Appeal decision

Appeal No. 2016-5019

Tokyo, Japan
Appellant HITACHI HIGH-TECH SCIENCE CORPORATION

Tokyo, Japan
Patent Attorney EIKOH PATENT FIRM, P.C.

The case of appeal against an examiner's decision of refusal of Japanese Patent Application No. 2011-268875, entitled "Apparatus and method for preparing lamella sample" [laid-open publication on Jun. 17, 2013: Japanese Unexamined Patent Application Publication No. 2013-120714, the number of claims: (5)] has resulted in the following appeal decision:

Conclusion

The examiner's decision is revoked.

The Invention of the present application shall be granted a patent.

Reason

No. 1 Outline of the procedures

The present application is an application dated December 8, 2011, reasons for refusal were notified on July 1, 2015, a written opinion was submitted on September 4 of the same year, and, in conjunction with this, a written amendment was submitted on the same day. However, the decision of refusal (hereinafter, referred to as "Examiner's decision") was made on December 21 of the same year.

The present case is that, in response to this, a demand for appeal was made on April 5, 2016 against the decision of refusal, and, simultaneously, a written amendment was submitted. After that, a reconsideration report was made on May 24 of the same year.

No. 2 Propriety of the amendment dated April 5, 2016 (hereinafter, referred to as "Amendment of the case")

1 Detail of Amendment

By Amendment of the case, the scope of claims before Amendment of the case, which was amended by the amendment dated September 4, 2015, of

"[Claim 1]

A lamella sample preparation apparatus for processing a sample by a focused ion beam irradiated from a focused ion beam lens tube to prepare a lamella sample, the lamella sample preparation apparatus comprising:

a sample stage on which a lamella sample is mounted;

an electron beam lens tube configured to irradiate an electron beam on the lamella sample;

a charged particle detector configured to detect reflected electrons or secondary electrons emitted from the lamella sample by irradiation of the electron beam;

a display unit configured to display an observation image of the lamella sample formed from a detection signal of the charged particle detector;

an input unit configured to set, in the observation image, a first measurement region in an upper side of the lamella sample and set a second measurement region in a bottom side; and

a slant angle calculation unit configured to calculate a slant angle of the lamella sample from a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region by the irradiation of the electron beam and a distance between the first measurement region and the second measurement region.

[Claim 2]

The lamella sample preparation apparatus according to claim 1, wherein

the input unit is capable of setting a reference region in a part of the sample having a thickness that does not allow the electron beam to penetrate through in a periphery of the lamella sample, and wherein

the slant angle calculation unit standardizes a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region by a detection amount of the reflected electrons or secondary electrons generated from the reference region.

[Claim 3]

A lamella sample preparation method for processing a sample by a focused ion beam to prepare a lamella sample, the lamella sample preparation method comprising:

forming an observation image by irradiating an electron beam to the lamella sample;

setting, in the observation image, a first measurement region in an upper side of the lamella sample, and a second measurement region in a bottom side;

irradiating the electron beam to the first measurement region and the second measurement region and detecting reflected electrons or secondary electrons generated;

calculating a slant angle of the lamella sample from a detection amount of the reflected electrons or secondary electrons detected in the first measurement region, a detection amount of the reflected electrons or secondary electrons detected in the second measurement region, and a distance between the first measurement region and the second measurement region;

slanting the lamella sample with respect to the focused ion beam by the slant angle; and

performing finish processing by irradiating the lamella sample with the focused ion beam.

[Claim 4]

The lamella sample preparation method according to claim 3, further comprising:

setting a reference region in a part of the sample having a thickness that does not allow the electron beam to penetrate through in a periphery of the lamella sample; irradiating the reference region by the electron beam; and detecting reflected electrons or secondary electrons that occur, wherein

the slant angle is calculated by standardizing a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region by a detection amount of the charged particles generated from the reference region.

[Claim 5]

The lamella sample preparation method according to claim 3 or 4, wherein the lamella sample is a sample for TEM observation."

to

"[Claim 1]

A lamella sample preparation apparatus for processing a sample by a focused ion beam irradiated from a focused ion beam lens tube to prepare a lamella sample <u>of a film thickness of 100 nm or less</u>, the lamella sample preparation apparatus comprising:

a sample stage on which a lamella sample is mounted;

an electron beam lens tube configured to irradiate an electron beam on the lamella sample;

a charged particle detector configured to detect reflected electrons or secondary electrons emitted from the lamella sample by irradiation of the electron beam;

a display unit configured to display an observation image of the lamella sample formed from a detection signal of the charged particle detector;

an input unit configured to set, in the observation image, a first measurement region in an upper side of the lamella sample and set a second measurement region in a bottom side, the first and second measurement regions being set at locations having a thickness thin enough to enable a part of the electron beam to penetrate through; and

a slant angle calculation unit configured to calculate a slant angle of the lamella sample from a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region through the radiation of the electron beam and a distance between the first measurement region and the second measurement region.

[Claim 2]

The lamella sample preparation apparatus according to claim 1, wherein

the input unit is capable of setting a reference region in a part of the sample having a thickness that does not allow the electron beam to penetrate through in a periphery of the lamella sample, and wherein

the slant angle calculation unit standardizes a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region by reference to a detection amount of the reflected electrons or secondary electrons generated from the reference region.

[Claim 3]

A lamella sample preparation method for processing a sample by a focused ion beam to prepare a lamella sample of a film thickness of 100 nm or less, the lamella sample preparation method comprising:

forming an observation image by irradiating an electron beam to the lamella sample;

setting, in the observation image, a first measurement region in an upper side of the lamella sample and setting a second measurement region in a bottom side, the first and second measurement regions being set at locations having a thickness thin enough to enable a part of the electron beam to penetrate through;

irradiating the electron beam to the first measurement region and the second measurement region and detecting reflected electrons or secondary electrons generated;

calculating a slant angle of the lamella sample from a detection amount of the reflected electrons or secondary electrons detected in the first measurement region, a detection amount of the reflected electrons or secondary electrons detected in the second measurement region, and a distance between the first measurement region and the second measurement region;

slanting the lamella sample with respect to the focused ion beam by the slant angle; and

performing finish processing by irradiating the lamella sample with the focused ion beam.

[Claim 4]

The lamella sample preparation method according to claim 3, further comprising:

setting a reference region in a part of the sample having a thickness that does not allow the electron beam to penetrate through in a periphery of the lamella sample; irradiating the reference region by the electron beam; and detecting reflected electrons or secondary electrons that occur, wherein

the slant angle is calculated by standardizing a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region by reference to a detection amount of the charged particles generated from the reference region.

[Claim 5]

The lamella sample preparation method according to claim 3 or 4, wherein the lamella sample is a sample for TEM observation." that are the claims after Amendment of the case. (The underlines were added by Appellant)

2 Propriety of amendment

Amendment of the case is an amendment that respectively adds limitations of "a film thickness of 100 nm or less" to "lamella sample" of claims 1 and 3 before Amendment of the case, and of "having a thickness thin enough to enable a part of the electron beam to penetrate through" to "the first measurement region" and "the second measurement region" of claims 1 and 3 before Amendment of the case, and these fall under the category of ones for the purpose of restriction of the scope of claims of Article 17-2(5)(ii) of the Patent Act.

In addition, there is no matter that violates Article 17-2(iii) and (iv) of the Patent Act.

Therefore, whether the inventions according to claims 1-5 after Amendment of the case (hereinafter, respectively called "the Amended Invention 1" to "the Amended Invention 5," and "the Amended Invention 1" to "the Amended Invention 5" are collectively called "the Amended Inventions") comply with the provisions of Article 126(7) of the Patent Act as applied mutatis mutandis pursuant to Article 17-2(6) of the same Act (whether Appellant could be granted a patent independently at the time of filing of the patent application) will be examined hereinafter.

3 Judgment on independent requirements for patentability

(1) Amended Inventions

It is recognized that the Amended Invention 1 to the Amended Invention 5 are specified by the matters described in claims 1-5 of the scope of claims amended by Amendment of the case, and the Amended Inventions 1-5 are as described in the above-mentioned "1" as claims 1-5 after Amendment of the case.

(2) Described matters in the cited documents

A In Japanese Unexamined Patent Application Publication No. H7-333120 (hereinafter, referred to as "Cited Document 1") cited in the reasons for refusal of the Examiner's decision, the following matters are described.

(A) "[0001]

[Industrial Application Field] The present invention relates to a sample preparation method for observing a specific portion of such as a solid-state device by a transmission electron microscope, and, more particularly, to a sample preparation method according to focused ion beam processing, and an apparatus thereof.

[0002]

[Conventional Art] In recent years, focused ion beam (hereinafter, abbreviated to FIB) processing has come to be used for preparation of a sample of a specific portion for a transmission electron microscope (hereinafter, referred to as TEM), such as for analysis of the gate portion of a particular memory cell of a solid-state device and the like, and for analysis and the like of a metal bonding interface of a particular contact hole portion. One example of this is described by reference to drawings; as shown in FIG. 2, for example, the surface of a sample 42 is ground by a polishing machine, a protruding portion 1 of a width of 30-100 μm (typically 50 μm) and a height of 10-100 μm (typically 50 μm) is left, and it is made such that the portion desired to be observed exists in the almost center of this protruding portion.

[0003] Next, as shown in FIG. 3, processing of depth d = 3-10 μm and width w = 4-15 μm is applied by a focused ion beam 2 on either side of the protruding portion 1, and a lamella portion 3 of thickness t is left in the middle part. It is made such that a portion desired to be observed exists in this lamella portion 3. The lamella portion 3 needs to be of the thickness t of about 100 nm to perform TEM observation. In order to leave such small thickness, first, processing is carried out by a focused ion beam of a beam diameter of a size of 0.5-1 μm such that a film thickness of about 1 μm is left, and, further, using a beam of a diameter thinner than about 0.1 μm or less, the thickness t of

the lamella portion 3 is gradually narrowed to finish with the final thickness of about 100 nm or less required for an observation sample for TEM.
[0004] Meanwhile, as a first prior art associated with this, Japanese Unexamined Patent Application Publication No. H5-15981 is cited, for example, and there is known a method, as a processing method of a sample for cross-section SEM observation, in which marks that can specify positions desired to be finally obtained in a cross section are processed, and, using a scanning ion image (SIM image) of the marks, finish processing positions are set."

(B) "[0015] In addition, on the occasion of processing a processed object by a focused ion beam, it may be such that a processed surface of the processed object is slightly slanted during the processing, and this slant is monitored. The reason for this is that, since a current density distribution of a focused ion beam has a tail, there is a case where a processed end face of a processed object slightly tilts due to influence of the tail even if a beam is focused thinner, and thus there is a necessity to compensate this. Therefore, a slant angle of a processed surface of a processed object in this case is made to be suited to attributes (the tail of current density distribution) of the focused ion beam that is used. It is possible to deal with this easily using a method and the like for measuring a reflection angle of light irradiated on a processed surface, for example, as a method for monitoring slant of such processed surface."

(C) "[0029]
[Examples] Hereinafter, by reference to drawings, an example of the present invention will be described.
<Example 1> This example is one that describes an example of a sample preparation method due to ion beam processing according to the present invention, and, hereinafter, description will be made specifically and in detail in conformity with the procedures of processing of a processed object, including a mark observation method for measuring drift of a position of an ion beam and drift correction of a beam position, with reference to FIG. 5-FIG. 7.
[0030] First, as shown in FIG. 5, crude processing is carried out in such a way that the lamella portion 3 formed in the protruding portion 1 of the sample 42 comes to be of a thickness of around 2 μm that is thick enough compared with 100-200 nm that is the final processing finish thickness. Before entering finish processing, an SIM image of an observation area 4 indicated in FIG. 5 is taken such that its left end corresponds to the targeted finish surface of the lamella portion 3. Then, an SIM image shown in FIG. 6 is

taken, and distance x0 of x direction between the left end of the screen (that is, targeted finish processed surface) and a mark 6 is measured here. At the same time, regarding the respective marks, distances x1 and y1 between the center line of the screen and each mark are also measured.

[0031] Next, on the SIM image shown in FIG. 6, a processing area in which cutting is made to be around 1 μm is set to perform processing. After the processing has finished, an SIM image is observed once again. On this occasion, as shown in FIG. 7, when the position of the mark 6 has come to be x2, y2 (in this regard, however, $x2 \neq x1$, $y2 \neq y1$), the observation area 4 is parallelly moved in x direction and y direction by x2-x1 and y2-y1 respectively, because the positional deviations (drift) of the beam are x2-x1 and y2-y1. As a result, the left end of the screen corresponds to the targeted finish processed surface. Then, the distance between the finish processed surface and the mark is x0 is reconfirmed.

[0032] Then, cutting is set to 0.5 μm. That is, the remained film thickness will be 2 μm - 1 μm - 0.5 μm = 0.5 μm. Then, processing is carried out. By repeating such operation, cutting is made small gradually, and the targeted finish processed surface is reached. By making the observation area 4 not overlapping with the lamella portion 3 in this way, there is no worry that the lamella portion 3 is scraped, and, high-precision processing can be performed while correcting drift of the beam by measuring deviation of the marks in the middle of the processing.

[0033] <Example 2> This example relates to a method for monitoring the thickness and, further, to the thickness distribution of the lamella portion 3, and, hereinafter, description will be made by reference to FIG. 1 and FIG. 8-FIG. 19. FIG. 1 indicates a cross-sectional schematic view of an optical system to measure a film thickness of the lamella portion 3 during processing by the focused ion beam 2. As shown in this figure, observation light 7 is irradiated on a processed surface in order to measure the thickness of the lamella portion 3 of the sample 42, light 8 reflected by the surface of the lamella portion 3 and light 9 reflected by the opposite surface are made to interfere with each other, and the thickness of the lamella portion is measured by observing change in interference by the interferometer 11 as the processing progresses.

[0034] Similarly, FIG. 8 is a diagram also indicating a cross-sectional schematic view of an optical system to determine the film thickness of the lamella portion 3 during processing by the focused ion beam 2. As shown in this figure, the thickness is determined by: making the observation light 7 penetrate through the lamella portion 3; making it interfere with reference light 10 that does not pass through the lamella portion; and detecting a phase shift of the observation light due to the lamella portion 3.

In the cases of FIG. 1 and FIG. 8, the observation light 7 needs to penetrate through the lamella portion, and, therefore, if the sample is Si, infrared light is desirable.

[0035] Similarly, FIG. 9 also indicates a cross-sectional schematic view of an optical system to determine the film thickness of the lamella portion 3 during processing by the focused ion beam 2. As shown in this figure, it is one that radiates the observation light 7 of a wavelength that is absorbed in the lamella portion 3 to the lamella portion 3, measures intensity of the light that has penetrated through by a measuring instrument 12 such as a photo multiplier tube, and determines the thickness. In this case, it is preferable that the wavelength be shorter, and, specifically, the wavelength should be determined according to material of the sample.

[0036] In addition, as indicated in FIG. 10, a side wall of the lamella portion 3 tends to be tilted. As indicated later, this angle is due to a tail shape of the current distribution of an ion beam, and, in order to perform high-accuracy processing, it is important to know this tail shape and slant angle of a side wall of the lamella portion 3. Therefore, using a focused laser beam as the observation light 7, and by detecting the beam 8 made by the observation light 7 being reflected by a side wall of the lamella portion 3 by an array-shaped detector 12, it is possible to obtain the position of the reflected light 8 and obtain the angle of side wall of the lamella portion 3.

[0037] FIG. 11 illustrates a method similar to that of FIG. 10, but it is one that makes the observation light 7 be sheet light, measures the intensity distribution by the measuring instrument 12 that is of an array shape, and detects the thickness distribution of the lamella portion 3. In many cases, it is detected that the tip portion is thin.

[0038] In addition, using a focused laser beam as the observation light 7 in FIG. 9, and, by scanning this in the area of the lamella portion 3, a scanning transmitted light image can be obtained.

[0039] The method illustrated in FIG. 12 is one that radiates an electron beam 14 from a focused electron gun 13 to the lamella portion 3, and detects a penetrating electron beam by an electron beam detector 16 such as a Faraday cup and a scintillator to measure a thickness. A suitable transmission amount can be obtained by adjusting energy of the electron beam 14. There is a case where the lamella portion 3 is made up of a plurality of materials having significantly different transmissivities of the electron beam 14, and, in this case, it is insufficient just to measure an average transmission amount of the lamella portion. Therefore, by making the electron beam 14 be capable of scanning, it becomes possible to measure the distribution of the film thickness. Furthermore, by making it be of a structure the same as that of a transmission electron microscope, there is an effect that it is also possible to observe a TEM image during the focused ion beam processing.

[0040] In FIG. 13-FIG. 15, when pulsed laser light 15 is radiated to the lamella portion 3, and the lamella portion 3 is heated by this to cause displacement δ due to thermal expansion as shown in FIG. 14 or FIG. 15, this displacement δ will be a function of thickness. By calculating thickness and displacement from the material, the shape of the lamella portion, the absorption coefficient, and the like of laser in advance, or by confirming these by experimentation in advance, it is possible to estimate thickness from displacement. In order to measure displacement δ, the observation light 7 is made to be reflected by the surface of the lamella portion 3, and is made to interfere with reference light (not shown) reflected by another fixed portion.

[0041] As shown in FIG. 16, the current density distribution has a tail such as curved line 50 as shown in Fig. 16(a) in the focused ion beam processing, and, therefore, a processed end face of a processed object might tilt several degrees as shown by reference symbol 51 of Fig. 16(b) due to influence of the tail even if the beam 2 is focused thinner. For example, assuming that the slant is 2 degrees, and the height of the lamella portion 3 is 6 μm, there will be a thickness difference of the scale of 6 μm × tan (2 degrees) × 2 = 0.4 μm between the upper portion and the lower portion of that. Under such circumstances, a TEM sample of a uniform thickness cannot be fabricated, and, thus, a sample should be tilted by θ = 2 degrees in the case of this example, on the occasion of processing the sample as shown in FIG. 17 in advance. However, when the observation light 7 is made to enter horizontally, the reflection light tilts by 2θ, and, therefore, there is a problem that the reflection light is not incident on the interference detector of reflection light fixed to a place distant from the sample. In addition, also in a case where transmitted light is used, there is a problem that the length of the optical path passing the lamella portion 3 becomes longer by $1/\cos\theta$. Furthermore, even if a sample is not slanted, it will be difficult work to adjust the observation light 7 to the lamella portion 3 of the size of 10 μm.

[0042] Therefore, as shown in FIG. 18, a lens unit 52 for observation light irradiation and a light-receiving unit 53 of the interference detector of transmitted light are mounted on the sample stage 39, and a fiber optic cable 54 and an output cable 55 should be connected thereto. The observation light irradiation unit 52 and the light-receiving unit 53 may be aligned relative to a position where a lamella portion is desired to be fabricated in the atmosphere in advance. Alternatively, it may be arranged such that, even after putting them in the vacuum chamber, fine-tuning of the position can be performed. Meanwhile, in FIG. 18, a case where the irradiation unit 52 and the light-receiving unit 53 are divided into the left side and the right side is indicated. However, in the case of a detection system of reflection light, these can be placed on the same side."

(D) "[0068] <Example 8> FIG. 25 is a main part cross-sectional schematic diagram of an apparatus of the present invention realized by mounting a device to measure a transmission electron beam indicated in FIG. 12 to a focused ion beam processing apparatus. As shown in this figure, in a sample room chamber 40, there are provided a focused ion beam optical system 21, an electron gun 13, a secondary electron detector 56, the detector 16 for an electron beam penetrating the sample, and the stage 39. As indicated in FIG. 3, the sample 42 to be processed is mounted on the stage 39. The focused ion beam 25 for processing the sample 42 is made to perform deflection-scan by applying a signal from a deflection controller 30 to a deflection electrode 31. The electron beam 14 is made to perform deflection-scan by applying a signal from an electron beam deflection controller 57 to a deflection electrode 58.

[0069] A secondary electron that is obtained by irradiation of the focused ion beam 25 and a secondary electron that is obtained by irradiation of the electron beam 14 are detected by the secondary electron detector 56, and a secondary electron image obtained by irradiation of the focused ion beam 25 is used for plane observation of the sample 42 and a secondary electron image obtained by irradiation of the electron beam 14 is used for cross-section observation of a sample lamella portion that has been processed.

[0070] In addition, an electron beam that has penetrated the lamella portion of the sample 42 is detected by the electron beam detector 16, and is used for measurement of the film thickness or the film thickness distribution of the lamella portion.

[0071] The output of the secondary electron detector 56 and the output of the electron beam detector 16 are inputted to an electron beam output switch 59. In this switch 59, a low-frequency-pass filter and a high-frequency-pass filter are also included, as will be described later. An electron beam deflection signal and a focused ion beam deflection signal are inputted to a deflection signal switch 60.

[0072] When a scanning ion image (SIM image) is observed by these switches 59 and 60, the ion beam deflection signal and the secondary electron detection output are inputted to the image display monitor 37.

[0073] When observing a scanning electron image (SEM image), the electron beam deflection signal and the secondary electron detection output are inputted to the image display monitor 37.

[0074] When observing a transmission electron beam intensity distribution, the electron beam deflection signal and the transmission electron beam detector output are inputted to the image display monitor 37.

[0075] As a matter of course, a detector for obtaining a scanning ion image 5 may be a micro-channel plate 3, as indicated in FIG. 20 and the like. In addition, although, in FIG. 25, one piece of image display monitor 37 is used to make the device configuration inexpensive, there is no need that it is limited to this, and it is also possible to install two or more pieces of image display monitor 37, and a scanning ion image, a scanning electron image, and a transmission electron beam image are respectively projected on exclusive-use image display monitors.

[0076] Regarding an irradiation method of two beams of the focused ion beam 25 and the electron beam 14, it is possible to radiate the two simultaneously or separately by setting a different time. When irradiating simultaneously, it is possible to observe a scanning electron image (SEM image) of the processed cross section at the same time while processing by an ion beam.

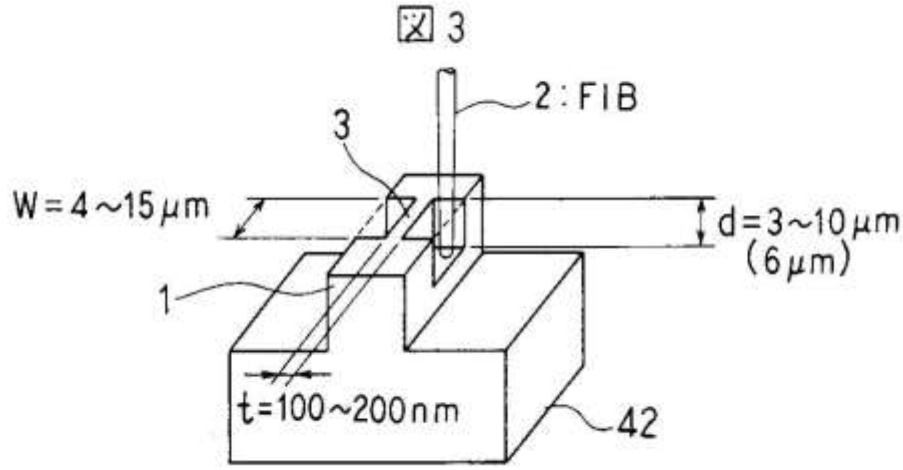
[0077] When there are two pieces of image display monitor 37, an SEM image and a scanning ion image (SIM image) can be observed simultaneously. However, in the case of simultaneous scanning, a secondary electron signal captured by the secondary electron detector 56 will be one in which, as shown in FIG. 26(a), a secondary electron signal 66 according to an electron beam and a secondary electron signal 67 according to a focused ion beam overlap, and it becomes a noisy screen if an SEM image and an SIM image are projected using this signal just as it is.

[0078] Regarding a scanning speed, since, in focused ion beam processing, it is better to make scanning speed fast to make a processed surface be finished flat, a focused ion beam should be scanned at a high speed of a scale that a time for scanning one surface is 1 ms, for example, and, in contrast, an electron beam should be scanned at a slow speed of a scale that a time for scanning one surface is 1 sec., for example. Then, as indicated in FIG. 26(b), the signal 66 according to an electron beam comes to include mainly low frequency components, and the signal 67 according to an ion beam comes to include mainly high frequency components.

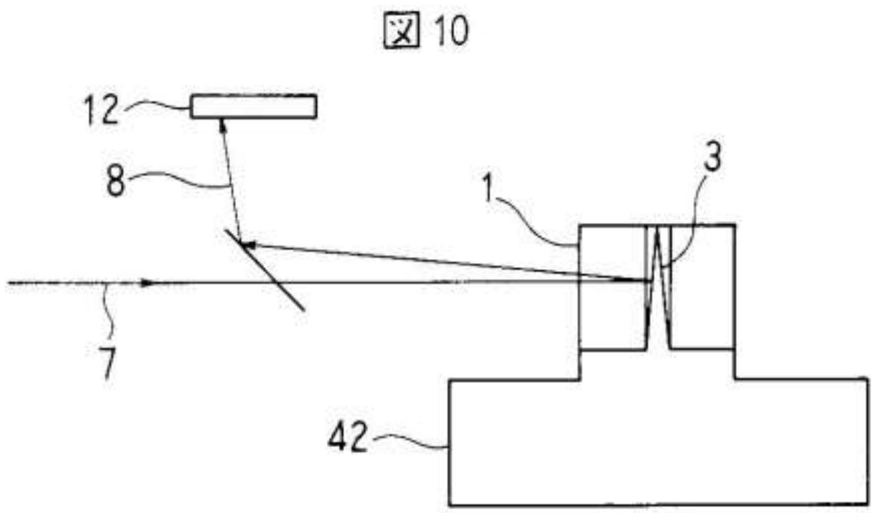
[0079] Therefore, using filters (not shown) provided within the switching device 59, and using a secondary electron signal that is made to pass through a low-frequency-pass filter when an SEM image is obtained, and, using a secondary electron signal that is made to pass through a high-frequency-pass filter when an SIM image is obtained, excellent images for both an SEM image and an SIM image can be obtained.

[0080] In this method, not only when making out a sample for TEM observation but also on the occasion of processing a sample for cross-section SEM observation, focused ion beam processing can be carried out while looking at a cross-section SEM image, and, therefore, there is an effect that a processing state is captured more accurately, and a processing effect of good finishing can be obtained."

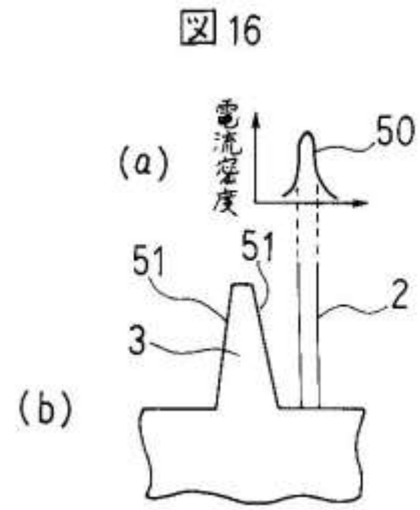
(E) "[FIG. 3]



[FIG. 10]

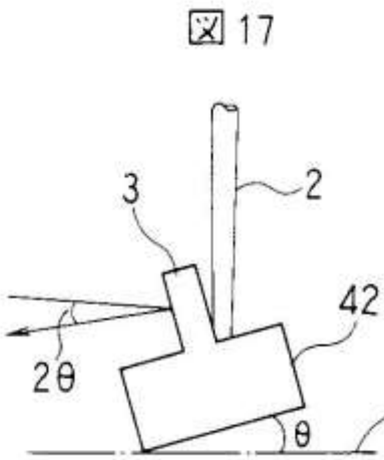


[FIG. 16]



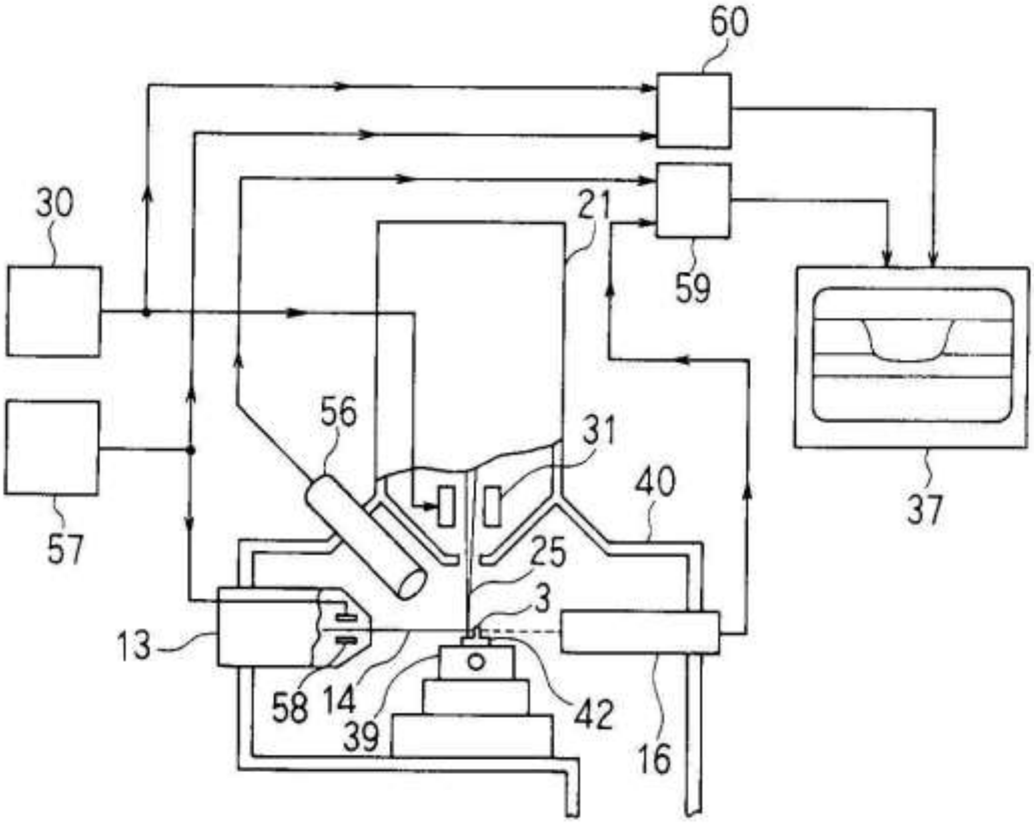
電流密度　　Current density

[FIG. 17]



[FIG. 25]

図 25



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Then, in the above-mentioned Cited Document 1, there is described the following invention (hereinafter, referred to as "the Cited invention").

"A focused ion beam processing apparatus, including a device to measure a transmission electron beam mounted thereon, to prepare a sample having a lamella portion of final processing finish thickness of 100-200 nm, wherein

in the sample room chamber 40, the focused ion beam optical system 21, the electron gun 13, the secondary electron detector 56, the detector 16 for an electron beam penetrating a sample, and the stage 39 are provided, and the sample 42 to be processed is mounted on the stage 39, wherein

output of the secondary electron detector 56 and output of the electron beam detector 16 are inputted to the electron beam output switch 59, an electron beam deflection signal and a focused ion beam deflection signal are inputted to the deflection signal switch 60, the ion beam deflection signal and the secondary electron detection output are inputted to the image display monitor 37 when a scanning ion image (SIM image) is observed by these switches 59 and 60, the electron beam deflection signal and the secondary electron detection output are inputted to the image display monitor 37 when a scanning electron image (SEM image) is observed, and the electron beam deflection signal and the transmission electron beam detector output are inputted to the image display monitor 37 when a transmission electron beam intensity distribution is observed, and wherein

a secondary electron obtained by irradiation of the focused ion beam 25 and, a secondary electron obtained by irradiation of the electron beam 14 are detected by the secondary electron detector 56, a secondary electron image obtained by irradiation of the focused ion beam 25 is used for plane observation of the sample 42, and, a secondary electron image obtained by irradiation of the electron beam 14 is used for cross-section observation of the lamella portion of a processed sample, and an electron beam penetrating the lamella portion of the sample 42 is detected by the electron beam detector 16, and used for measurement of the film thickness or the film thickness distribution of the lamella portion."

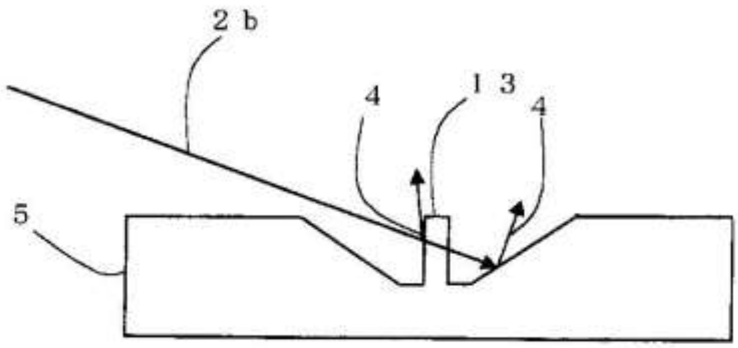
In addition, in the above-mentioned Cited Document 1, the following technical matters (hereinafter, called as "Technical matters of Cited Document 1") are described.
"Due to a tail shape of the current distribution of an ion beam, the lamella portion 3 tends to have a tilted side wall, and, therefore, in order to perform high-accuracy processing, it is important to know this tail shape and the slant angle of a side wall of the lamella portion 3. Then, using a focused laser beam as the observation light 7, it is possible to obtain the position of the reflection light 8 and find the angle of a side wall of the lamella portion 3 by detecting the beam 8 made by the focused laser beam being reflected by the side wall of the lamella portion 3 using the array-shaped detector 12."

B In International Publication No. WO 2006-073063 (hereinafter, referred to as "Cited Document 2") cited in the reasons for refusal stated in the Examiner's decision, the following matters are described.

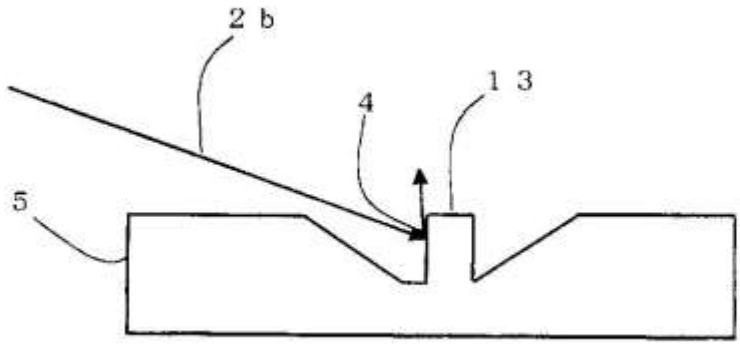
(A) "[0057] FIG. 2 is a sample pattern diagram indicating a conventional film thickness measurement method. When the film thickness of the lamella portion 13 is thin, an electron beam 2b penetrates through the lamella portion 13 to enter the sample 5, as shown in FIG. 2 (a). On this occasion, a secondary electron 4 occurs from the surface of the lamella portion 13 and the sample 5. On the other hand, when the film thickness of the lamella portion 13 is thick, the electron beam 2b cannot penetrate through the lamella portion 13, as FIG. 2 (b). On this occasion, the secondary electron 4 occurs only from the surface of the sample. FIG. 3 is a relationship diagram between a film thickness and a secondary electron amount indicating a conventional film thickness measurement method. FIG. 3 (a) is a graph of a film thickness of the lamella portion 13 and an amount of detected secondary electrons. It is understood that the smaller the film thickness, the larger a secondary electron amount. This is considered to occur because, as indicated in FIG. 2, a detected secondary electron amount increases when the film thickness is thin, because the electron beam 2b penetrates through the lamella portion 13 and enters the sample 5, and, as a result, a secondary electron occurs from the sample 5 and the lamella portion 13. Here, it has been confirmed by experimentation that a secondary electron amount is not reduced linearly relative to a film thickness. It is considered that the reason for this is that, since there is an energy loss when an electron beam penetrates through the lamella portion 13, the energy of electrons radiated on the sample 5 varies due to a film thickness of the lamella portion 13. In the meantime, it is understood that, when a current amount of the electron beam 2b differs, relation between a film thickness and a secondary electron amount becomes as shown in FIG. 3 (b). The symbol A in the figure indicates a case where an electron beam current amount is large, and B a case where an electron beam amount is small. From this, it is understood that, when performing film thickness measurement of a desired sample based on calibration data, an error is caused in a measured film thickness if film thickness measurement of the desired sample is not performed by a current amount the same as the current amount of the electron beam used when the calibration data has been measured.

[0058] FIG. 4 is a sample pattern diagram indicating an embodiment of the present invention, and FIG. 4 (a) is a pattern diagram of a sample and FIG. 4 (b) is a top view of FIG. 4 (a) seen from the irradiation direction of the electron beam 2b. When the electron beam 2b penetrates the lamella portion 13, a portion at which the electron beam 2b that has penetrated collides exists, although not illustrated here. A film thickness measurement method will be described in accordance with the flow chart of lamella sample measurement of FIG. 5 that indicates an embodiment of the present invention. First, calibration data are generated using a standard lamella sample that is of material the same as that of a lamella sample for which the film thickness measurement is performed or is the identical portion of the same device, and, in addition, that has a known film thickness. The electron beam 2b is irradiated on an area including the lamella portion of the standard lamella sample, and the secondary electron 4 that has occurred is detected by the secondary electron detector 6. Using secondary electron amounts generated in the lamella portion within the film thickness measurement area and the reference region, a calculation value constituted of a secondary electron amount detected in the film thickness measurement area and a secondary electron amount detected in the reference region is calculated by a first calculation means 11. This is carried out using standard lamella samples of a plurality of film thicknesses. Calibration data are created from relation between the calculation value that has been calculated and the film thicknesses of the standard lamella samples. Next, when performing film thickness measurement of the lamella portion 13 of a sample, the electron beam 2b is irradiated on an area including the lamella portion 13, and the secondary electron 4 that occurs is detected by the secondary electron detector 6. Using amounts of secondary electrons generated in the film thickness measurement area 14a within the lamella portion 13 and the reference area 15a within a thick portion of the sample 5, a calculation value constituted of a secondary electron amount detected in the film thickness measurement area 14a and a secondary electron amount detected in the reference area 15a is calculated by the first calculation means 11. Here, calculation values of a secondary electron amount detected in the film thickness measurement area 14a and a secondary electron amount detected in the reference area 15a are a function of a secondary electron amount generated by the electron beam 2b of an identical beam current amount. In other words, this function is a function that is uniquely determined by the film thickness of the film thickness measurement area 15a independent of a current amount of an electron beam to be irradiated. Accordingly, even if beam current amounts of electron beams irradiated to a lamella measurement sample and to a standard lamella sample differ from each other, calculation values will be the same value if the film thicknesses are the same. Therefore, even if a current amount of the electron beam 2b to be irradiated fluctuates, a calculation value is not affected by this. It is possible to calculate the film thickness of the film thickness measurement area 14a also from calibration data indicating relation between a calculation value of a standard lamella sample and a film thickness of the standard lamella sample, and a calculation value obtained by the sample 5. Here, since a location of the secondary electron detector 8 has an influence on a secondary electron amount that is detected, it is performed such that, in measurement of a standard lamella sample and measurement of a lamella sample, the location of the secondary electron detector 8 is not changed."

(B) "[FIG. 2]



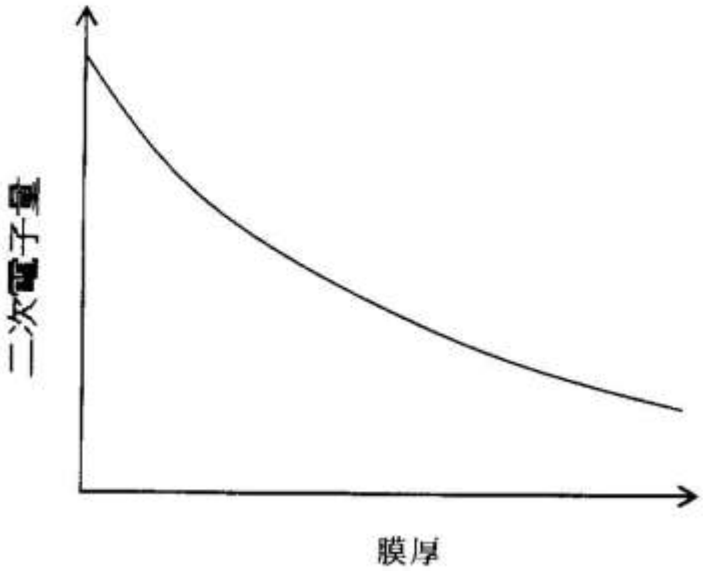
(a)



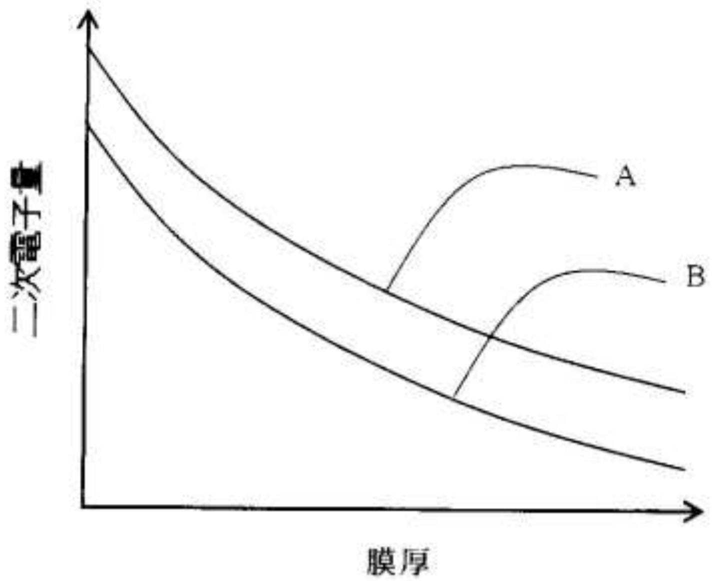
(b)

[FIG. 3]

二次電子量　Secondary electron amount
膜厚　Film thickness



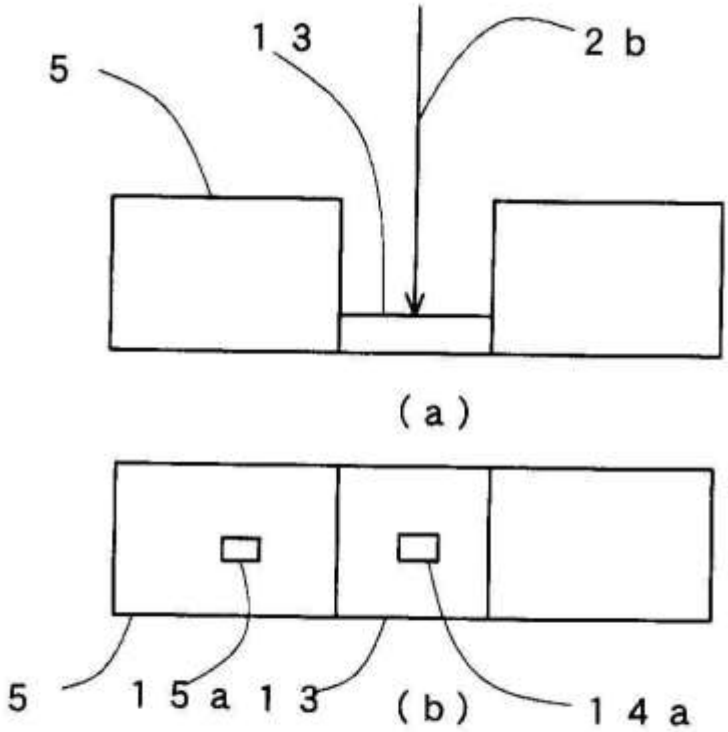
（a）



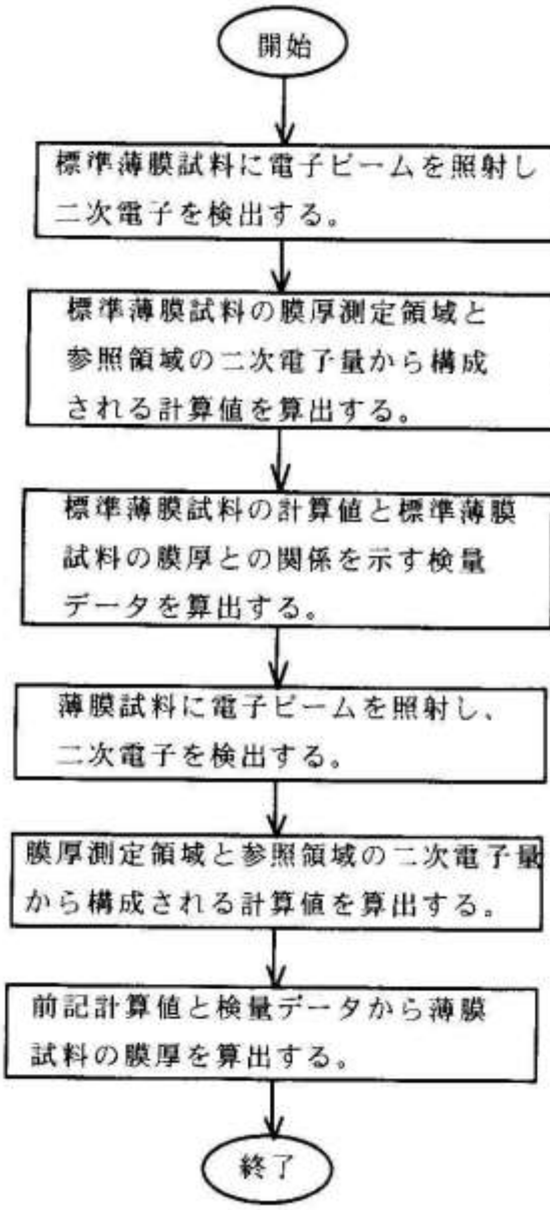
（b）

二次電子量　Secondary electron amount
膜厚　Film thickness

[FIG. 4]



[FIG. 5]



開始　Start

標準薄膜試料に電子ビームを照射し二次電子を検出する。　Irradiate electron beam on standard lamella sample and detect secondary electron.

標準薄膜試料の膜厚測定領域と参照領域の二次電子量から構成される計算値を算出する。　Calculate calculation value constituted of secondary electron amount of film thickness measurement area of standard lamella sample and reference region.

標準薄膜試料の計算値と標準薄膜試料の膜厚との関係を示す検量データを算出する。　Calculate calibration data indicating relation between calculation value

of standard lamella sample and a film thickness of standard lamella sample.
薄膜試料に電子ビームを照射し、二次電子を検出する。　Irradiate electron beam on lamella sample, and detect secondary electron.
膜厚測定領域と参照領域の二次電子量から構成される計算値を算出する。　Calculate calculation value constituted of secondary electron amounts of film thickness measurement area and reference region.
前期計算値と検量データから薄膜試料の膜厚を算出する。　Calculate film thickness of lamella sample from calculation value and calibration data.
終了　End

"

Then, in the above-mentioned Cited Document 2, the following technical matters (hereinafter, referred to as "Technical matters of Cited Document 2") are described.

"When performing film thickness measurement of the lamella portion 13 of a sample, the electron beam 2b is irradiated on an area including the lamella portion 13, the secondary electron 4 that has occurred is detected by the secondary electron detector 6, and, using secondary electron amounts generated in the film thickness measurement area 14a within the lamella portion 13 and the reference area 15a within a thick portion of the sample 5, a calculation value constituted of a secondary electron amount detected in the film thickness measurement area 14a and a secondary electron amount detected in the reference area 15a is calculated by the first calculation means 11. Here, calculation values of a secondary electron amount detected in the film thickness measurement area 14a and a secondary electron amount detected in the reference area 15a are a function of a secondary electron amount generated by the electron beam 2b of an identical beam current amount. In other words, this function is a function that is uniquely determined by the film thickness of the film thickness measurement area 15a independent of a current amount of an electron beam to be irradiated."

C In Japanese Unexamined Patent Application Publication No. 2005-30799 (hereinafter, referred to as "Cited Document 3") cited in the reasons for refusal stated in the Examiner's decision, the following matters are described.

(A)"[0023]

[Embodiments of the invention]
An example of an apparatus of the present invention will be described by reference to FIG. 1.
[0024]
Attached to the sample room 4 are: a first focused-ion-beam lens tube 1 to focus ions generated from a liquid metal ion source, and perform scanning irradiation of the ions by a focused ion optical system focusing on a sample surface; a second focused-ion-beam lens tube 2 to focus ions generated by a liquid metal ion source by a focused ion optical system, and perform scanning irradiation of the ions focusing on the sample surface; and an inactive-ion-beam lens tube 3 to generate an inactive ion beam such as argon and irradiate the beam on the sample. The interior of the sample room is evacuated by a vacuum pump 5, and a high-vacuum state is maintained. Inside the sample room 4, a sample stage 7 that moves in a manner placing a sample 6 on it is installed.
[0025]
The first focused-ion-beam lens tube 1, the second focused-ion-beam lens tube 2, and the inactive-ion-beam lens tube 3 are arranged on the same plane. Then, a first focused ion beam emitted from the first focused-ion-beam lens tube 1, a second focused ion beam emitted from the second focused-ion-beam lens tube 2, and an inactive ion beam emitted from the inactive-ion-beam lens tube 3 are adjusted in a manner that these intersect with each other at one place on the surface of the sample 6 mounted on the sample stage 7. At this time, arrangements of the first focused-ion-beam lens tube 1, the second focused-ion-beam lens tube 2, and the inactive-ion-beam lens tube 3 may be exchanged with each other.
[0026]
The sample stage 7 has a plurality of drive axes and is capable of traveling in a three-dimensional space while placing the sample 6 thereon, and, as shown in FIG. 2, has a structure capable of change intersection angles of the first focused-ion-beam lens tube 1, the second focused-ion-beam lens tube 2, and the inactive-ion-beam lens tube 3 based on a second plane 9 perpendicular to a first plane 8 including the tubes. A changeable range of the intersection angles should be at least ± 1 degree. This is a slant angle provided in order to make a side wall of a sample stage at a right angle to the sample surface. Experimentally, if it is possible to make it slant more than the angle of this size, the purpose can be accomplished. That is, slant of a side wall surface of a sample can be corrected.
[0027]

The first focused ion beam that is emitted from the first focused-ion-beam lens tube 1 and irradiated in a scanning manner on a sample surface also performs sputter etching processing of a to-be-processed area of the surface of the sample 6. At the same time or while suspending the first focused ion beam, the second focused ion beam that is emitted from the second focused-ion-beam lens tube 2 and is irradiated in a scanning manner on the sample surface is irradiated in a scanning manner on an area including a to-be-processed area of the surface of the sample 6. Then, a secondary charged particle such as an electron generated from the surface of the sample 6 is detected by a secondary charged particle detector not shown in FIG. 1, and, in a device control system also not shown, it becomes a scanning electron microscope image. In addition, it is also possible to interchange the roles of the first focused-ion-beam lens tube 1 and the second focused-ion-beam lens tube 2. Furthermore, it is also possible for the first focused-ion-beam lens tube 1 and the second focused-ion-beam lens tube 2 to perform the same sputter etching processing to an identical place or different locations of the sample surface.

[0028]

When preparing a thin leaf sample using the present apparatus, a state that sputter etching processing is being carried out by one focused ion beam is observed by a scanning ion microscope image according to the other focused ion beam scanning irradiation, and the device control system finishes irradiation of the first and the second focused ion beams on the sample when the thickness of the thin leaf comes to be the thickness that has been set.

[0029]

Furthermore, after having processed a thin leaf to a predetermined thickness by a focused ion beam, an inactive ion beam emitted from the inactive-ion-beam lens tube 3 is irradiated around the thin leaf of the surface of the sample 6 to perform sputter etching processing, and, at the same time, either one of the first and the second focused ion beams is irradiated in a scanning manner to observe around the lamella by a scanning ion microscope image, and, at the time when the thickness of the thin leaf comes to be the set thickness, the device control system finishes irradiation of the focused ion beam and inactive ion beam on the sample.

[0030]

By reference to FIG. 3, one example of a method according to the present invention will be described.

[0031]

As shown in FIG. 3a, on either side of an area 11 on a sample surface that is left as a

thin leaf, processing frames 12a and 12b are set.
Then, the processing frame 12a is processed by sputter etching using a first focused ion beam 101, and, in parallel with this, the processing frame 12b is processed by sputter etching using a second focused ion beam 102.
Next, although not shown, the processing frame 12b is processed by sputter etching using the first focused ion beam, and the processing frame 12a using the second focused ion beam.
At that time, the first focused ion beam and the second focused ion beam are on a plane perpendicular to the sample surface, and are arranged at positions by which the beams are radiated on an identical place of the sample surface at different angles. Then, both perform sputter etching processing at a first focused ion beam condition in which accelerating voltage is high and etching speed is fast.
As a result, both sides of the area including the area 11 to be left as a thin leaf are etched.
[0032]
Next, as shown in FIG. 3b, a processing frame 13 is set in the side of one side wall of the area 11 to be left as a thin leaf. Then, the sample is tilted, and sputter etching processing is performed by applying scanning irradiation of the first focused ion beam 101 on a second focused ion beam condition of a smaller beam diameter compared with the first focused ion beam condition. It is supposed that a slant angle is set so as to make a side wall of a thin leaf be perpendicular to the sample surface. At that time, while irradiating the first focused ion beam or suspending the first focused ion beam, the second focused ion beam is irradiated in a scanning manner on the third focused ion beam condition to perform scanning ion microscope observation of the surface of the thin leaf. Then, when the thickness of the thin leaf comes to be a predetermined thickness, the irradiation of the first and the second focused ion beams is finished.
[0033]
Next, as shown in FIG. 3c, a processing frame 14 is set to the side wall in the other side of the area 11 to be left as a thin leaf. Then, the sample is slanted, and the first focused ion beam 101 is irradiated in a scanning manner on the second focused ion beam condition to perform sputter etching processing. The slant angle in this case is determined with the same condition as that of the slant of the other side. As with the step of FIG. 3b, the second focused ion beam is irradiated in a scanning manner under the third focused ion beam condition to perform scanning ion microscope observation of the surface of the thin leaf. Then, when the thickness of the thin leaf comes to be a predetermined thickness, the irradiation of the first and the second focused ion beams is finished.

[0034]

Then, here, it may be such that the periphery of the thin leaf is processed by sputter etching processing according to the first or second focused ion beam to separate the thin leaf from the sample.

[0035]

When damage due to sputter etching processing by a focused ion beam remaining in the thin leaf has an influence on observation by a transmission electron microscope, the observation may be performed in a manner setting the accelerating voltage to a low voltage of 10 kV or less in the second focused ion beam condition.

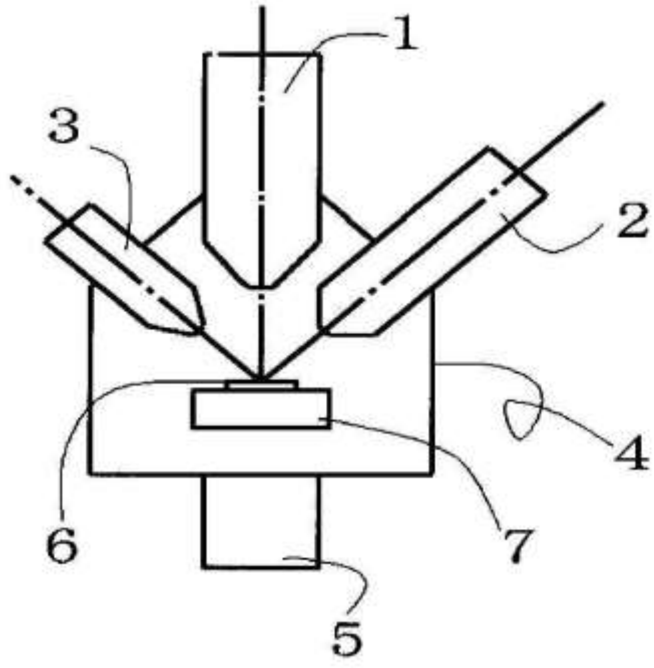
[0036]

In addition, as shown in FIG. 3d, the sample is made to return to the horizontal state, and an inactive ion beam is irradiated on an area 15 including the thin leaf. Then, sputter etching processing may be performed around the thin leaf. At that time, the first or second focused ion beam is irradiated in a scanning manner around the thin leaf under the third focused ion beam condition to perform scanning ion microscope observation of the surface of the thin leaf, and, when the thickness of the thin leaf comes to be a predetermined thickness, irradiation of the focused ion beam and inactive ion beam is finished.

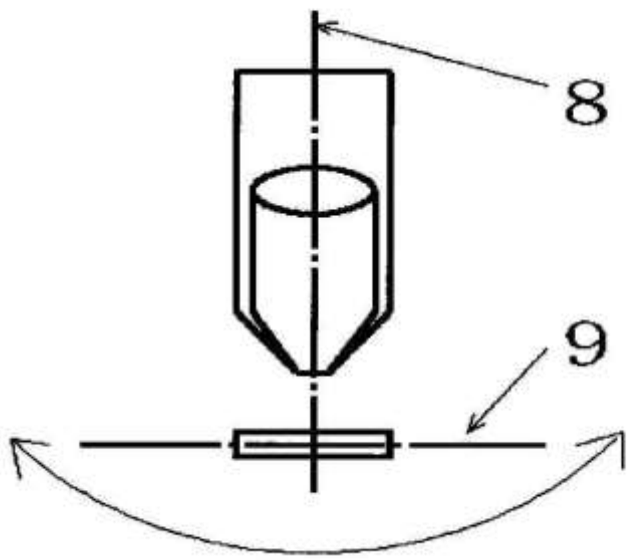
[0037]

After that, as with the above description, the periphery of the thin leaf is processed by sputter etching processing by a focused ion beam to separate the thin leaf from the sample."

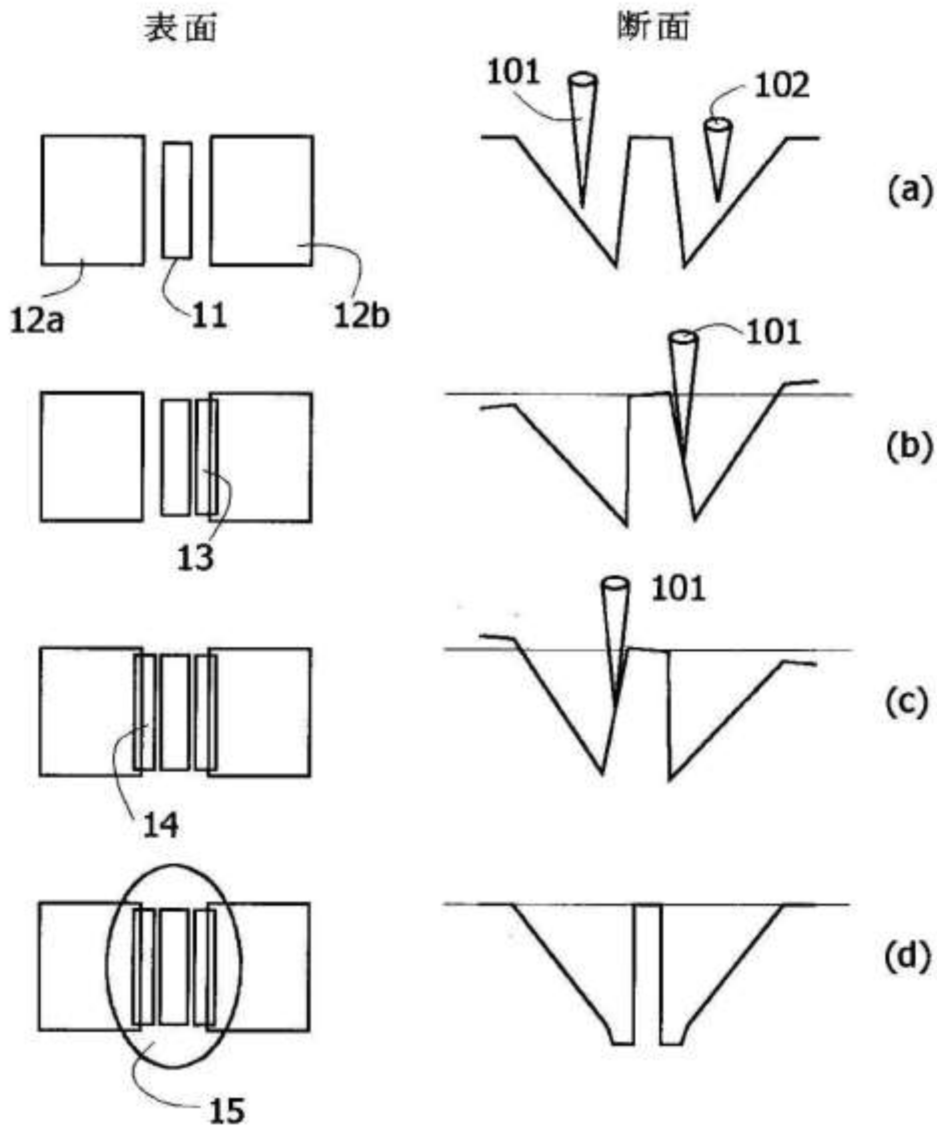
(B) "[FIG. 1]



[FIG. 2]

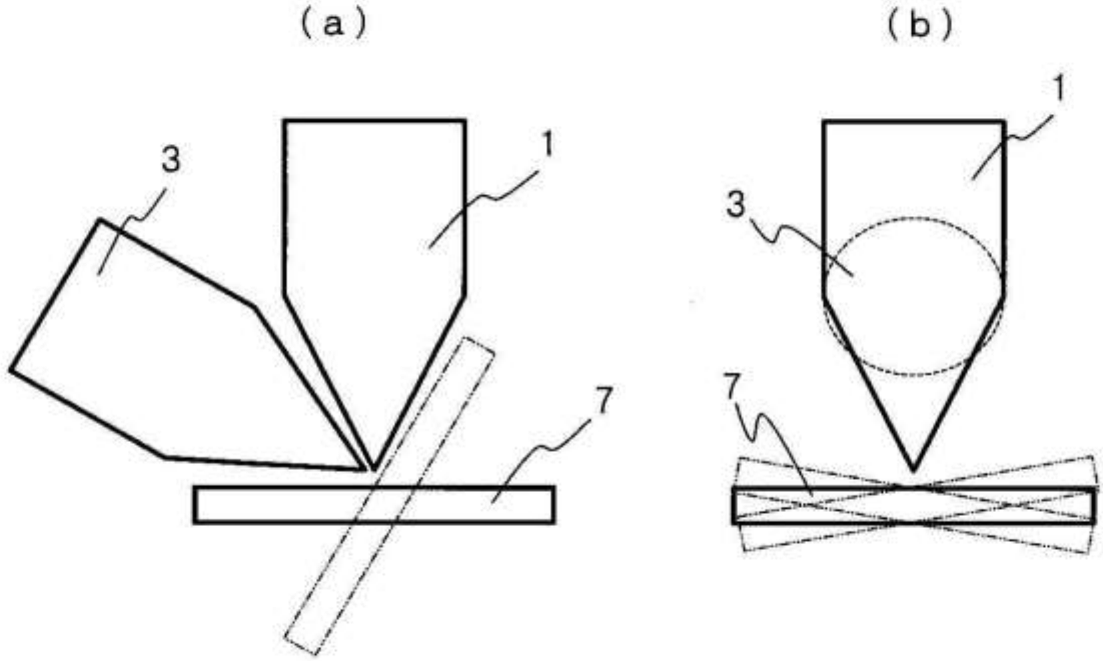


[FIG. 3]



表面　Surface

断面　Cross-section



[FIG. 4]
"

Therefore, there is described in the above-mentioned Cited Document 3 the following technical matters (hereinafter, referred to as "Technical matters of Cited Document 3").
"It has a structure capable of changing intersection angles of the first focused-ion-beam lens tube 1, the second focused-ion-beam lens tube 2, and the inactive-ion-beam lens tube 3 on the basis of the second plane 9 perpendicular to the first plane 8 including these tubes. A changeable range of the intersection angles should be at least ± 1 degree. This is a slant angle provided in order to make a side wall of a sample stage at right angle to the sample surface. Experimentally, if it is possible to make it slant more than the angle of this size, the purpose can be accomplished. That is, slant of a side wall surface of a sample can be corrected."

(3) Comparison

Comparing the Amended Invention 1 and the Cited invention, the two are identical in
"A lamella sample preparation apparatus for processing a sample by a focused ion beam

irradiated from a focused ion beam lens tube to prepare a lamella sample, the lamella sample preparation apparatus comprising:

a sample stage on which a lamella sample is mounted;

an electron beam lens tube configured to irradiate an electron beam on the lamella sample; a charged particle detector configured to detect reflected electrons or secondary electrons emitted from the lamella sample by irradiation of the electron beam; and

a display unit configured to display an observation image of the lamella sample formed from a detection signal of the charged particle detector.", but different in each of the following points.

(The different feature A)

A point that the Amended Invention 1 is one "to prepare a lamella sample of a film thickness of 100 nm or less," whereas the Cited invention is one to "prepare a sample having a lamella portion of final processing finish thickness of 100-200 nm."

(The different feature B)

A point that the Amended Invention 1 includes "an input unit configured to set, in the observation image, a first measurement region in an upper side of the lamella sample and set a second measurement region in a bottom side, the first and second measurement regions being set at locations having a thickness thin enough to enable a part of the electron beam to penetrate through," whereas, in the Cited invention, it is not specified that an input unit to set a measurement area of a film thickness is included.

(The different feature C)

A point that the Amended Invention 1 includes "a slant angle calculation unit configured to calculate a slant angle of the lamella sample from a detection amount of the reflected electrons or secondary electrons generated from the first measurement region and the second measurement region through the radiation of the electron beam and a distance between the first measurement region and the second measurement region," whereas, in the Cited invention, although there is a specification about "measurement of the film thickness or the film thickness distribution of the lamella portion," there is no specification about calculation of slant angle of a "lamella portion."

(4) Judgment

The aforementioned different feature C will now be discussed below.

It is respectively disclosed that:

in Cited Document 1, as Technical matters of Cited Document 1, "using a focused laser beam as the observation light 7, (omitted) to obtain the position of the reflection light 8 and find the angle of a side wall of the lamella portion 3 by detecting the beam 8 made by the focused laser beam being reflected by the side wall of the lamella portion 3 using the array-shaped detector 12";

in Cited Document 2, as Technical matters of Cited Document 2, "using secondary electron amounts generated in the film thickness measurement area 14a within the lamella portion 13 and the reference area 15a within a thick portion of the sample 5, a calculation value constituted of a secondary electron amount detected in the film thickness measurement area 14a and a secondary electron amount detected in the reference area 15a is calculated by the first calculation means 11"; and,

in Cited Document 3, as Technical matters of Cited Document 3, "should be at least ± 1 degree. This is a slant angle provided in order to make a side wall of a sample stage at right angle to the sample surface. Experimentally, if it is possible to make it slant more than the angle of this size, the purpose can be accomplished." However, there is no disclosure or suggestion that a slant angle of a lamella portion is obtained from a detection amount of reflected electrons or secondary electrons (an amount corresponding to a film thickness) of two measurement areas and a distance between the two areas.

In addition, there is also no other evidence showing that the constitution of the Amended Invention 1 concerning the aforementioned different feature C is publicly known.

Therefore, even if the technical matters and the like described in Cited Documents 1-3 are referred to in addition to the Cited invention, it cannot be said that the constitution of the Amended Invention 1 concerning the aforementioned different feature C is a design matter that can be done by a person skilled in the art accordingly.

Then, due to the aforementioned different feature C, the Amended Invention 1 has an effect described in the description of the present application.

Therefore, due to at least the aforementioned different feature C, even if a person skilled in the art refers to the technical matters and the like described in Cited Documents 1-3 in addition to the Cited invention, it cannot be said that the Amended Invention 1 can be invented by the person skilled in the art with ease.

(5) Summary

Accordingly, even if a person skilled in the art refers to the technical matters and the like described in Cited Documents 1-3 in addition to the Cited invention, it cannot be said that the Amended Invention 1 can be invented by the person skilled in the art with ease.

Furthermore, there is no other reason to determine that the Amended Invention 1 violates the independent requirements for patentability.

Therefore, the Amended Invention 1 complies with the provisions of Article 126(7) of the Patent Act as applied mutatis mutandis pursuant to the provisions of Article 17-2(6) of the same Act.

(6) Regarding the Amended Inventions 2-5

The Amended Invention 2 is an invention that further limits the Amended Invention 1, and the Amended Inventions 3-5 are inventions concerning "lamella sample preparation method" including the matter specifying the Invention similar to that of the Amended Invention 1. Therefore, as with the Amended Invention 1, even if a person skilled in the art refers to the technical matters and the like described in Cited Documents 1-3 in addition to the Cited invention, it cannot be said that these inventions can be invented by the person skilled in the art with ease.

Furthermore, there is no other reason to determine that the Amended Inventions 2-5 violate the independent requirements for patentability.

Therefore, the Amended Inventions 2-5 comply with the provisions of Article 126(7) of the Patent Act as applied mutatis mutandis pursuant to the provisions of Article 17-2(6) of the same Act.

4 Closing

Amendment of the case complies with the provisions of Article 17-2(iii) to (vi) of the Patent Act.

No. 3 The Invention

As described above, Amendment of the case complies with the provisions of Article 17-2(iii) to (vi) of the Patent Act, and, therefore, the inventions according to claims 1-5 of the present application are the Amended Inventions 1-5.

Then, as examined in the above-mentioned "No. 2" "3," even if a person skilled in the art refers to the technical matters and the like described in Cited Documents 1-3 in addition to the Cited invention, it cannot be said that the Amended Inventions 1-5 can be invented by the person skilled in the art with ease.

Accordingly, although the reasons for refusal of Examiner's decision have been examined, it cannot be determined that the present application should be rejected due to these reasons.

In addition, no other reasons for refusal were found.

Therefore, the appeal decision shall be made as described in the conclusion.

November 1, 2016

Chief administrative judge: MORI, Ryosuke
Administrative judge: ITO, Masaya
Administrative judge: MATSUKAWA, Naoki