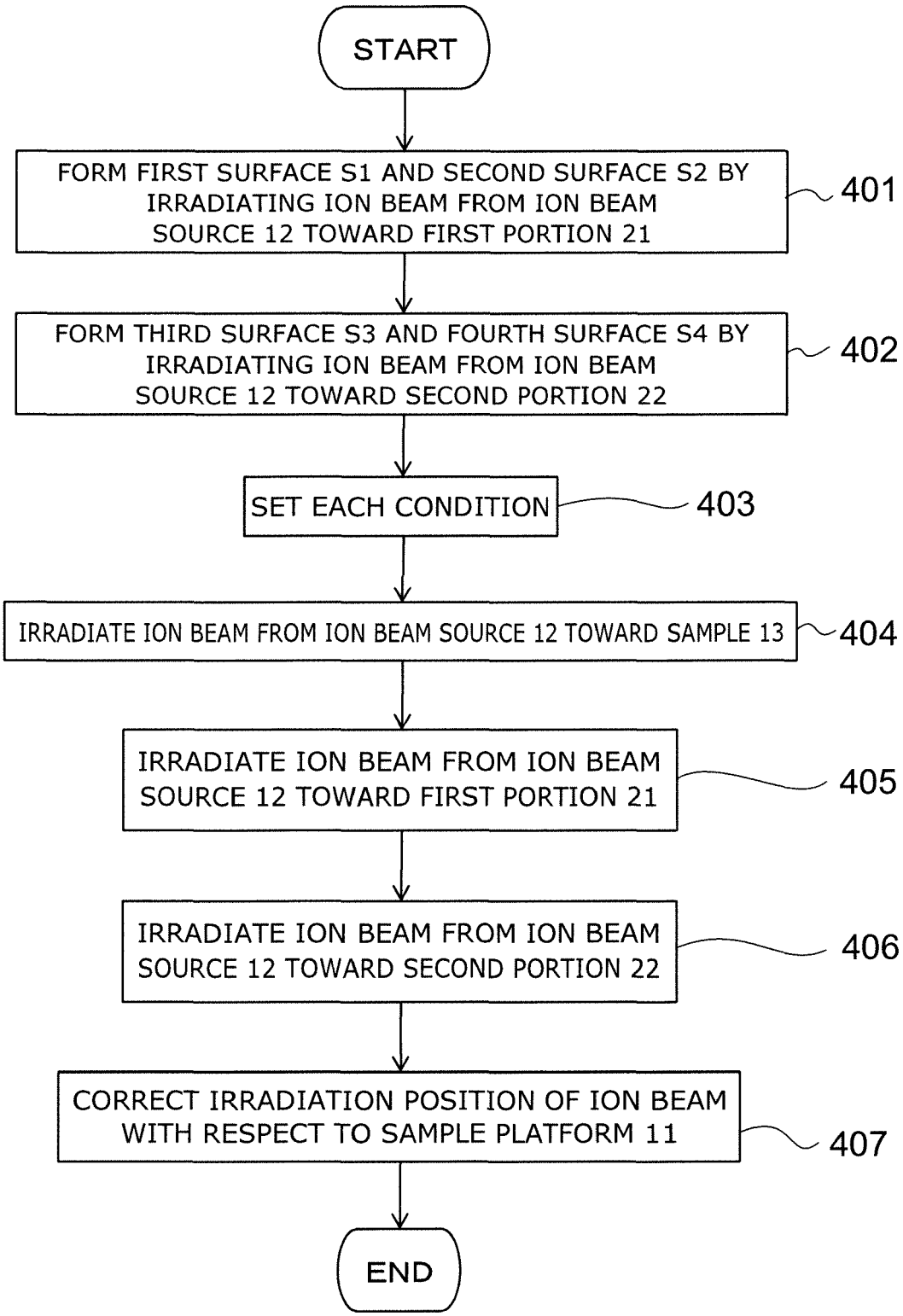

START
FORM FIRST SURFACE S1 AND SECOND SURFACE S2 BY IRRADIATING ION BEAM FROM ION BEAM SOURCE 12 TOWARD FIRST PORTION 21
401
FORM THIRD SURFACE S3 AND FOURTH SURFACE S4 BY IRRADIATING ION BEAM FROM ION BEAM SOURCE 12 TOWARD SECOND PORTION 22
402
SET EACH CONDITION
403
IRRADIATE ION BEAM FROM ION BEAM SOURCE 12 TOWARD SAMPLE 13
404
IRRADIATE ION BEAM FROM ION BEAM SOURCE 12 TOWARD FIRST PORTION 21
405
IRRADIATE ION BEAM FROM ION BEAM SOURCE 12 TOWARD SECOND PORTION 22
406
CORRECT IRRADIATION POSITION OF ION BEAM WITH RESPECT TO SAMPLE PLATFORM 11
407
END

FIG. 4

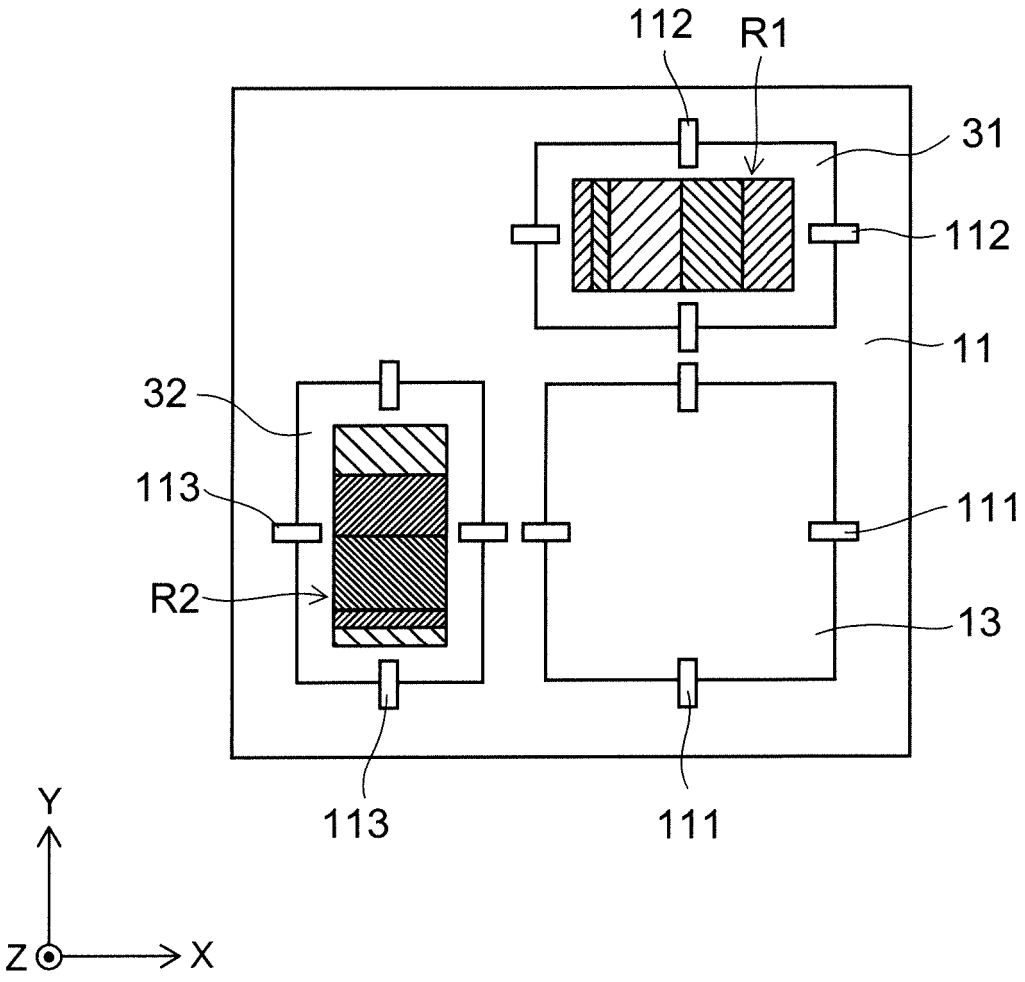



FIG. 5

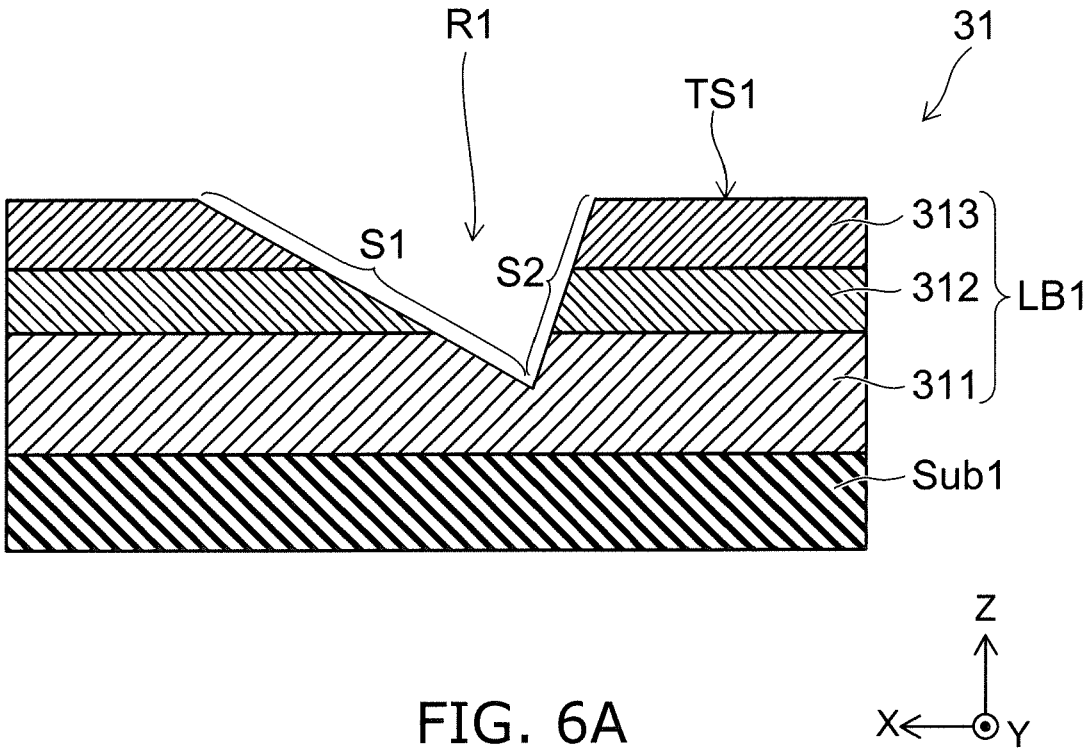

R1
31
TS1
S1
S2
313
312
LB1
311
Sub1
Z
X
Y

FIG. 6A

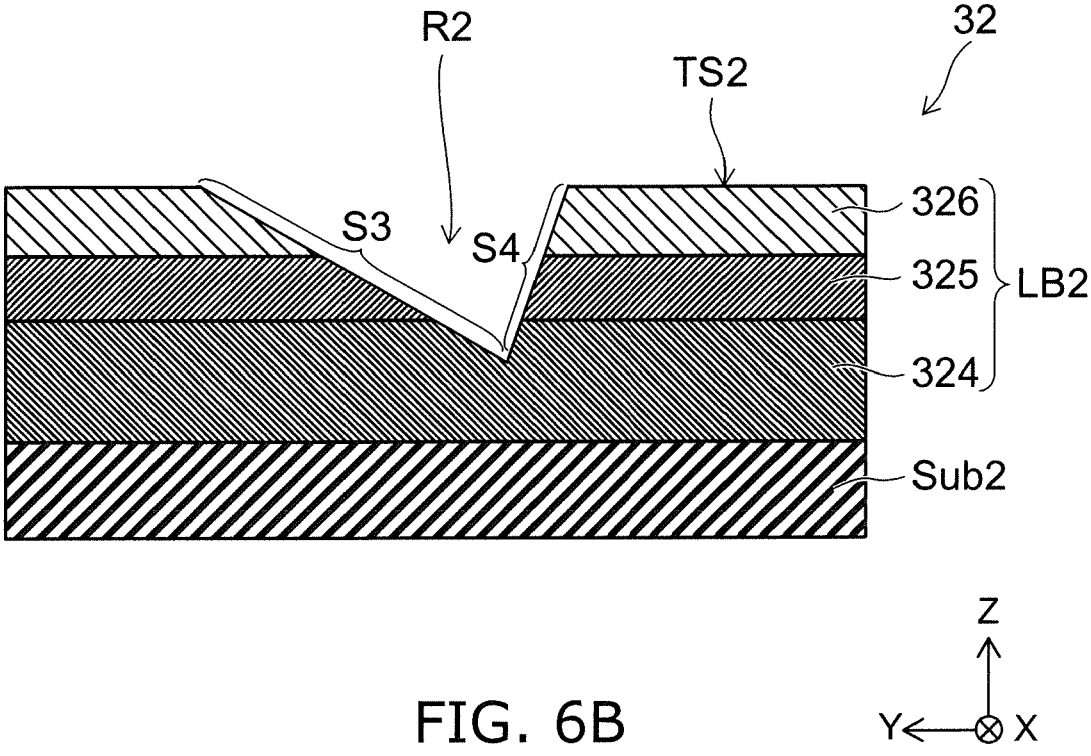

R2
32
TS2
S3
S4
326
325
LB2
324
Sub2
Z
Y
X

FIG. 6B

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Application Number
EP 16 18 5874

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