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(54) Apparatus and method for inspecting a surface of a sample.

(57) The invention relates to an apparatus for inspecting a surface of a sample, wherein the apparatus comprises:
at least one charged particle source for generating an array of primary charged particle beams,
a condenser lens for directing all charged particle beams to a common cross-over,
a lens system for directing the primary charged particle beams from the common cross-over towards the sample surface and for focusing all primary charged particle beams into an array of individual spots on the sample surface, and
a position sensitive secondary electron detector positioned at least substantially in or near a plane comprising said common cross-over

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No. NLP191540A

Apparatus and method for inspecting a surface of a sample

BACKGROUND

The invention relates to an apparatus and a method for inspecting a surface of a sample. In particular the invention relates to an apparatus for inspecting a sample surface using a plurality of charged particle beams, such as a multi-beam scanning electron microscope. The invention may be applied to charged particles of any type, such as electrons, positrons, ions and others.

Such an apparatus is for example disclosed in US patent 7,554,094. This US patent discloses an electron microscope comprising a charged particle source for generating an array of primary electron beams. These primary electron beams pass a field lens. Downstream of this field lens, the primary electron beam path is a converging beam path having a cross-over in an intermediate plane upstream of an objective lens. The objective lens directs the primary charged particle beams from the common cross-over towards the sample surface and focuses the primary charged particle beams into an array of individual spots on the sample surface.

From the individual spots of the array of spots on the sample, secondary electrons emanate from the sample surface. In order to detect these secondary electrons, the secondary electron beam path, comprising the plurality of secondary electron beams, is separated from the primary electron beam path. To separate the secondary electron beam path from the primary electron beam path, the known apparatus comprises a beam splitter arrangement between the field lens and the cross-over. The beam splitter utilizes a magnetic field portion to deflect the primary electron beams by an angle β to the right (as viewed in the traveling direction of the primary electron beams) and to deflect the secondary electron beams by an angle γ to the right (as viewed in the traveling direction of the secondary electron beams). After the beam splitter, the separated secondary electron beams are directed towards a detector.

A disadvantage of this system is that the use of the beam splitter as described in US 7,554,094 deteriorates the imaging quality of the apparatus. In other words, the apparatus as described in US 7,554,094 requires a number of additional electron-optical components to correct stigmatism, distortion and/or dispersion introduced by the magnetic field portion, in order to substantially maintain the imaging quality. Additional electron-optical components are arranged both in the primary electron beam path and in the secondary electron beam path.

It is an object of the present invention to provide a multi charged particle beam apparatus for inspecting a sample surface which provides a new detection arrangement for detecting the secondary electrons.

SUMMARY OF THE INVENTION

According to a first aspect, the invention provides an apparatus for inspecting a surface of a sample, wherein the apparatus comprises

a multi beam charged particle generator for generating an array of primary charged particle beams,

a condenser lens for directing all charged particle beams to a common cross-over,

a lens system for directing the primary charged particle beams from the common cross-over towards the sample surface and for focusing all primary charged particle beams into an array of individual spots on the sample surface, and

a position sensitive secondary electron detector positioned at least substantially in or near a plane comprising said common cross-over.

The invention thus provides a simple detection system in which the secondary electrons are detectable without the use of a beam splitter or Wien filter to separate the secondary charged particle beam path from the primary charged particle beam path. The disadvantages inherent with the use of such a beam splitter or Wien filter can thus be avoided.

The invention utilizes the energy difference between the secondary electrons and the primary charged particle, for example in a SEM the energy of the primary electrons is usually from 1 keV to 30 keV and the energy of secondary electrons is usually from 0 eV to 50 eV. The result of this energy difference is that the lens system performs differently for primary charged particles than for secondary electrons. On the one hand, the lens system is arranged for focusing all primary charged particle beams into an array of individual spots on the sample surface. On the other hand, the same lens system is used for directing the secondary electron beams towards the common cross-over. Since the secondary electrons have an energy which is much less than the energy of the primary charged particles, the lens system does not necessarily focus the secondary electrons back into the common cross-over, but is preferably designed to spread the secondary electrons over an area which essentially surrounds the common cross-over. Thus, in or near a plane comprising said common cross-over, most of the secondary electron beams are spatially separated from the primary charged particle beams which are all concentrated in the common cross-over. By positioning a position sensitive secondary electron detector at least substantially in or near a plane comprising said common cross-over, preferably adjacent to and/or surrounding the common cross-over, most of the secondary electron beams can be detected without any interference to the primary charged particle beams.

In an embodiment, the lens system is arranged for projecting the secondary electrons from the individual spots on the sample surface to individual spots on the secondary electron detector. In an embodiment, the lens system is arranged for imaging the sample surface onto the secondary electron detector using the secondary electrons. Because the secondary electrons only originate from the points in the sample surface which are hit by primary electrons, the image is an array of dots. In these embodiments, when the spatial resolution of the position sensitive secondary electron detector is chosen to be sufficiently large, the position sensitive secondary electron detector can acquire an individual secondary electron signal from most of the individual primary charged particle spots on the sample surface. Only the secondary electrons which are projected or imaged back at the position of the common cross-over cannot be detected. The secondary electrons which originated from all other spots can be detected simultaneous and separately for each spot on the sample surface. Accordingly high resolution scanning charged particle microscope images can be made n times the speed of a single beam scanning charged particle microscope, wherein n is substantially equal to the number of secondary beams that are simultaneously and separately detected by the detector. For example, n can be as large as 200, or even more.

In an embodiment, the lens system is arranged for imaging the sample surface onto the secondary electron detector with an optical magnification in a range from 5 to 400 times. The magnification increases the pitch between individual spots of the secondary electron beams on the secondary electron detector, which makes it easier to resolve the individual secondary electron spots in the image on the secondary electron detector.

In an embodiment, said secondary electron detector comprises a hole for passing said primary charged particle beams there-through. Preferably the primary charged particle beam path comprises an optical axis and the secondary electron detector is arranged such that the optical axis passes through the hole, preferably such that the optical axis is arranged substantially at the central axis of the hole. Preferably the secondary electron detector is arranged such that the common cross-over is in or near the hole.

In an embodiment, the lens system comprises a magnetic objective lens. In an embodiment, the apparatus comprises a sample holder which is arranged for positioning the sample surface to be immersed in the magnetic field of the objective lens. Such an arrangement gives low aberrations for the primary electrons, which is an advantage in a microscope. Here an immersion arrangement is even more advantageous, because there must be space between the sample and a non-immersion lens to accelerate the electrons upwards, which would further increase the aberrations of the non-immersion lens. In an immersion lens the acceleration is inside the lens, which reduces aberrations. Also extracting the secondary electrons from the immersion field gives an additional possibility to set the magnification of the projection of the secondary electrons onto the secondary electron detector to a desired value.

In an embodiment, the lens system comprises a single objective lens, preferably a single objective lens for all primary electron beams. Alternatively the lens system comprises an objective lens array having an array of small objective lenses, preferably one lens for each primary electron beam.

In an embodiment, the apparatus comprises a field generator for providing an electrostatic field that accelerates the secondary electrons from the sample surface towards the secondary electron detector. The electrostatic field is arranged to direct the secondary electrons from the sample towards the secondary electron detector and to narrow the opening angle of the secondary electron beams. In addition the electrostatic field is used to balance the focusing requirements in the primary charged particle beams and the secondary electron beams focusing. The electrostatic field is arranged to focus the primary charged particle beams with a good resolution and to focus the secondary electron beams at the specified detection plane with sufficient magnification.

In an embodiment in which the lens system comprises a magnetic objective lens, the field generator is arranged for providing an electrostatic field is between the sample and a pole piece of the magnetic objective lens. In an embodiment, the field generator comprises an electrostatic lens, also called a retarding lens, which is arranged below the magnetic objective lens to form an electrostatic-magnetic objective lens.

In an embodiment, the pitch between the spots on the sample surface is between 0.3 and 30 micrometers. Preferably the pitch is less than 1 micrometer.

In an embodiment, the detector is a CCD camera, a CMOS camera, an array of avalanche photo diodes or photo multipliers or PN junction semiconductor detectors which gets signal from secondary electrons directly.

In an embodiment the detector comprises a fluorescent screen arranged at least substantially in or near a plane comprising said common cross-over and an optical arrangement for conveying photons from the fluorescent screen to a CCD camera, a CMOS camera, an array of avalanche photo diodes or photo multipliers. In this embodiment the CCD camera, CMOS camera, array of avalanche photo diodes or photo multipliers can be arranged at a distance from the charged particle beams.

According to a second aspect, the invention provides a method for inspecting a surface of a sample comprising the steps of:

generating an array of primary charged particle beams using a multi beam charged particle generator;

directing all charged particle beams to a common cross-over using a condenser lens;

directing the primary charged particle beams from the common cross-over towards the sample surface and focusing all primary charged particle beams into an array of individual spots on the sample surface using a lens system; and

detecting secondary electrons which originate from the individual spots on the sample surface using a position sensitive secondary electron detector positioned at least substantially in or near a plane comprising said common cross-over.

In an embodiment of this method, the sample surface is moved at constant speed in a first direction while the primary charged particle beams are scanned repeatedly in a second direction at least substantially perpendicular to the first direction. This provides a new way of studying samples with a scanning charged particle beam microscope: off-line microscopy wherein a full sample surface, for example over an area of one square millimeter, is scanned and imaged at nanometer resolution after which the full sample surface is available to the specialist, for example a biologist, for studying and/or inspecting the image on a computer, instead of behind the microscope.

In an embodiment of this method, the position sensitive secondary electron detector comprises pixels which are arranged to detect one particular secondary electron beam and to at least partially separate neighboring secondary electron beams. Preferably the secondary electron beams are at least substantially fully spatially separated on the surface of the secondary electron detector, and the size of the pixels is smaller than the spots of the secondary electron beams on the surface of the secondary electron detector. When the spots of the secondary electron beams are partially overlapping, the one particular secondary electron beam can be distinguished from its neighboring secondary electron beam by analyzing the intensity distribution in the two secondary electron beam spots and acquiring the centers and effective diameters of these spots. From such an analysis the intensity of the individual secondary electron beams can be determined.

In an embodiment of this method, the lens system comprises a scanner for scanning the primary charged particle beams, wherein the method comprises the step of selecting the pixels for detecting one specific secondary electron beam in dependence on the settings of the scanning of the primary charged particle beams by the scanner. This provides a way of undoing a movement of the secondary electron beams on the detector due to the scanning of the primary charged particle beams on the sample surface, which can be provided by providing suitable software to control the secondary electron detector.

The various aspects and features described and shown in the specification can be applied, individually, wherever possible. These individual aspects, in particular the aspects and features described in the attached dependent claims, can be made subject of divisional patent applications.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be elucidated on the basis of an exemplary embodiment shown in the attached drawings, in which:

Figure 1 shows an example of a Multi-Beam Scanning Electron Microscope (MBSEM) of the invention,

Figure 2 shows an envelope presentation of the primary electron beam path in the MBSEM of figure 1,

Figure 3 shows the beam path of one primary electron beam of the array of primary electron beams in the MBSEM of figure 1,

Figure 4 shows the primary electron beams in the part of the MBSEM of figure 1 from the common cross-over to the sample,

Figure 5 shows an envelope presentation of the secondary electron beam path in the MBSEM of figure 1,

Figure 6 shows the beam path of a two secondary electron beams in the MBSEM of figure 1,

Figure 7 shows a part of the MBSEM comprising a different detector setup, and

Figure 8 shows a part of an MBSEM comprising an array of small objective lenses.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows an example of a Multi-Beam Scanning Electron Microscope (MBSEM) of the invention.

The MBSEM 1 comprises a multi beam charged particle generator 2 for generating an array of primary charged particle beams 3, in this case an array of primary electron beams 3. The multi beam electron generator 2 comprises at least one electron source 4 for generating a diverging electron beam 5. The diverging electron beam 5 is split into an array of focused primary electron beams 3 by an aperture lens array 6. The primary electron beams 3 are subsequently directed towards a sample 15, as schematically indicated by the arrow P.

The multiple images of the source 4 are positioned on the object principle plane of an accelerator lens 7. The accelerator lens 7 directs the primary electron beams 3 towards the optical axis 8 and creates a first common cross-over 9 of all the primary electron beams 3.

The first common cross-over 9 is imaged by the magnetic condenser lens 10 onto a variable aperture 11 that acts as a current limiting aperture. At the variable aperture 11 a second common cross-over of all the primary electron beams 3 is created.

The MBSEM comprises a lens system 13, 14 for directing the primary charged particle beams from the common cross-over at the variable aperture 11 towards the sample surface 15 and for focusing all primary charged particle beams 3 into an array of individual spots on the sample surface 15. The lens system comprises an intermediate magnetic lens 13 for imaging the variable aperture 11 onto a coma free plane of the objective lens 14, which objective lens 14 creates an array of focused primary electron beams on the sample surface 15.

In addition the MBSEM is provided with scan coils 16 for scanning the array of focused primary electron beams over the sample surface 15.

The MBSEM is furthermore provided with a position sensitive secondary electron detector 12 positioned at least substantially in or near a plane comprising a common cross-over, in this case directly below the variable aperture 11. Alternatively the position sensitive secondary electron detector 12 can be arranged in stead of the variable aperture 11, substantially at the position of the variable aperture 11, as for example shown in figures 2 to 8. This secondary electron detection system 12 is arranged to acquire the individual secondary electron image of each single primary electron beam spot on the sample surface 15. This means, that when the sample surface 15 is scanned in this MBSEM 1, multiple images can be acquired at the same time in one single scan period.

It is preferred that the secondary electron detection system collects most secondary electrons which are emitted over a large energy range and at a large opening angle. Besides, this secondary electron detection system should also work for a large landing energy range of the primary electrons.

It is further preferred that the secondary electron beams are focused in the detection plane with sufficient magnification, for example a magnification in a range from 5 to 400 times. The focusing provides secondary electron beams with a small spot size on the secondary electron detector, and sufficient magnification provides a large pitch between neighboring secondary electron beams in the detection plane. In order to separate the images of different secondary electron beams, the pitch of neighboring secondary electron beams is preferably larger than the spot size of each secondary electron beam in the detection plane.

To achieve this goal, the invention uses in-lens secondary electron detection, which will be explained in more detail below.

Preferably the MBSEM comprises a field generator for providing an electrostatic field that accelerates the secondary electrons from the sample surface towards the secondary electron detector 12, as indicated schematically by the arrow S. The field generator is for example arranged for providing an electrostatic field between the sample surface 15 and pole pieces 17 of the magnetic objective lens 14, as schematically shown in figure 7. The generator is for example a voltage source 18 which provides the sample surface 15 with a negative potential with respect to the pole pieces 17.

This set-up of the field generator 18 provides an electrostatic field which operates as an electrostatic lens (retarding lens), which is arranged between the magnetic objective lens 14 and the sample surface 15. The electrostatic lens and the magnetic objective lens 14 together form an electrostatic-magnetic objective lens. This electrostatic-magnetic objective lens accelerates the secondary electrons and narrows their opening angle.

The energy of the secondary electrons is quite small, for example in a range from 0 to 50eV with a cosine angular distribution. So the electrostatic acceleration field directs the secondary electrons in an upward direction, schematically indicated by the arrow S, with a fast velocity.

After passing through this electrostatic lens, the opening angle α of the secondary electrons with respect to the optical axis is close to:

$$\alpha = \sqrt{E_{SE}}/E_{RL}$$

where E_{SE} is the original energy of secondary electrons. E_{RL} is the energy given to the secondary electrons by the retarding lens. It is well known that in charged particle optics, a paraxial condition is needed to achieve good resolution and other optical property. So in order to minimize the beam spread introduced by the focusing lenses, it is better to employ a high potential difference electrostatic lens to limit this opening angle α when the SE secondary electrons passes it.

Since there is a huge energy difference between energy of the secondary electrons and the energy of the primary electrons, which is usually from 1KeV to 30KeV, the focusing conditions of the lens system 13, 14 for primary electrons and secondary electrons are totally different. Also in order to simplify the detection system, avoiding using Wien Filter or other beam splitters as used in the prior art, the same lens system 13, 14 is shared in primary electron and secondary electrons focusing system.

In addition, the electrostatic lens is introduced to balance the focusing requirements in the focusing of the primary and secondary electron beams. The electrostatic lens is arranged to focus the primary electrons with good resolution, and also to focus the secondary electrons at one specified detection plane with sufficient magnification.

The most practical plane to collect the secondary electrons is the variable aperture 11 plane, because it has smallest primary electron spot size, and it is easy to insert a position sensitive secondary electron detector at that location for practical reason.

Accordingly, the apparatus of this example comprises a position sensitive secondary electron detector 12 positioned at least substantially in or near a plane 11 comprising said second common cross-over.

From principle analyses, this MBSEM 1 can be divided into four sub-systems, including single-source system, multi-sources system both for primary electron focusing system and secondary electron detection system. At a certain working distance and a certain landing energy, the focusing lenses make these 4 sub-systems work well.

The 1st sub-system as shown in figure 2 is arranged to form crossovers 9, 11 of multi-beams 3 in certain planes to reduce off-axis aberrations of the whole system. The accelerating lens 7 and condenser lens 10 focus the multi-beam in the variable aperture plane 11. The accelerating lens 7 is adjustable to attain different resolutions and pitches for different applications. Intermediate lens 13 focuses the multi-beams 3 to have a Common cross-over near the coma-free plane of objective lens 14 in order to get small aberrations.

The 2nd sub-system as shown in figure 3 is arranged to focus each single primary electron beam 3′ with good resolution. Aperture lens array 6 is a combination of two mechanical electrodes and an array of apertures, for example of 18 micron diameter with a 25 micron pitch, micro fabricated in a thin Si membrane. It is designed to correct for the field curvature, to have a low spherical aberration, and to nullify the chromatic deflection error. This lens array 6 creates an array of focused primary electron beams in the accelerator lens plane 7, with a geometrical spot size of for example 95 nm at a pitch of for example 70 micron. This ratio of spot size and pitch keeps the same on the sample. The objective lens 14 provides the major focusing contribution to the final spot size and aberration of the primary electron beams on the sample surface 15.

The 3rd sub-system as shown in figure 5 is arranged to achieve the large magnification of secondary electron beams 20 by analyzing the outline of secondary electron detection system. The intermediate lens 13, and the objective and retarding lens 14′ together project the secondary electron beams 20 with sufficient linear magnification in the detection plane of the secondary electron detector 12. A certain given primary beam energy determines the strength of intermediate lens 13, because in charged particle optics, the focusing condition is related to the strength of lens and the energy of electron. So in order to achieve desired magnification, or proper magnification ranges, the energy of secondary electron beam 20, or the potential difference of the electrostatic lens is limited. Proper potential difference should be optimized. After selecting a good potential difference and proper settings of lenses 13, 14, the neighboring secondary electron beams can have large enough pitch to be separately detected by the position sensitive secondary electron detector 12 positioned substantially in the plane comprising said common cross-over of the primary electron beams 3 as shown in figure 4.

The 4th sub-system as shown in figure 6 provides the focusing situation of single secondary electron beams 21, 22. Under the effect of the lens system 13, 14, each single secondary electron beam 21, 22 is well focused in order to get a small enough spot size in the detection plane 12.

At one landing energy of the primary electron beams on the sample surface 15, the final focusing plane of the secondary electrons, the working distance and the potential difference of the retarding lens are adjustable. Unlike the focusing of the primary electrons, the final focusing plane of the secondary electrons does not have to strictly be fixed in the same position for every landing energy of the primary electrons. The final focusing plane of the secondary electrons just needs to be close to the detection plane 12 as long as it does not give rise to large secondary electron beam spread.

Besides, the pitch of primary beams is also adjustable. By using the condenser lens 10 to change the common cross-over of primary electron beams 3, the total magnification and the pitch of primary electron beams 3 can be changed.

As schematically shown in figure 4, the sample 15 is arranged on top of a stage 30 for moving the sample surface 15 with respect to the array of primary electron beams 3. The movement of the stage 30 is controlled by a controller 40. The controller 40 also controls the scan coils 16 and, in this example, also collects the image data obtained by the CCD detector 12.

When inspecting a surface of a sample 15, the MBSEM generates an array of primary electron beams 3 using a multi beam charged particle generator, wherein all primary electron beams 3 are directed to a common cross-over using a condenser lens, wherein the primary electron beams 3 are directed from the common cross-over towards the sample surface 15 and all primary electron beams 3 are focused into an array of individual spots on the sample surface 15 using a lens system 13, 14, and wherein secondary electrons which originate from the individual spots on the sample surface 15 are detected using a position sensitive secondary electron detector 12 positioned at least substantially in or near a plane comprising said common cross-over.

In order to obtain an image of a large surface, in one exemplary embodiment, the sample 15 is moved by the stage 30 in a first direction, preferably at a constant speed, while the primary electron beams 3 are scanned by the scan coils 16 repeatedly in a second direction, which second direction is at least substantially perpendicular to the first direction.

When the primary electron beams 3 are scanned over the sample surface 15, the secondary electron beams 20, 21, 21 may move over the detection surface of the secondary electron detector 12. This movement is for example compensated by selecting the pixels for detecting one specific secondary electron beam in dependence on the settings of the deflection of the primary electron beams 3 by the scan coils 16.

In figure 7, an alternative detector set-up is shown. In stead of using a detector 12 which gives a signal when hit directly by secondary electrons 20, 21, 22, such as a CCD, and which can be arranged at the common cross-over and which detector comprises a centre axis, which centre axis is at least substantially arranged at the optical axis of the primary charged particle beam 3 path as discussed in the previous examples, the detector of this alternative detector set-up comprises a fluorescent screen 121 arranged at least substantially in or near a plane comprising said common cross-over and an optical arrangement 122, 123 for conveying photons from the fluorescent screen 121 to a CCD camera, a CMOS camera, an array of avalanche photo diodes or photo multiplier 124. The optical arrangement in this example comprises a mirror 122 which is provided with a through-opening for allowing the primary electron beams 3 to pass there through, and an optical lens 123 for projecting the photons from the fluorescent screen 12 onto the CCD camera 124. An example of such a fluorescent screen 12 is a thin disc of a YAG crystal, provided with a through opening for the primary electrons to pass there through.

In figure 8, an alternative of the single lens objective 14 is shown. In the alternative set-up, the lens system 13', 14' comprises an objective lens array 14' having an array of small objective lenses, preferably one lens for each primary electron beam 31. As schematically shown, the primary electron beams 31 pass through the hole in the position sensitive secondary electron detector 12 and are in this example substantially collimated by a collimator lens 13′. Subsequently each primary electron beam 31 is directed to its own lens in the objective lens array 14′ which focuses said primary electron beam 31 on the sample surface 15. The secondary electron beams 32 are collected by the lenses of the objective lens array 14′ and are projected onto the detecting surface of the secondary electron detector 12.

It is to be understood that the above description is included to illustrate the operation of the preferred embodiments and is not meant to limit the scope of the invention. From the above discussion, many variations will be apparent to one skilled in the art that would yet be encompassed by the spirit and scope of the present invention.

CONCLUSIES

1. Een inrichting voor het inspecteren van een oppervlak van een monster, waarbij de inrichting omvat

een meervoudige bundel geladen-deeltjes-generator voor het genereren van een reeks primaire geladen-deeltjes-bundels,

een condensorlens voor het richten van alle geladen-deeltjes-bundels naar een gemeenschappelijke overkruising,

een lenssysteem voor het richten van de primaire geladen-deeltjes-bundels vanaf de gezamenlijke overkruising naar het monsteroppervlak en voor het focusseren van alle primaire geladen-deeltjes-bundels in een reeks van individuele stippen op het monsteroppervlak,

met het kenmerk, dat de inrichting een positiegevoelige secundaire-elektronendetector omvat die ten minste in hoofdzaak geplaatst is in of nabij een vlak dat de gemeenschappelijke overkruising omvat.

2. Inrichting volgens conclusie 1, waarbij het lenssysteem is ingericht voor het projecteren van de secundaire elektronen vanaf de individuele stippen op het monsteroppervlak naar individuele stippen op de secundaire-elektronendetector.

3. Inrichting volgens conclusie 2, waarbij het lenssysteem is ingericht voor het afbeelden van het monsteroppervlak op de secundaire-elektronendetector onder gebruikmaking van de secundaire elektronen.

4. Inrichting volgens conclusie 3, waarbij het lenssysteem is ingericht voor het afbeelden van het monsteroppervlak op de secundaire-elektronendetector met een optische vergroting in een bereik van 5 tot 400 keer.

5. Inrichting volgens een der voorgaande conclusies, waarbij de secundaire-elektronendetector een gat omvat voor het hierdoor passeren van de primaire geladen-deeltjes-bundels.

6. Inrichting volgens een der voorgaande

conclusies, waarbij het lenssysteem een magnetische objectief-lens omvat.

7. Inrichting volgens conclusie 6, waarbij de inrichting een monsterhouder omvat die is ingericht voor het positioneren van het monsteroppervlak om in het magnetische veld van de objectief-lens gedompeld te zijn.

8. Inrichting volgens een der voorgaande conclusies, waarbij het lenssysteem een enkelvoudige objectief-lens omvat.

9. Inrichting volgens een van de conclusies 1-7, waarbij het lenssysteem een matrix objectief-lens omvat met een matrix van kleine objectief-lenzen, bij voorkeur één lens voor elke primaire elektronenbundel.

10. Inrichting volgens een der voorgaande conclusies, waarbij de inrichting een veldgenerator omvat voor het verschaffen van een elektrostatisch veld dat de secundaire elektronen versnelt vanaf het monsteroppervlak naar de secundaire-elektronendetector.

11. Inrichting volgens conclusie 10, indien afhankelijk van conclusie 6, waarbij de veldgenerator is ingericht voor het verschaffen van een elektrostatisch veld tussen het monster en een pooldeel van de magnetische objectief-lens.

12. Inrichting volgens een der voorgaande conclusies, waarbij de steek tussen de stippen op het monsteroppervlak tussen 0,3 en 30 micrometer is.

13. Inrichting volgens een der voorgaande conclusies, waarbij de detector een CCD camera, een CMOS camera, een matrix van lawinefotodiodes, fotomultipliers of PN-overgang-halfgeleiderdetector die direct signalen krijgt van secundaire elektronen, is.

14. Inrichting volgens een van de conclusies 1-12, waarbij de detector een fluorescerend scherm omvat dat geplaatst is ten minste in hoofdzaak in of nabij een vlak dat de gemeenschappelijke overkruising omvat en een optisch samenstel voor het overbrengen van fotonen vanaf het fluorescerend scherm naar een CCD camera, een CMOS camera,

een matrix van lawinefotodiodes of fotomultiplier.

15. Werkwijze voor het inspecteren van een oppervlak van een monster omvattende de stappen van:

het genereren van een reeks primaire geladen-deeltjes-bundels onder gebruikmaking van een meervoudige bundel geladen-deeltjes-generator;

het richten van alle geladen-deeltjes-bundels naar een gemeenschappelijke overkruising onder gebruikmaking van een condensorlens;

het richten van de primaire geladen-deeltjes-bundels vanaf de gemeenschappelijke overkruising naar het monsteroppervlak en het focusseren van alle primaire geladen-deeltjes-bundels in een reeks van individuele stippen op het monsteroppervlak onder gebruikmaking van een lenssysteem; en

het detecteren van secundaire elektronen die afkomstig zijn van de individuele stippen op het monsteroppervlak onder gebruikmaking van een positiegevoelige secundaire-elektronendetector die ten minste in hoofdzaak in of nabij een vlak geplaatst is dat de gemeenschappelijke overkruising omvat.

16. Werkwijze volgens conclusie 15, waarbij het monsteroppervlak wordt bewogen met een constante snelheid in een eerste richting terwijl de primaire geladen-deeltjes-bundels herhaaldelijk gescand worden in een tweede richting ten minste in hoofdzaak loodrecht op de eerste richting.

17. Werkwijze volgens conclusie 16, waarin het lenssysteem een aftastinrichting omvat voor het scannen van de primaire geladen-deeltjes-bundels, waarbij de werkwijze de stap omvat van het selecteren van de pixels voor het detecteren van één specifieke secundaire elektronenbundel in afhankelijkheid van de instellingen van het scannen van de primaire geladen-deeltjes-bundels door de aftastinrichting.

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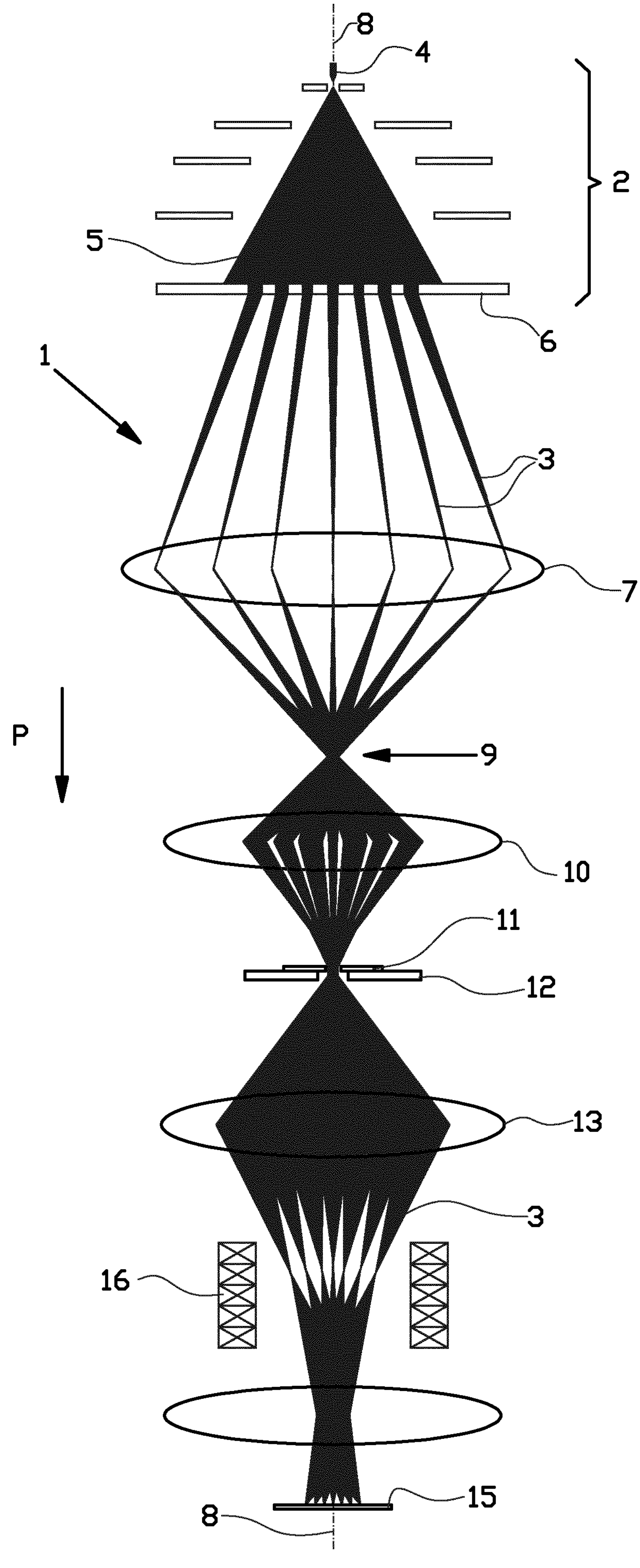

FIG. 1

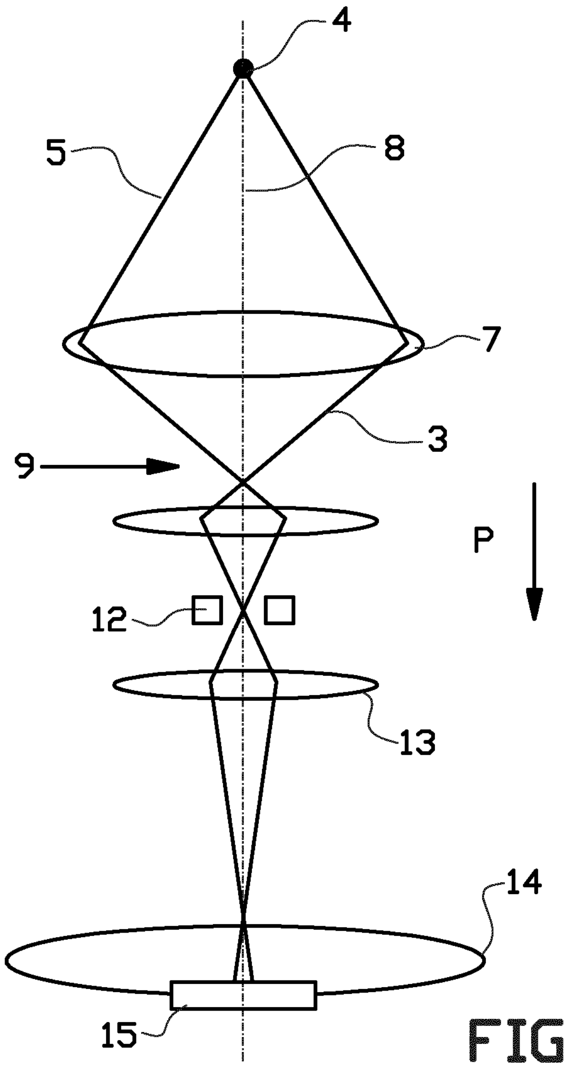

FIG. 2

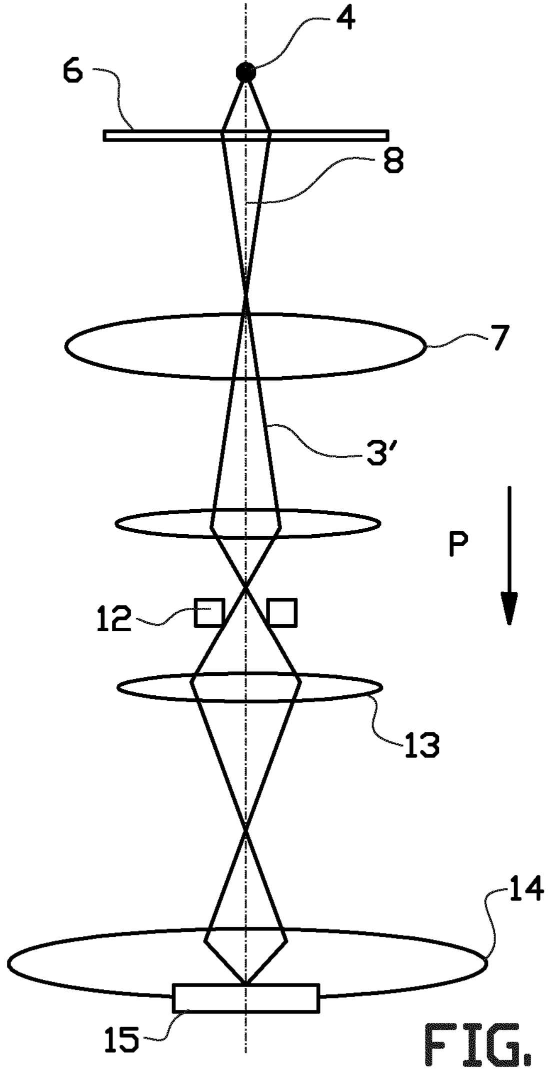

FIG. 3

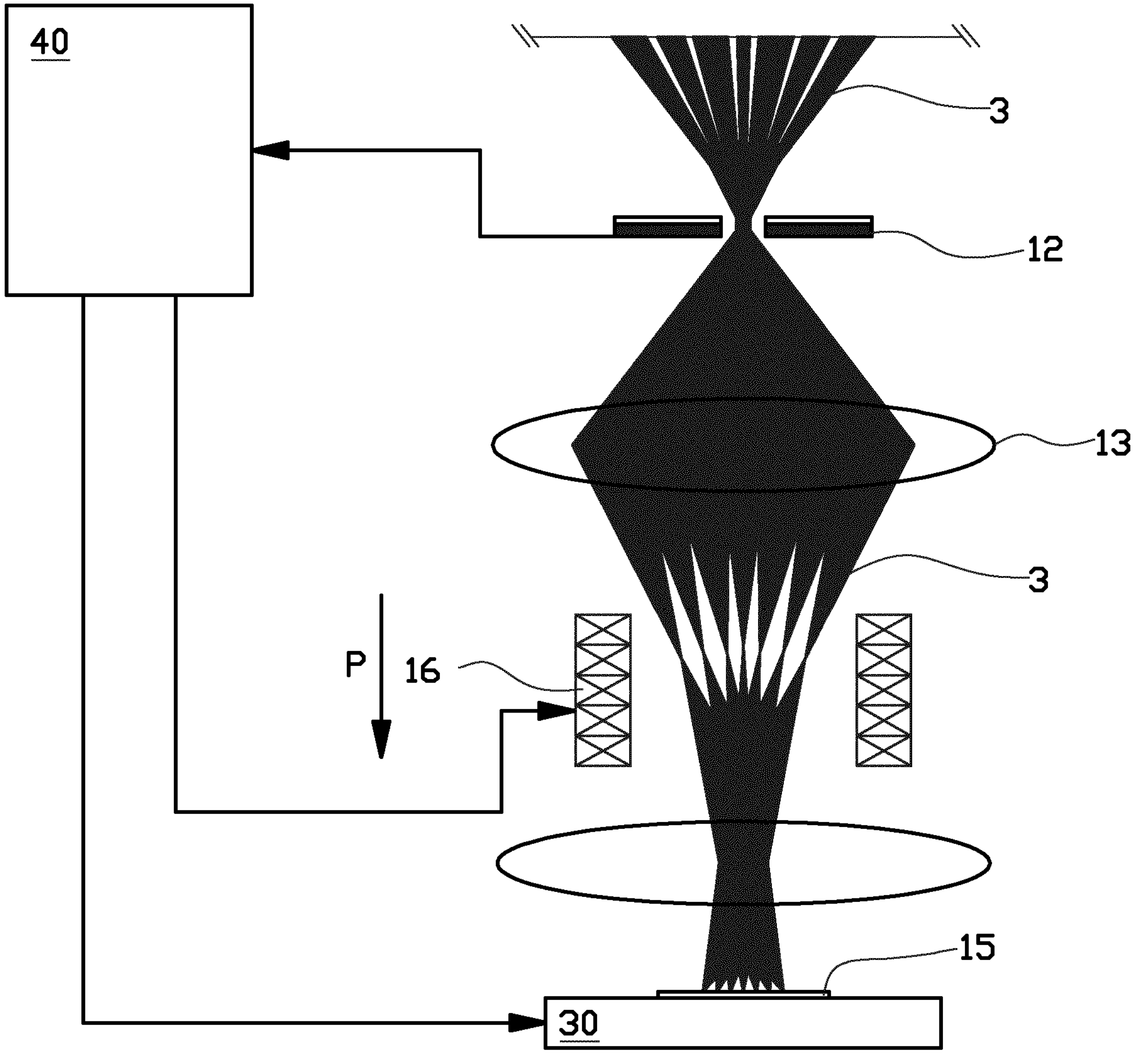

FIG. 4

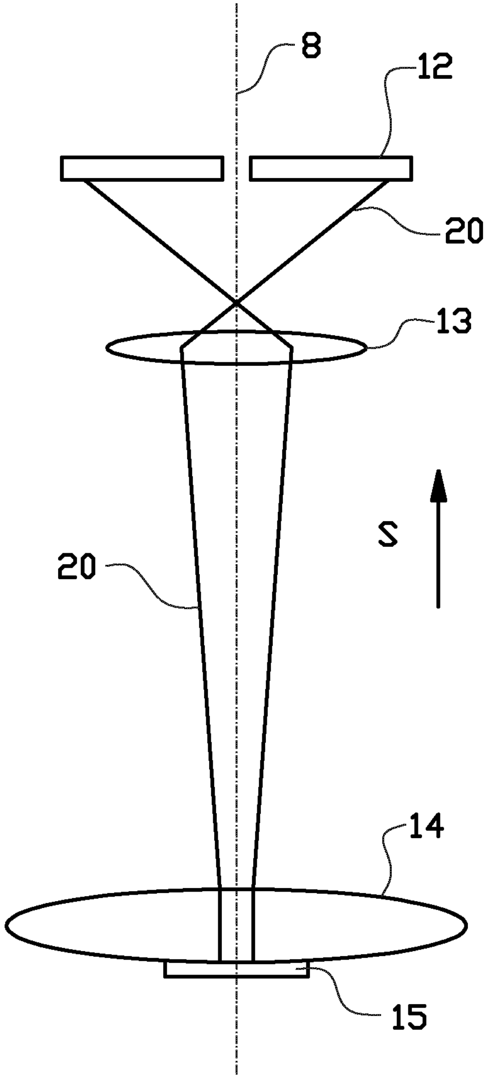

FIG. 5

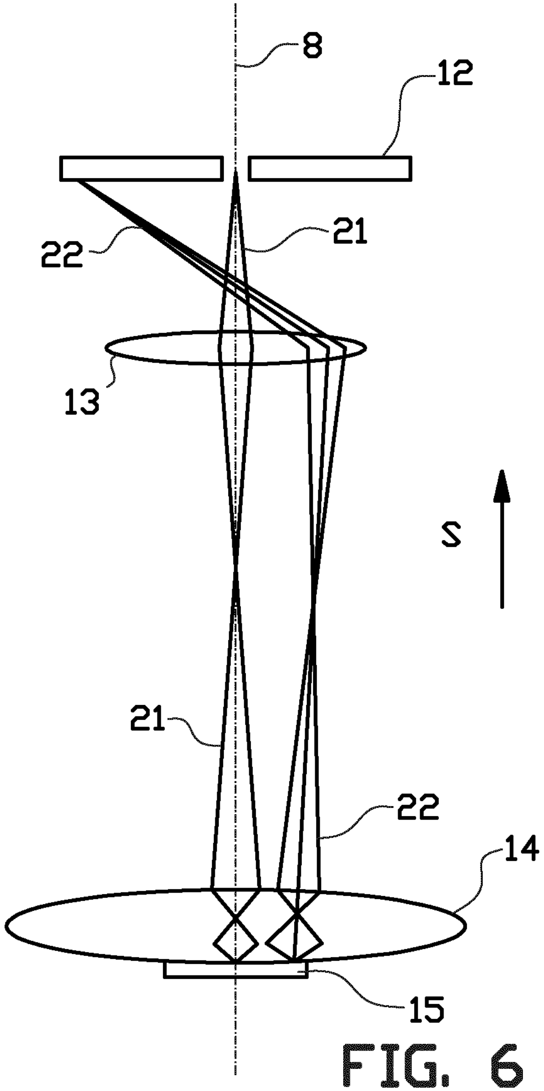

FIG. 6

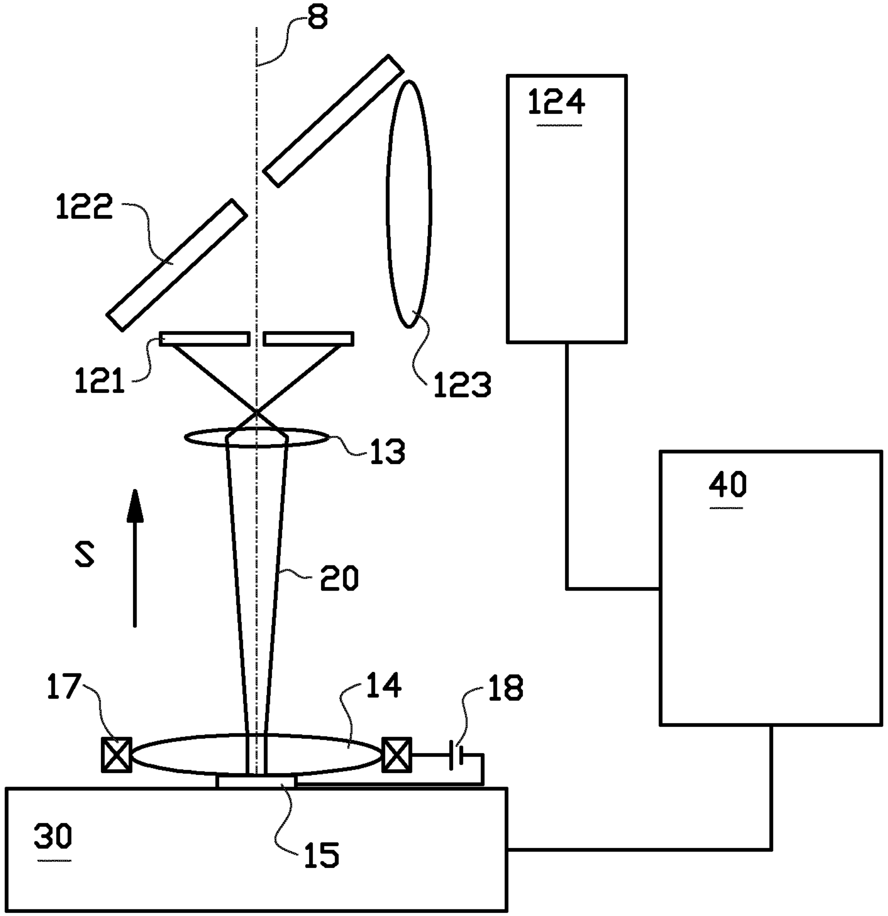

FIG. 7

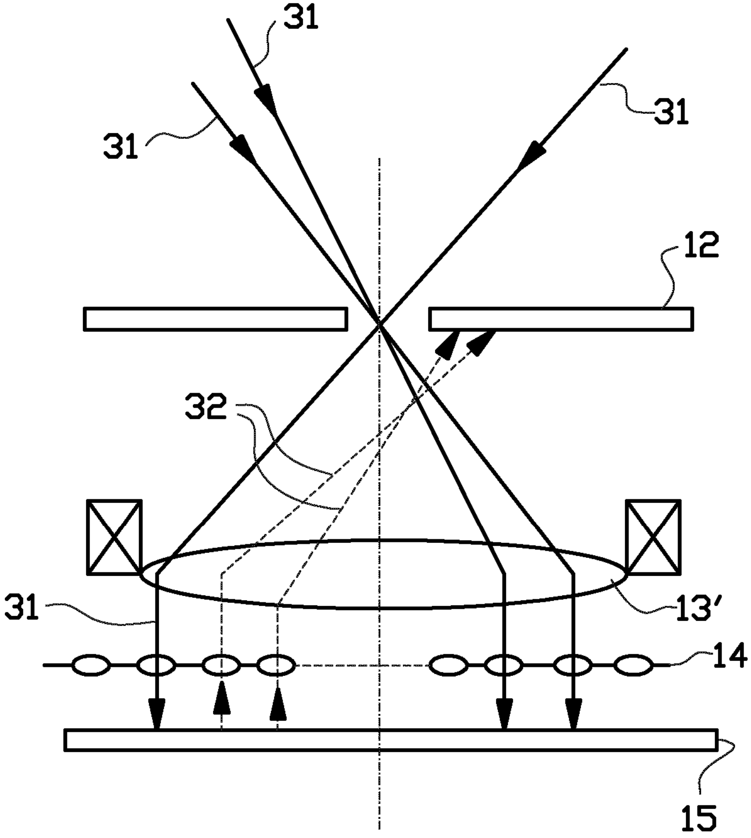

FIG. 8

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	**KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE** **NLP191540A**
Nederlands aanvraag nr. **2009053**	Indieningsdatum **22-06-2012**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Technische Universiteit Delft**	
Datum van het verzoek voor een onderzoek van internationaal type **29-09-2012**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN 58883**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

H01J37/244 **H01J37/28**

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC	**H01J**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

Form PCT/ISA 201 A (11/2000)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2009053

A. CLASSIFICATIE VAN HET ONDERWERP
INV. H01J37/244 H01J37/28
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
H01J

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	WO 2007/028596 A1 (ZEISS CARL SMT AG [DE]; APPLIED MATERIALS ISRAEL LTD [IL]; KEMEN THOMA) 15 maart 2007 (2007-03-15) * bladzijde 28, regels 20-21 * * bladzijde 37, regel 6 - regel 19; figuur 3a * -----	1,5,6, 12-15

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid
5 maart 2013

Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type

Naam en adres van de instantie
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

De bevoegde ambtenaar
Oestreich, Sebastian

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2009053

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
WO 2007028596 A1	15-03-2007	AT 503265 T	15-04-2011
		AT 545147 T	15-02-2012
		EP 1941528 A2	09-07-2008
		EP 1943661 A1	16-07-2008
		EP 2267751 A2	29-12-2010
		EP 2267752 A2	29-12-2010
		EP 2270833 A2	05-01-2011
		EP 2270834 A2	05-01-2011
		JP 2009507351 A	19-02-2009
		JP 2009507352 A	19-02-2009
		JP 2012234827 A	29-11-2012
		US 2009114818 A1	07-05-2009
		US 2009256075 A1	15-10-2009
		WO 2007028595 A2	15-03-2007
		WO 2007028596 A1	15-03-2007

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN58883	22.06.2012		NL2009053

International Patent Classification (IPC)
INV. H01J37/244 H01J37/28

Applicant
Technische Universiteit Delft

This opinion contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the application
☐	Box No. VIII	Certain observations on the application

Examiner
Oestreich, Sebastian

Application number

NL2009053

WRITTEN OPINION

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	2-4, 6-14, 16, 17
	No:	Claims	1, 5, 15
Inventive step	Yes:	Claims	2-4, 7-11, 16, 17
	No:	Claims	1, 5, 6, 12-15
Industrial applicability	Yes:	Claims	1-17
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1 WO 2007/028596 A1 (ZEISS CARL SMT AG [DE]; APPLIED MATERIALS ISRAEL LTD [IL]; KEMEN THOMA) 15 maart 2007 (2007-03-15)

2 The present application does not meet the criteria of patentability, because the subject-matter of claim 1 is not new.

D1 discloses (see Fig. 3a, and page 37, lines 6-19): A multi beam charged particle inspection device with a condenser lens directing the multiple beam to a common crossing (which is situated in the opening of member BP), and a lens directing the beams to the sample (s) (the lenses are not shown but apparent due to the angles in the optical path). Member (D) refers to a position sensitive detector (page 28, lines 20-21).

Claim 15 is the corresponding method claim, and does not have any additional technical limitations. Its subject matter therefore lacks novelty for the same reasons.

3 Dependent claims 5, 6, 12-14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty and/or inventive step, because they refer to well known design alternatives at the reach of the person skilled in the art.

4 The combination of the features of dependent claims 2-4, 7-11, 16, 17 cannot be derived from the disclosure of document D1, nor are they rendered obvious by the available prior art.