

(19)



NL Octrooicentrum

(11)

2007604

(12) C OCTROOI

(21) Aanvraagnummer: **2007604**

(51) Int.Cl.:

G21K 1/087 (2006.01)

H01J 37/317

(2006.01)

G03F 7/20 (2006.01)

H01J 29/46 (2006.01)

H01J 37/09 (2006.01)

(22) Aanvraag ingediend: **14.10.2011**

(43) Aanvraag gepubliceerd:
24.04.2013

(73) Octrooihouder(s):

Mapper Lithography IP B.V. te Delft.

(47) Octrooi verleend:
01.05.2013

(72) Uitvinder(s):

Marco Jan Jaco Wieland te Delft.
Alexander Hendrik Vincent van Veen
te Rotterdam.
Stijn Willem Herman Steenbrink
te Den Haag.
Alrik van den Brom te Utrecht.

(45) Octrooischrift uitgegeven:
08.05.2013

(74) Gemachtigde:

ir. F.A. Geurts te Den Haag.

(54) **Charged particle system comprising a manipulator device for manipulation of one or more charged particle beams.**

(57) The invention relates to a charged particle system such as a multi beam lithography system, comprising a manipulator device for manipulation of one or more charged particle beams, wherein the manipulator device comprises at least one through opening in the plane of the planar substrate for passing at least one charged particle beam there through. Each through opening is provided with electrodes arranged in a first set of multiple first electrodes along a first part of a perimeter of said through opening and in a second set of multiple second electrodes along a second part of said perimeter. An electronic control circuit is arranged for providing voltage differences the electrodes in dependence of a position of the first and second electrode along the perimeter of the through opening.

NL C 2007604

Dit octrooi is verleend ongeacht het bijgevoegde resultaat van het onderzoek naar de stand van de techniek en schriftelijke opinie. Het octrooischrift wijkt af van de oorspronkelijk ingediende stukken. Alle ingediende stukken kunnen bij NL Octrooicentrum worden ingezien.

No. NLP189404A

Charged particle system comprising a manipulator device for manipulation of one or more charged particle beams.

BACKGROUND

The invention relates to a charged particle system, such as a multi beam lithography system, comprising 5 a manipulator device for manipulation of one or more charged particle beams.

Charged particle systems, such as (multi) electron beam systems, are being developed for high throughput maskless lithography systems, (multi) electron beam 10 microscopy and (multi) electron beam induced deposition devices. In particular for maskless lithography systems, individual beam modulation or manipulation is needed during the writing of a pattern on a substrate.

Those lithography systems comprise either 15 continuous sources or sources operating at constant frequency or at a varying frequency. Pattern data can be sent towards a manipulator device (or modulation means),

which may be able to completely or partly stop the emitted beams from reaching the target exposure surface when necessary. The manipulator device (or modulation means) can also be provided for changing other characteristics of the emitted beam, such as a position, a cross-section, an intensity, a direction and/or an opening angle of the beam.

Preferably, the maskless lithography system comprises one source which can emit a diverging beam of charged particles, which charged particle beam is directed to an aperture array. The aperture array splits the charged particle beam into a plurality of charged particle beams or beamlets. This method of producing a plurality of charged particles has the advantage that it yields a large number of closely spaced beams or beamlets.

However, any manipulator device for such closely spaced plurality of charged particle beamlets requires closely spaced arrays of manipulators. Such closely spaced arrays are difficult to produce. In particular electrical circuits for controlling many manipulators are difficult to arrange in the lithography system. In addition, cross-talk between manipulators and other circuits in the vicinity of the manipulators can cause errors in the manipulation of the beams.

Furthermore, it can be difficult to produce a manipulator device that is able to manipulate the charged particle beam with sufficient accuracy. The manipulation by a manipulation device can depends on the exact location of the projection of the beam on the manipulation device. Any misalignment of the charged particle beam will then result in large manipulation errors.

It is an object of the present invention to provide a solution, at least in part, for at least one of the above identified problems.

35 SUMMARY OF THE INVENTION

According to a first aspect, the object of the

invention is achieved by providing a charged particle system, such as a multi beam lithography system, comprising a manipulator device for manipulation of one or more charged particle beams, wherein the manipulator device comprises:

- a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through and each through opening is provided with electrodes arranged in a first set of multiple first electrodes along a first part of a perimeter of said through opening and in a second set of multiple second electrodes along a second part of said perimeter; and,

- an electronic control circuit arranged for providing voltage differences to pairs of a first electrode and a second electrode in dependence of a position of the first and second electrode along the perimeter of the through opening.

Charge particle beams can be manipulated (or deflected) by applying an electric field over a through opening, through which the beams pass. The characteristics of the electric field (e.g. strength and form) define, at least partly, the manipulation or deflection of the beam(s). An electric field can be created by applying a voltage over two electrodes that are arranged around the through opening. In that case, the strength and form of the electrical field will depend on the distance between those electrodes. Dividing each of said two electrodes in a set of multiple electrodes and providing voltage differences to the pairs of a first electrode and a second electrode in dependence of positions of the respective electrodes along the perimeter of the through opening allows adjustment of the electric field in the through opening. By providing a suitable voltage distribution, the electrical field can be optimized, for example to obtain a more homogeneous electric field in said through opening.

The first set of first multiple electrodes and the second set of second multiple electrodes may each consist of two electrodes or more, preferably of $2n$ electrodes, n being a natural number. The electrodes may 5 be provided partly in and/or on the planar substrate.

Manipulator devices that are known in the art comprise two electrodes arranged on opposite sides of an opening. It has been found that the electrical field generated by such manipulator devices is not sufficiently 10 homogeneous to manipulate the charged particle beam with sufficient accuracy. Because of the lack of homogeneity of the electrical field inside the opening, the manipulation of the charged particle beams or beamlets is dependent on the location where the beam is projected in the opening.

Because of this, beams are usually projected in a small centre part of the electrical field, where the electrical field is more or less homogeneous. However, this requires a relatively large through opening for a beam and only the centre part of the through opening is used for 20 passing a beam there through. Evidently the manipulators that are known in the art use a small fill factor; that is the ratio between the cross-section area of the beam and the area of the through opening.

Since the manipulation device according to the 25 invention provides a much more homogeneous field inside the through opening, the manipulation device is able to manipulate the beam with a higher accuracy than manipulator devices known in the art. Furthermore, the fill factor of the manipulator device according to the 30 invention can be much higher than in manipulator devices known in the art. Due to the larger fill factor of the manipulators of the invention, the through openings for manipulating the beams can be much smaller than in the prior art. On the one hand, this can provide additional 35 space between the through openings for arranging control circuitry. On the other hand, the through openings can be arranged much closer to each other for providing a larger

beam density in a charged particle system according to an embodiment of the invention.

In an embodiment of the charged particle system according to the invention, the electronic control circuit
5 is arranged for providing said voltage differences to said pairs in dependence of a distance between a first electrode and a second electrode of the respective pair. Preferably said voltage differences are directly proportional to said distance.

10 Since an electrical field generated by two electrodes is dependent on (or in particular, direct proportional to) the distance between the two electrodes, the homogeneity of the electrical field in the through opening may be improved by providing voltage difference in dependence of the distance between the first electrode and
15 the second electrode.

In an embodiment of the charged particle system, a plane is defined between the first part of the perimeter and the second part of the perimeter, a line is defined
20 between an electrode and a diametrically opposite other electrode and an angle alpha (α) is defined by said plane and line, wherein the electronic control circuit is arranged for providing voltage differences to said electrode and said other electrode in dependence of the angle alpha (α).
25 Preferably said voltage differences are directly proportional to $\sin(\alpha)$.

In an embodiment of the charged particle system, a plane is defined between the first part of the perimeter and the second part of the perimeter, a line is defined
30 between a respective electrode and a centre of the though opening, and an angle beta (β) is defined by said plane and said line, wherein the electronic control circuit is arranged for providing voltages to respective electrodes in dependence of the angle beta (β). Preferably said voltages
35 are directly proportional to $\sin(\beta)$.

The electrical field lines of the electrical field, generated by the electrodes, may be perpendicular

to said plane. The strength of the electrical field may depend on the voltage applied to the respective electrodes and a distance of a respective electrode to said plane. Since both $\sin(\alpha)$ and $\sin(\beta)$ are each a measure for the 5 distance of a respective electrode to said plane, providing voltage (differences) in dependence of the angle alpha (α) or the angle (β) may enable providing a homogeneous electrical field.

In this document, a plane defined between the 10 first part of the perimeter and the second part of the perimeter may be a plane defined centrally between the first part of the perimeter and the second part of the perimeter. The plane may comprise the central axis of the through opening.

15 In an embodiment of the charged particle system according to the invention, the electrodes are arranged substantially symmetrically with respect to said plane and/or the electrodes are uniformly distributed along said perimeter. Providing the electrodes symmetrically or/and uniformly distributed may increase the homogeneity of the 20 electrical field across the through opening.

In an embodiment of the charged particle system, a plane is defined between the first part of the perimeter and the second part of the perimeter and the first electrode 25 of said pair is located opposite to the second electrode of said pair with respect to the plane. In this case, the electrical field lines of the electrical field generated by the electrodes are at least substantially perpendicular to said plane.

30 In an embodiment of the charged particle system according to the invention, the electronic control circuit is arranged for providing a positive voltage V to the first electrode and a negative voltage $-V$ to the second electrode. In an embodiment of the manipulator according 35 to the invention, the electronic control circuit is arranged for providing a positive voltage V to two electrodes from the first set and preferably a negative

voltage $-V$ to two electrodes from the second set.

An advantage of providing multiple electrodes with the same voltage V or with the polarity inverted voltage $-V$ is that this would require a relatively simple
5 electronic control circuit.

In an embodiment of the charged particle system according to the invention, the manipulator device further comprises two electrodes arranged along the perimeter of the through opening and substantially on said plane,
10 wherein the electronic control circuit is arranged for providing one voltage to each of said two electrodes, said one voltage preferably being an offset voltage and preferably being substantially equal to 0 Volt.

Since the electrical field lines of the homogeneous electrical field generated by the electrodes should be perpendicular to the plane, these two electrodes should be provided with the same voltage, such that the voltage difference between these two electrodes is 0 Volt. Providing these two electrodes with an (off-set) voltage of 0 volt (or grounding them) would require a relatively simple circuit. However, these two electrodes may also be provided with any other offset voltage, for example - 1 kV. In both cases, the other electrodes may be provided with a voltage relative to this off-set voltage, for example with a positive voltage V and/or a negative voltage $-V$ with respect to the offset voltage.
25

In an embodiment of the charged particle system, the electronic control circuit comprises resistors arranged as a voltage divider for providing voltages to respective electrodes, preferably as a feedback resistor of an operational amplifier. Preferably each of said first and/or second set of electrodes receives a maximum voltage, wherein said maximum voltage is then divided by said voltage divider for providing each electrode in a set of electrodes with a part of the maximum voltage.
35

Preferably said voltage divider is arranged for providing each electrode in a set of electrodes with a

part of the maximum voltage, so that said voltages are proportional with the distance between a respective electrode and the above-mentioned plane.

In an embodiment said voltage divider comprises
5 a set of resistors, which are preferably arranged around said through opening. A voltage divider is a relatively simple circuit for providing a number of different voltages on the basis of one particular maximum voltage. In a further embodiment, the voltage divider may comprise
10 resistors with the same resistance. This would further increase the simplicity of the circuit.

An advantage of such a simple circuit is that it can be easily made, for example with lithography technologies. It may be integrated with other circuits in
15 or on the planar substrate. The electronic control circuit may be at least partly arranged near to or in the vicinity of the through openings.

In an embodiment of the charged particle system according to the invention, the electronic control circuit comprises a first operational amplifier with a voltage divider as a feedback resistor for providing voltages to the first electrodes, and a second operational amplifier with a voltage divider as a feedback resistor for providing voltages to the second electrodes.
20

In an embodiment of the charged particle system, the electronic control circuit further comprises a digital-to-analogue converter for outputting a single control signal to the first and the second operational amplifier and a polarity inverter arranged for inverting a
30 polarity of said control signal, wherein the first operational amplifier is directly connected to the digital-to-analogue converter to receive said control signal and the second operational amplifier is connected to the digital-to-analogue converter via said polarity inverter to receive an inverted control signal.
35

An advantage of this embodiment is the relatively simple circuit: only a single digital-to-

analogue-converter is required that outputs a single control signal to the first operational amplifier. The same control signal is provided to the second operational amplifier after inversion of the polarity of the signal by 5 the polarity inverter.

In another embodiment, the electronic control circuit comprises two digital-to-analogue-converters for outputting two control signals to the first and the second operational amplifier respectively.

10 In an embodiment of charged particle system according to the invention, gaps are provided between adjacent electrodes. The perimeter of said through opening consists of a first area covered by the electrodes and a second area covered by the gaps, and an electrode-to-gap 15 ratio is defined by said first area divided by said second area. In an embodiment said electrode-to-gap ratio is in the range of 5-15, or preferably substantially 10.

When adjacent electrodes are provided closer to each other, the generated electrical field could be more 20 homogeneous. However, this is also more difficult to produce. It appears that with an electrode-to-gap ratio being in the range of 5-15, or preferably substantially 10, the two effects are optimally balanced.

25 In an embodiment of the charged particle system according to the invention, the manipulator comprises a cross-talk shield, the cross-talk shield comprising a planar shield substrate comprising at least one through opening in the plane of the planar shield substrate, wherein the at least one through opening of the planar 30 shield substrate is arranged in alignment with the at least one through opening of the planar substrate. An advantage of a cross-talk shield is that it prevents to some extend cross-talk between electrodes of the same through opening, between electrodes of different through 35 openings and/or between an electrode and other circuitry present in the vicinity of the electrode.

In an embodiment of the charged particle system

according to the invention, a distance between the planar substrate and the planar shield substrate is smaller than 10 micrometer, preferably smaller than 5 micrometer and more preferably about 3 micrometer. In an embodiment of
5 the manipulator according to the invention, a thickness of the shield planar substrate is about a diameter of the at least one through opening of the planar substrate.

In an embodiment of the charged particle system according to the invention, the charged particle system
10 further comprises:

- a first planar lens substrate comprising at least one first planar lens aperture, wherein the at least one first planar lens aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device and the first planar lens substrate is arranged above and parallel with the planar substrate of the manipulator device; and,

- a second planar lens substrate comprising at least one second planar lens aperture, wherein the at least one second planar lens aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device and the second planar lens substrate is arranged below and parallel with the planar substrate of the manipulator device,

25 wherein the system is arranged for providing a voltage difference between the first planar lens substrate and the planar substrate of the manipulator device and between the planar substrate of the manipulator device and the second planar lens substrate for generating an Einzel
30 lens for said beams.

In this embodiment, the manipulator device forms a part of an Einzel lens, comprising the first and second planar lens substrate and the planar substrate of the manipulator device in between. This Einzel lens may be
35 arranged for focusing or projecting the charged particle beam.

In this way, the manipulator device may be

integrated in the Einzel lens and this combined device may require less space in the charged particle system than providing a separate manipulator device and a separate Einzel lens.

5 And because of the compactness of the combined device, the effects of angular alignment errors may be limited.

10 The terms "above" and "below" in this document are defined with respect to the direction of a charged particle beam which passes through a though opening. The beam may travel or be directed from an upper part of the charged particle system to a lower part of the charged particle system.

15 In an embodiment of the charged particle system according to the invention, the charged particle system further comprises a planar current limiter substrate, comprising at least one current limiter aperture, wherein the current limiter planar substrate is arranged above the planar substrate of the manipulator device and the at least one current limiter aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device.

20 An advantage of providing a current limiter is that it may enhance the homogeneity of the beams. The beam intensity of a beam may be more homogeneous in the centre of the beam than in the radial outer parts of the beam. The cross-sectional area of the beams projected on the current limiter can be arranged to be larger than the area of the respective current limiter aperture. In this case, 25 the outer charged particles (for example electrons) of the beam will be absorbed by the current limiter and the overall homogeneity of the remaining beam will be improved.

30 In an embodiment of the charged particle system according to the invention, the at least one current limiter aperture is smaller than the at least one through opening of the planar substrate of the manipulator device.

In an embodiment, a cross-sectional area of the at least one through opening of the planar substrate of the manipulator device is in the range of 50%-95% or preferably in the range of 70-90% of a cross-sectional area of the at least one current limiter aperture.

In this way, the cross-section of the beam passing through the though opening may be significantly smaller than the through opening itself. This would reduce the number of charged particles (for example electrodes) that hit or contact the planar substrate of the manipulator device. And this would reduce the damage these charged particles may cause to the electronic control circuit provided at least partly on or in the planar substrate of the manipulator device.

15 In an embodiment of the charged particle system according to the invention,

- said manipulator device is a first manipulator device arranged for deflecting the one or more charged particle beams in an x-direction;

20 - the charged particle system further comprises a second manipulator device according to any embodiment described above, arranged for deflecting said one or more charged particle beams in an y-direction, wherein the x-direction is perpendicular to the y-direction, wherein the second manipulator device is arranged parallel with and adjacent to the first manipulator device and the at least one through opening of the second manipulator device is arranged in alignment with the at least one through opening of the first manipulator device,

30 wherein the system is arranged for providing a voltage difference between the first planar lens substrate and the second planar substrate of the first manipulator device and between the planar substrate of the second manipulator device and the second planar lens substrate for generating an Einzel lens for said beams.

In this embodiment, the two manipulator devices form a part of an Einzel lens, comprising the first and

second planar lens substrate and the planar substrates of the two manipulator device in between.

Also in this embodiment, the manipulator devices may be integrated in the Einzel lens and this combined 5 device may be more compact than providing two separate manipulator device and a separate Einzel lens.

In an embodiment of the charged particle system according to the invention, the first and second planar lens substrate are grounded and the system is arranged for 10 providing a negative voltage to the planar substrate(s) of the manipulator device(s), wherein said negative voltage is preferably in the range of -1500 Volt to -500 Volt, or more preferably about -1000 Volt or -1 kV.

In charged particle systems, so called secondary 15 electrons may be generated by the charged particles of the charged particle beam when they hit or are in contact with surfaces in the charged particle system, for example the surface of the target. These secondary electrons may cause damage to the manipulator device(s). By providing the a 20 negative voltage, for example of about -1 kV to the planar substrate of the manipulator device(s), these secondary electrons may be deflected away from the manipulator device(s).

According to a second aspect, the invention 25 provides a manipulator device for manipulating a charged particle beam in a charged particle system, such as a multi beam lithography system, according to any of the embodiments described above.

According to a third aspect, the invention 30 provides a charged particle system such as a multi beam lithography system, comprising:

- a manipulator device for manipulation of one or 35 more charged particle beams, comprising a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through;

- a first planar lens substrate comprising at least one first planar lens aperture, wherein the at least one first planar lens aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device and the first planar lens substrate is arranged above and parallel with the planar substrate of the manipulator device; and,

- a second planar lens substrate comprising at least one second planar lens aperture, wherein the at least one second planar lens aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device and the second planar lens substrate is arranged below and parallel with the planar substrate of the manipulator device,

wherein the system is arranged for providing a voltage difference between the first planar lens substrate and the planar substrate of the manipulator device and between the planar substrate of the manipulator device and the second planar lens substrate for generating an Einzel lens for said beams.

In an embodiment of the charged particle system according to the invention, the charged particle system further comprises a planar current limiter substrate, comprising at least one current limiter aperture, wherein the current limiter planar substrate is arranged above the planar substrate of the manipulator device and the at least one current limiter aperture is arranged in alignment with the at least one through opening of the planar substrate of the manipulator device.

In an embodiment of the charged particle system according to the invention, the at least one current limiter aperture is smaller than the at least one through opening of the planar substrate of the manipulator device.

In an embodiment of the charged particle system according to the invention, the charged particle system further comprises cooling tubes for transporting a cooling fluid, wherein said cooling tubes are arranged around the at

least one current limiter aperture.

In an embodiment of the charged particle system according to the invention,

- said manipulator device is a first manipulator device arranged for deflecting the one or more charged particle beams in an x-direction;

- the charged particle system further comprises a second manipulator device arranged for deflecting said one or more charged particle beams in an y-direction, wherein the x-direction is perpendicular to the y-direction, the second manipulator device comprising a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through, wherein the second manipulator device is arranged parallel with and adjacent to the first manipulator device and the at least one through opening of the second manipulator device is arranged in alignment with the at least one opening of the first manipulator device,

wherein the system is arranged for providing a voltage difference between the first planar lens substrate and the planar substrate of the first manipulator device and between the planar substrate of the second manipulator device and the second planar lens substrate for generating an Einzel lens for said beams.

In an embodiment of the charged particle system according to the invention, the charged particle system further comprises cooling tubes for transporting a cooling fluid, wherein said cooling tubes are arranged between the first and the second manipulator device.

Both the first and the second manipulator device may deform due to thermal expansion. When the cooling tubes are arranged between the first and the second manipulator device, the manipulator devices will expand symmetrically.

This may prevent the manipulator devices from bending.

In an embodiment of the charged particle system according to the invention, the electrodes arranged in a

first set of multiple first electrodes and in a second set of multiple second electrodes and the electronic control circuit form a single CMOS device.

According to a fourth aspect, the invention
5 provides a charged particle system such as a multi beam lithography system, comprising:

- a first manipulator device arranged for deflecting one or more charged particle beams in an x-direction, the first manipulator device comprising a planar substrate comprising at least one through openings in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through; and,

- a second manipulator device arranged for deflecting said one or more charged particle beams in an y-direction, wherein the x-direction is perpendicular to the y-direction, the second manipulator device comprising a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through, wherein the second manipulator device is arranged parallel with and adjacent to the first manipulator device and the at least one through opening of the second manipulator device is arranged in alignment with the at least one opening of the first manipulator device;

wherein the first and the second manipulator device each form a single CMOS device.

According to a fifth aspect, the invention
30 provides a charged particle system such as a multi beam lithography system, comprising:

- a first manipulator device arranged for deflecting one or more charged particle beams in an x-direction, the first manipulator device comprising a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged

particle beam there through; and,

- a second manipulator device arranged for deflecting said one or more charged particle beams in an y-direction, wherein the x-direction is perpendicular to

5 the y-direction, the second manipulator device comprising a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through, wherein the second

10 manipulator device is arranged parallel with and adjacent to the first manipulator device and the at least one through opening of the second manipulator device is arranged in alignment with the at least one opening of the first manipulator device;

15 - cooling tubes arranged for transport a cooling fluid, wherein the cooling tubes are arranged between the first and the second manipulator device.

According to a sixth aspect, the invention provides a charged particle system such as a multi beam lithography system, comprising a manipulator device for manipulation of one or more charged particle beams, wherein the manipulator device comprises:

- a planar substrate comprising at least one through opening in the plane of the planar substrate, wherein each through opening is arranged for passing at least one charged particle beam there through and each through opening is provided with electrodes arranged in a first set of multiple first electrodes along a first part of a perimeter of said through opening and in a second set of multiple second electrodes along a second part of said perimeter; and,

- an electronic control circuit arranged for providing different voltages to at least two first electrodes of the first set of multiple first electrodes.

35 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.

5 BRIEF DESCRIPTION OF THE DRAWINGS

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

10 Figure 1 shows a schematic overview of a part of an embodiment of a charged particle system according to the invention;

15 Figure 2 shows a schematical overview of a part of an embodiment of a manipulator device according to the invention;

Figure 3A shows a schematical overview of a part of an embodiment of a manipulator device according to the invention;

20 Figure 3B shows a schematical overview of a part of an embodiment of a manipulator device according to the invention;

Figure 4 shows a schematical overview of a part of an embodiment of a manipulator device according to the invention;

25 Figure 5A shows a schematical overview of a part of an electronic control circuit for use in a manipulator device according to the invention;

30 Figure 5B shows a schematical overview of a part of another electronic control circuit for use in a manipulator device according to the invention;

Figure 6A shows a schematical overview of a part of an embodiment of a charged particle system according to the invention;

35 Figure 6B shows a schematic overview of a part of another embodiment of a charged particle system according to the invention; and,

Figure 7 shows a schematic overview of a part of

an embodiment of a through opening according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

5

Figure 1 shows a schematic overview of a part of a charged particle multi-beam or multi-beamlet lithography system 100 according to an embodiment of the invention for processing at least a part of a target 110, which may be a wafer. In an embodiment of the invention, the lithography system is without common cross-over of all the charged particle beams or beamlets and/or maskless.

The lithography system as shown in figure 1 comprises a charged particle source 101, for example an electron source, for producing an expanding charged particle beam 111. The expanding beam passes a collimator lens 102 for collimating the charged particle beam 111.

Subsequently the collimated beam 111 impinges on an aperture array 104, which blocks part of the collimated beam 111 for creating sub-beams 112. The sub-beams 112 impinge on a further aperture array 105 for creating beamlets 115. A condenser lens array 103 (or set of condenser lens arrays) is provided for focusing the sub-beams 112 towards a corresponding opening in the beam stop array 108 of end module 107.

The beamlet creating aperture array 105 is preferably included in combination with a beamlet blanker array 106, for example arranged close together with aperture array 105 before the blanker array 106. The condenser lens or lenses 103 may focus sub-beam 112 either in or towards a corresponding opening in beam stop array 108 of end module 107.

In this example, the aperture array 105 produces three beamlets 115 from sub-beam 112, which strike the beam stop array 108 at a corresponding opening so that the three beamlets 115 are projected onto the target 110 by the projection lens system 109 in end module 107. In practice a

group of beamlets with a much larger number of beamlets may be produced by aperture array 105 for each projection lens system 109 in end module 107. In a practical embodiment typically around fifty beamlets (for example 49 beamlets 5 generated by a 7x7 aperture array) may be directed through a single projection lens system 109, and this may be increased to two hundred or more.

However, it is also possible that the aperture array 105 produces only one beamlet 115 for each single 10 projection lens system 109. In that case, aperture array 104 may be omitted.

The beamlet blanker array 106 may deflect individual beamlets in a group of beamlets 115 at certain times in order to blank them. This is illustrated by blanked 15 beamlet 116, which has been deflected to a location on the beam stop array 108 near to but not at an opening.

It may be understood that the term beam in this document, in particular in the enclosed claims, may refer to beam 111, sub-beam 112 and beamlets 115. The charged 20 particle optical column may be provided with one or more manipulator devices according to the invention at different locations in the charged particle system or in particularly at different locations in its optical column.

A manipulator device 113 according to the 25 invention may be arranged behind the collimator lens 102 for:

- providing a deflection in a plane substantially perpendicular to an optical axis of the charged particle optical column in order to correct for misalignments of one 30 or more of the devices of charged particle optical column, and/or

- providing a correction for any astigmatism which may be caused by a macroscopic lens - usually a magnetic lens - which diffracts the whole beam 111, all sub-beams 112 35 or all beamlets 115, such as the collimator lens 102.

A manipulator device according to the invention may also be arranged behind the beamlet blanker array 106

(not shown in figure 1).

A manipulator device 114 according to the invention may be provided as part of the end module 107 for providing a two dimensional deflection in the projection lens system 109 and, possibly enabling a vector scan of the beamlets in one group. Said dimension deflection may take place at a high frequency, i.e. a higher frequency than manipulation takes place in manipulator device 113. Figure 2 shows a schematical overview of a part of an embodiment of a manipulator device 201 according to the invention. This embodiment may be used as manipulator device 113 or manipulator device 114 in figure 1.

The manipulator device 201 comprises a planar substrate 202 comprising an array of through openings 203 in the plane of the planar substrate. Through the through openings 203 one or more charged particle beamlets may pass. The through openings 203 extend substantially transverse to the surface of the planar substrate 202. Each of openings 203 may be provided with electrodes 204 along the perimeter 205 of through opening 203.

The through openings 203 may be grouped in so-called beam areas 207. Adjacent to the beam areas 207 non-beam areas 208 are provided on the planar substrate 202. In the non-beam areas electronic circuits (such as an electronic control circuit) may be at least partly provided to control the operation of the electrodes 204 in the beam area 207.

The number of electrodes may vary but is preferably in the range of 16 - 32 electrodes or 26. In general, the number of electrodes may be multiple of 2 or 4 electrodes, or may be equal to $2k$ or $4k$, k being a natural number.

When the number of electrodes is even and the electrodes are arranged uniformly distributed along the perimeter of the through opening, it may be the case that a rotation of the electrodes 204 by 90 degrees around a centre axis of the through opening would yield the same

distribution of the electrodes along the perimeter.

The manipulator device 201 may comprise an array of manipulators 206, each comprising a through opening 203 and electrodes 204 arranged around the through opening 203.

5 The manipulators 206 preferably have lateral sizes ranging from approximately 150 micrometers to 2 micrometers, depending on their purpose. The manipulator may be regularly arranged in rows and columns, as for example is shown in figure 2.

10 One of the challenges is to design electrodes with a fabrication process that is compatible with chip fabrication and electron optical design rules. Furthermore it is desirable to control thousands of beams without having thousands of external control wires.

15 The manipulator device may be manufactured using MEMS technology. This fabrication process is bipolar compatible allowing local electronics to be incorporated, for example the electronic control circuit. The local electronics (such as an electronic control circuit) may be 20 arranged between the through openings or adjacent to the through openings or to the electrodes 204.

Figures 3A and 3B show a schematical overview of a part of an embodiment of a manipulator according to the invention. In the example of figure 3 the through opening 203 is provided with 20 electrodes 301 - 320 along the perimeter of the through opening 203. When operational, a beam may enter the through opening 203 in a direction into the paper. This direction may be parallel with the optical axis of the optical column or with a central axis of the 25 through opening. The cross-sectional area of one beam passing the through opening 203 is indicated by 324 in figure 3A. In figure 3B the cross-sectional area of multiple beams passing the through opening 203 is indicated by 327. In figure 3A the cross-sectional area of only four beams are 30 indicated, but more beam could pass through the through opening, for example 49 beams.

A plane 321 may be defined parallel with the

central axis of the through opening and may comprise said central axis. It may be understood that all planes and lines mentioned in this document are imaginary. A first set of first electrodes 302-310 has been arranged along a first part 322 of the perimeter and a second set of second electrodes 312-320 has been arranged along a second part 323 of the perimeter. The first set of first electrodes 302-310 is arranged opposite to the second set of electrodes 312-320 with respect to the plane 321. The plane 321 is defined centrally between the first and second set of electrodes.

The electrodes according to this example, are arranged substantially symmetrically with respect to the plane 321 and the electrodes are uniformly distributed along said perimeter, as can be seen in figure 3A and 3B. A voltage may be applied or provided to each of the electrodes by an electronic control circuit (not shown in figure 3). To the voltages provided to each electrode may be referred to as V<number of the electrode>, for example, a voltage V306 may be applied to electrode 306 and a voltage V309 may be applied to electrode 309.

The electronic control circuit may be arranged for providing voltage differences to pairs of a first electrode and a second electrode in dependence of positions of the respective electrodes along the perimeter of the through opening. It may be the case that, the first electrode of a pair from the first set and the second electrode of said pair from the second set are arranged opposite to each other with respect to plane 321. For example, in figure 3, first electrode 307 from the first set of electrodes 302-310 and second electrode 315 from the second set of electrodes 312-320 are arranged opposite with respect to plane 321. A distance between the electrodes of the pair is indicated by D4.

The electronic control circuit is arranged for providing said voltage differences to said pair of first electrode 307 and second electrode 315 in dependence of the distance D4, wherein preferably said voltage differences are

directly proportional to said distance D4.

In figure 3A, a distance between electrode 306 and plane 321 is indicated by arrow D1, while a distance between electrode 309 and plane 321 is indicated by D2. And a distance between electrode 303 and the plane is indicated by D3. The electronic control circuit may be arranged for providing voltages to the electrodes in dependence of a distance between a respective electrode and said plane.

For example in figure 3A, because the distances D1 and D2 are different, the voltage V306 and V309 provided by the electronic control circuit is also different. The voltages V309 and V303 may be (substantially) identical, since the distances D2 and D3 are also (substantially) identical.

In an embodiment, the voltages increase with said distance, preferably proportionally. In the example of figure 3, voltage V306 may be higher than V309 or may be equal to the ratio D1/D2 times the voltage V309. This may also be applicable to the other electrodes 204, mutatis mutandis.

Among the electrodes 204 a first electrode from the first set of electrodes 302-310 (i.e. a set of the so-called first electrodes) and a second electrode from the second set of electrodes 312-320 (i.e. a set of the so-called second electrodes) may be arranged diametrically across the through opening 203. For example, in figure 3A, first electrode 308 from the first set and second electrode 318 from the second set are arranged diametrically. A line connecting the (positions of) the first electrode 308 and second electrode 318 has been indicated by 325 in figure 3A. The plane 321 and this line 325 define an angle alpha (α), as is shown in figure 3A. It may be understood that the angle alpha (α) depends on the distance between electrode 308 and plane 321. The electronic control circuit may be arranged for providing voltages to the electrodes in dependence of said angle alpha (α), or in particular in dependence of $\sin(\alpha)$.

A line connecting an electrode and the centre of the through opening may define an angle with said plane. In the example of figure 3 is an angle beta (β) defined by the plane 321 and line 326 connecting electrode 304 and the 5 centre of the through opening 203. The electronic control circuit may be arranged for providing a voltage to an electrode in dependence of said angle beta (β). The voltage may be (directly) proportional to $\sin(\beta)$.

It may be the case that the voltages provided by 10 the electronic control circuit is a function of angle beta (β), or more particular the provided voltage is a function of the sinus of angle beta (β), such as:
 $V(\beta) = V_{max} \cdot \sin(\beta)$

Figure 4 shows a schematical overview of a part of 15 an embodiment of a manipulator according to the invention.

The electronic control circuit may be arranged for providing a voltage V to two electrodes from the first set, and preferably a voltage $-V$ to two electrodes from the second set. In the example of figure 3, voltage V309 may thus be identical to voltage V303. And voltage V313 may thus also be identical to voltage V319 and $V313 = - V309$. The 20 electronic control circuit may be arranged for providing a positive voltage V to the first electrode and a negative voltage $-V$ to the second electrode of a pair. In the example of figure 3, voltage V307 may thus be $V307 = - V315$.
 25

The electrodes 204 may comprise two electrodes arranged along the perimeter of the through opening and substantially on the plane 321 and the electronic control circuit may be arranged for providing a voltage to each of 30 said two electrodes, said voltage preferably being an offset voltage. The offset voltage may be substantially equal to 0 Volt. In the example of figure 3, electrodes 311 and 301 are arranged substantially on plane 321 and may be connected with the ground potential, providing a voltage of at least 35 substantially 0 volt, as is indicated by 402 in figure 4.

However, as explained below, the offset voltage may also be around - 1 kV with respect to the ground, when

the planar substrate 202 is part of an Einzel lens. The voltages of the electrodes 204 may be defined with respect to the offset voltage. In that case, when V306 is said to be 20 volt and the offset voltage is - 1 kV, it indicates a 5 voltage $V306 = - 1020$ volt with respect to the ground.

In figure 4, the electrical field lines of the electrical field generated by the electrodes 204 have been indicated by arrows 401. Because the voltages may be provided to the electrodes 204 as described above, the 10 electrical field may substantially homogeneous. Because the electrical field is substantially homogeneous across the through opening, the manipulation of the charged particles that passes through the through opening will take place regardless the position of the charged particles in the 15 through opening. This improves the accuracy of the manipulation of the beamlets.

However, the through opening 203 may be a circle (as is depicted in the figures), but may also have an ellipse shape or any other shape, for example because of 20 errors in the production process. In that case, the voltages provided by the electronic control circuit may be adjusted to correct these errors in order to obtain a substantially homogeneous electrical field.

Furthermore, it may be the case that the beamlets 25 are not centrally projected on the manipulator or does not have a circular cross-sectional area (not indicated in the figures). In that case, the voltages provided by the electronic control circuit may be adjusted in order to correct theses errors.

30 In the example of figure 4, the electronic control circuit comprises a number of resistors 406 connected in series. The number of resistors may be equal to the number of electrodes. The resistance of these resistors may be selected in order to provide a voltage to each of said 35 electrodes which voltage changes around the through opening. The voltage of a particular electrode is a function of the position of the electrode around the through opening. Such a

function be may a sinus function.

An electrode, for example electrode 306, may be connected to a voltage $V_{306} = V_{max}$ via connection 403, while another electrode, for example electrode 316, may be connected to a voltage $V_{316} = -V_{max}$ via connection 404. The voltage V_{max} may be in the range of 1-50 or in the range of 5-25, or about 20 Volt.

Electrodes 301 and 311 may be provided with the same voltage. They may be grounded or provided with a voltage $V_{310} = V_{311} = 0$ Volt. In this way, four voltage dividers have been arranged for dividing voltages V_{max} and $-V_{max}$ into respective voltages.

This yields a relatively simple electronic control circuit, which may be easily provided around each through opening 203, for example in the planar substrate 202 of the manipulator device 201 of figure 2. The electronic control circuit may be provided on the non-beam area 208 of the planar substrate 202 or may be provided around the through opening 203 in the beam-area 207.

It may be understood that the voltages provided to the electrodes of one through opening may also be provided to the electrodes of another through opening, preferably by the same electronic control circuit.

Between adjacent electrodes 204 gaps 407 may be provided. The perimeter of the through opening may thus be covered by electrodes 204 and gaps 407. An electrode-to-gap ratio may be defined as a first area of the perimeter covered by the electrodes divided by a second area of the perimeter covered by the gaps. The electrode-to-gap ratio may be considered as a measure for the distance between adjacent electrodes. When the distance between adjacent electrodes is small, a more homogeneous electrical field may be provided, but any cross-over between the adjacent electrodes is also more likely. An optimal balance has been found at an electrode-to-gap ratio in the range of 5-15, or preferably substantially 10.

In order to (further) minimize the cross-talk

between an electrode and other circuits in the vicinity of the electrode, or between electrodes provided around one or more through openings, the manipulator device may be provided with a cross-talk shield 602 (not shown in figure 4, but in figure 6A). The cross-talk shield may comprise a planar shield substrate comprising an array of through openings in the plane of the planer shield substrate, wherein the through openings of the planer shield substrate are arranged in alignment with the through openings of the planar substrate.

The cross-talk shield provides an electrical shielding of electrodes 204 against electro(magnetic) fields of any other circuitry in the vicinity of the electrodes. It appears that the shielding is at its optimum when a distance between the planar substrate and the planar shield substrate is smaller than 10 micrometer and/or a thickness of the shield planar substrate is about a diameter of the through openings of the planar substrate.

Figure 5A and figure 5B show a schematical overview of two examples of an electronic control circuit for use in a manipulator device according to the invention. In figure 5A, the electronic control circuit comprises a first operational amplifier 501 and a second operational amplifier 502. Each operational amplifier may be grounded and may be connected to a DAC (digital-to-analogue) converter, indicated by 505 and 504 respectively. Each DAC converter may be controlled via a serial/parallel+ bus interface (SPI), indicated by 508 and 509 respectively.

The DAC converter 504 connected to the first operational amplifier 501 may provide a positive voltage Vmax and the DAC converter 505 connected to the second operational amplifier 502 may provide a negative voltage -Vmax. Both operational amplifiers may comprise resistors 503 as a feedback resistor. In that case, the amplified voltages Vmax and -Vmax may be divided into voltage parts. Each of these voltages (or voltage parts) may be fed to the electrodes 204 of a through opening 203 as indicated by

arrows 506 and 507.

It may be understood that each voltage provided by the first or second operational amplifier may be fed to two electrodes among the electrodes 204. In this way, fewer resistors may be required in comparison with the example of figure 4. Furthermore, each voltage may also be fed to two electrodes of another through opening of the manipulation device. This would further reduce the number of resistors required.

In the embodiment of figure 5B, the two operational amplifiers 501 and 502 are connected to a single DAC converter 511. The first amplifier 501 is directly connected to the DAC converter 511 to receive a control signal from the DAC converter 511. The second operational amplifier 502 is connected to the DAC converter 511 via a polarity inverter 512 to receive the same control signal from the DAC converter 511 but with an inverted polarity. The DAC converter 511 may be controlled via a serial/parallel bus interface (SPI), indicated by 510.

It may be understood that the electronic control circuits of figure 5A and 5B are relatively simple with few elements. Therefore, they can be easily integrated with the planar substrate of the manipulator device. At least a part of the circuitry of the figure 5A and 5B, for example the operational amplifiers and the resistors, may be provided in the non-beam area 208 of the manipulator device.

Figure 6A shows a schematical overview of a part of an embodiment 603 of a charged particle system according to the invention. The system may be provided with a first manipulator device 202 according to one of the embodiments described above and with a second manipulator device 601 also according to one of the embodiments described above.

The first manipulator device 202 may be arranged for deflecting one or more charged particle beams in an x-direction and the second manipulator device 601 may be arranged for deflecting one or more charged particle beams in a y-direction, wherein the x-direction is perpendicular

to the y-direction. Both x-direction and y-direction may be perpendicular to the direction of the beam, indicated by arrow 607, which may be parallel with the optical axis of the optical column or parallel with the central axis of the through opening.

A first planar lens substrate 604 and a second planar lens substrate 605 may be arranged on opposite sides of the manipulator devices 202 and 601. Each planar lens substrate may comprise at least one planar lens aperture or an array of planar lens apertures, wherein the planar lens apertures are arranged in alignment with the through openings of the planar substrate of the manipulator(s).

The first planar lens substrate and the second planar lens substrate may form together with the manipulator device(s) a lens, e.g. an Einzel lens for focusing one or more beams. A voltage difference may be applied between the first planar lens substrate 604 and the first manipulator device 202, and another voltage difference may be applied between the second manipulator device 601 and the second planar lens substrate 605, in such way that a positive lens effect is generated. In this way, the manipulator device(s) is/are part of the lens or lens arrangement and a more compact device may be obtained.

In an embodiment, the first planar lens substrate 604 and the second planar lens substrate 605 are grounded while the manipulator device(s) are provided with an off-set voltage of, for example, -1 kilovolt.

A planar current limiter substrate 606 may be provided, which may comprising at least one current limiter aperture or an array of current limiter apertures, wherein the current limiter planar substrate is arranged above the first planar lens substrate, wherein the current limiter aperture is arranged in alignment with the through opening of the planar substrate of the manipulator(s).

Cooling tubes 608 (or a cooling system) for cooling one or more planar substrates may further be provided. The cooling system may comprise the cooling tubes

608 adjacent to the through openings and a pump for pumping a cooling fluid (such as water) through the cooling tubes.

A cooling tube 608 may be arranged between the first and the second manipulator device, preferably in a circle around the central axis of the through openings.

As can be seen in figure 6A, the cross-sectional area of beam 115 on the planar current limiter substrate 606 is larger than the respective current limiter aperture. Some of the charged particles in the beam 115 may therefore be absorbed by the planar current limiter substrate 606.

Using the above-mentioned positive lens, the remaining beam may be deflected. In figure 6A this is illustrated by a beam axis 620 that changes its direction. The beam 115 passes through the through openings of the manipulator device(s) without hitting or contacting the planar substrates thereof.

In an embodiment, the beam may be deflected in the x- and y-direction by first manipulator device 202 and the second manipulator device 601, during the exposure of the target.

Both manipulator devices 202 and 601 may be provided with respective cross-talk shield 602 and 609. The cross-talk shields may provide an electrical shielding of the circuits of the manipulator devices against any electro(magnetic) fields of any other circuitry in the vicinity.

Figure 6B shows a schematic overview of a part of another embodiment of a charged particle system according to the invention. The system may comprise a charged particle source 101 and collimation means 102 for collimating the charged particle beam 111. The collimated beam 111 may impinge on an aperture array 104, which blocks part of the collimated beam 111 for creating a sub-beam 112.

A deflector 610 may be provided for deflecting the sub-beam 112. In an embodiment, the deflector 610 may also comprise a manipulator device according to the invention. As in the embodiment of figure 6A, in figure 6B, a planar

current limiter substrate 606 is provided and a first planar lens substrate 604 and a second planar lens substrate 605 are arranged on opposite sides of the manipulator devices 202 and 601. Their working has been described with reference 5 to figure 6A.

The manipulated sub-beam 112 may then pass through aperture 611, by which the beamlets 115 are generated. Two deflectors 612 and 613 may be provided for deflecting the beamlets (or a group of beamlets) in an x- and a y-direction 10 respectively. Some beamlets may be deflected by blanking deflectors (not shown separately in figure 6B) such that they do not pass through the beam stop substrate 614.

The beamlets that do pass through the beam substrate 614 are focused or projected by projection lens system 109 on target 110. Target 110 may be wafer and may be placed on a moveable platform 615, which may be movable in the x- and y- direction with respect to the projection lens system 109.

The system of figure 6B may further be provided 20 with cooling tubes (or a cooling system) for cooling one or more planar substrates. The cooling system may comprise the cooling tubes 608 and a pump for pumping a cooling fluid (such as water) through the tubes.

Figure 7 shows a schematic overview of a part of 25 an embodiment of a manipulator according to the invention. In figure 7 half of a through opening 203 is shown with only three electrodes 204 and only two gaps 407 for clarity reasons. The through opening may be provided with more electrodes as is described above.

The electrodes 204 may be produced as a chip and 30 one or more metal layers may be used for supplying the voltages to the electrodes. In the example of figure 7, six metal layers 701, 702, 703, 704, 705, 706 are depicted. Between the metal layers, electrically insulating layers have been provided. Connections between the metal layers may 35 be provided by one or more vias 708.

The electrodes may be provided partly in and on

the planar substrate. Together with the metal layers the vias 708 may form pillars 709 that extend in the inner surface of through opening 203. In this way, the electrical field is not only generated in one plane, for example in the plane of metal layer 706, but in a larger portion of the through opening. The charged particles of the beam passing through will thus be affected longer (and thus more) by the electrical field when the charged particles pass through the through opening 203.

The electrodes 204 are preferably made from molybdenum, however they may also be made from other conducting materials. The electrodes 204 may be approximately 5 micrometers thick, and the electrodes may be made by anisotropic etching of the molybdenum using reactive ion etching.

The electrodes 204 arranged in a first set of multiple first electrodes and in a second set of multiple second electrodes and the electronic control circuit may form a single CMOS device.

According to an aspect of the invention a charged particle system, such as a multi beam lithography system, is provided, comprising:

- a first manipulator device 202 arranged for deflecting one or more charged particle beams 112 in an x-direction, the first manipulator device comprising a planar substrate 202 comprising at least one through opening 203 in the plane of the planar substrate 202, wherein each through opening 203 is arranged for passing at least one charged particle beam 112 there through; and,

- a second manipulator device 601 arranged for deflecting said one or more charged particle beams 112 in an y-direction, wherein the x-direction is perpendicular to the y-direction, the second manipulator device comprising a planar substrate 202 comprising at least one through opening 203 in the plane of the planar substrate 202, wherein each through opening 203 is arranged for passing at least one charged particle beam there through, wherein the second

manipulator 601 device is arranged parallel with and adjacent to the first manipulator device 202 and the at least one through opening of the second manipulator device is arranged in alignment with the at least one through opening of the first manipulator device,

In an embodiment, the system further comprises cooling tubes 608 arranged for transport a cooling fluid, wherein the cooling tubes 608 are arranged between the first and the second manipulator device.

Both the first and the second manipulator device may deform due to thermal expansion. When the cooling tubes are arranged between the first and the second manipulator device, the manipulator devices will expand symmetrically. This may prevent the manipulator devices from bending.

In an embodiment, the system further comprises an electronic control circuit arranged for providing different voltages to at least two first electrodes of the first set of multiple first electrodes.

In an embodiment, the first and the second manipulator device each form a single CMOS device.

It may be understood that the embodiments of a manipulator, of the first and/or second manipulator and/or the electronic control circuit as described above are also applicable to this charged particle system.

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.

In summary, the invention relates to a charged particle system such as a multi beam lithography system, comprising a manipulator device for manipulation of one or more charged particle beams, wherein the manipulator device comprises at least one through opening in the plane of the planar substrate for passing at least one charged

particle beam there through. Each through opening is provided with electrodes arranged in a first set of multiple first electrodes along a first part of a perimeter of said through opening and in a second set of 5 multiple second electrodes along a second part of said perimeter. An electronic control circuit is arranged for providing voltage differences the electrodes in dependence of a position of the first and second electrode along the perimeter of the through opening.

CONCLUSIES

5

1. Geladen-deeltjessysteem zoals een multibundellithografiesysteem, omvattende een manipulatorinrichting voor het manipuleren van een of meer geladen-deeltjesbundels, waarbij de manipulatorinrichting omvat:

- een vlak substraat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat, waarbij elke doorgaande opening ingericht is voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel en waarbij elke doorgaande opening voorzien is van elektroden die aangebracht zijn in een eerste set van meerdere eerste elektroden langs een eerste deel van een omtrek van de doorgaande opening en in een tweede set van meerdere tweede elektroden langs een tweede deel van de omtrek; en,

- een elektronische besturingsschakeling, die ingericht is voor het verschaffen van spanningsverschillen aan paren van een eerste elektrode en een tweede elektrode in afhankelijkheid van een positie van de eerste en tweede elektrode langs de omtrek van de doorgaande opening.

2. Geladen-deeltjessysteem volgens conclusie 1, waarbij de paren elk bestaan uit een eerste elektrode uit de eerste set en een tweede elektrode uit de tweede set.

30

3. Geladen-deeltjessysteem volgens conclusie 1 of 2, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van de spanningsverschillen om een elektrisch veld te verschaffen dat in hoofdzaak homogeen over de doorgaande opening is.

4. Geladen-deeltjessysteem volgens een van conclusies 1-3, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van de spanningsverschillen aan de paren in afhankelijkheid van een afstand
5 tussen een eerste elektrode en een tweede elektrode van het respectieve paar, waarbij de spanningsverschillen bij voorkeur direct proportioneel zijn met de afstand.

5. Geladen-deeltjessysteem volgens een van conclusies 1-4, waarbij een vlak gedefinieerd is tussen het eerste deel van de omtrek en het tweede deel van de omtrek, een lijn gedefinieerd is tussen een elektrode en een diametraal tegenoverliggende andere elektrode en een hoek alfa (α) gedefinieerd is door het vlak en de lijn, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van spanningsverschillen aan de elektrode en de andere elektrode in afhankelijkheid van de hoek alfa (α), waarbij de spanningsverschillen bij voorkeur direct proportioneel zijn met $\sin(\alpha)$.

20

6. Geladen-deeltjessysteem volgens een van conclusies 1-5, waarbij een vlak gedefinieerd is tussen het eerste deel van de omtrek en het tweede deel van de omtrek, een lijn gedefinieerd is tussen een respectieve elektrode en een middelpunt van de doorgaande opening, en een hoek bëta (β) gedefinieerd is door het vlak en de lijn, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van spanningen aan respectieve elektroden in afhankelijkheid van de hoek bëta (β), waarbij de spanningen bij voorkeur direct proportioneel zijn met $\sin(\beta)$.

7. Geladen-deeltjessysteem volgens een van conclusies 1-6, waarbij de elektroden uniform langs de omtrek verdeeld zijn.

35

8. Geladen-deeltjessysteem volgens een van conclusies 1-7, waarbij een vlak gedefinieerd is tussen het eer-

ste deel van de omtrek en het tweede deel van de omtrek en de elektroden in hoofdzaak symmetrisch met de betrekking tot het vlak aangebracht zijn.

5 9. Geladen-deeltjessysteem volgens conclusie 8, waarbij de elektrisch veldlijnen van het elektrische veld ten minste loodrecht met betrekking tot het vlak aangebracht zijn.

10 10. Geladen-deeltjessysteem volgens conclusie 8 of 9, waarbij het vlak een centrale as van de doorgaande opening omvat.

15 11. Geladen-deeltjessysteem volgens een van conclusies 1-10, waarbij een vlak gedefinieerd tussen het eerste deel van de omtrek en het tweede deel van de omtrek en de eerste elektrode van het paar tegenover de tweede elektrode van het paar met betrekking tot het vlak geplaatst is.

20 12. Geladen-deeltjessysteem volgens conclusie 11, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van een positieve spanning V aan de eerste elektrode en een negatieve spanning $-V$ aan de tweede elektrode.

25 13. Geladen-deeltjessysteem volgens een van conclusies 1-12, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van een positieve spanning V aan twee eerste elektroden en een negatieve spanning $-V$ aan twee tweede elektroden.

30 14. Geladen-deeltjessysteem volgens een van conclusies 1-12, waarbij de manipulatorinrichting verder twee elektroden omvat, die langs de omtrek van de doorgaande opening en in hoofdzaak op het vlak aangebracht zijn, waarbij de elektronische besturingsschakeling ingericht is voor het verschaffen van een spanning aan elk van de twee

elektroden, waarbij de ene spanning bij voorkeur een off-setspanning is en bij voorkeur in hoofdzaak gelijk aan 0 volt is.

5 15. Geladen-deeltjessysteem volgens een van conclusies 1-14, waarbij de elektronische besturingsschakeling weerstanden omvat, die aangebracht zijn als een spanningsdeler voor het verschaffen van spanningen aan respectieve elektroden, bij voorkeur als een terugkoppelweerstand van 10 een versterker.

15 16. Geladen-deeltjessysteem volgens een van conclusies 1-15, waarbij de elektronische besturingsschakeling een eerste versterker met een spanningsdeler als een terugkoppelingsweerstand omvat voor het verschaffen van spanningen aan de eerste elektroden, en een tweede versterker met een spanningsdeler als een terugkoppelingsweerstand omvat voor het verschaffen van spanningen aan de tweede elektroden.

20 17. Geladen-deeltjessysteem volgens conclusie 16, waarbij de elektronische besturingsschakeling verder een digitaal-naar-analoog omzetter omvat voor het uitvoeren van een enkel besturingssignaal naar de eerste en tweede versterker en een polariteitomkeringsinrichting omvat, die 25 ingericht is voor het omkeren van een polariteit van het besturingssignaal, waarbij de eerste versterker direct met de digitaal-naar-analoog omzetter verbonden is om het besturingssignaal te ontvangen en de tweede versterker via de polariteitomkeringsinrichting met de digitaal-naar-analoog omzetter verbonden is om een besturingssignaal met 30 omgekeerde polariteit te ontvangen.

35 18. Geladen-deeltjessysteem volgens een van conclusies 1-17, waarbij:

- openingen verschaft zijn tussen naastliggende elektroden langs de omtrek;

- de omtrek van de doorgaande opening uit een eerste gebied, dat met de elektroden voorzien is, en een tweede gebied, dat met de openingen voorzien is, bestaat;

- een elektrode-opening verhouding gedefinieerd is
5 door het eerste gebied gedeeld door het tweede gebied; en,
- de elektrode-opening verhouding in het bereik
van 5-15 ligt, of bij voorkeur in hoofdzaak 10 is.

19. Geladen-deeltjessysteem volgens een van conclusies 1-18, waarbij de manipulatorinrichting een overspraakafscherming omvat, waarbij de overspraakafscherming een vlak afschermingssubstraat omvat, dat ten minste een doorgaande opening in het vlak van het vlakke afschermingssubstraat omvat, waarbij de ten minste ene doorgaande
15 opening van het vlakke afschermingssubstraat uitgelijnd met de ten minste ene doorgaande opening van het vlakke substraat aangebracht is.

20. Geladen-deeltjessysteem volgens conclusie 19, waarbij een afstand tussen het vlakke substraat en het vlakke afschermingssubstraat kleiner is dan 10 micrometer, bij voorkeur kleiner is dan 5 micrometer, of ongeveer 3 micrometer is, en/of waarbij een dikte van het vlakke afschermingssubstraat ongeveer gelijk is aan een diameter
25 van de ten minste ene doorgaande opening van het vlakke substraat.

21. Geladen-deeltjessysteem volgens een van conclusies 1-20, verder omvattende:

- een eerste vlak lenssubstraat, dat ten minste een eerste-vlakke-lensopening omvat, waarbij de ten minste ene eerste-vlakke-lensopening uitgelijnd met de ten minste ene doorgaande opening van het vlakke substraat van de manipulatorinrichting aangebracht is en het eerste vlakke
35 lenssubstraat boven en parallel met het vlakke substraat van de manipulatorinrichting aangebracht is; en,

- een tweede vlak lenssubstraat, dat ten minste een tweede-vlakte-lensopening omvat, waarbij de ten minste ene tweede-vlakte-lensopening uitgelijnd met de ten minste ene doorgaande opening van het vlakte substraat van de manipulatorinrichting aangebracht is en het tweede vlakte lenssubstraat onder en parallel met het vlakte substraat van de manipulatorinrichting aangebracht is,

waarbij het systeem ingericht is voor het verschaffen van een spanningsverschil tussen het eerste vlakte lenssubstraat en het vlakte substraat van de manipulatorinrichting en tussen het vlakte substraat van de manipulatorinrichting en het tweede vlakte lenssubstraat voor het genereren van een Einzellens voor de bundels.

15 22. Geladen-deeltjessysteem volgens een van conclusies 1-21, verder omvattende een vlak stroombegrenzerssubstraat, dat ten minste een stroombegrenzersopening omvat, waarbij het vlakte stroombegrenzerssubstraat boven het vlakte substraat van de manipulatorinrichting aangebracht 20 is en de ten minste ene stroombegrenzersopening uitgelijnd met de ten minste ene doorgaande opening van het vlakte substraat van de manipulatorinrichting aangebracht is.

25 23. Geladen-deeltjessysteem volgens conclusie 22, waarbij de ten minste ene stroombegrenzersopening kleiner is dan de ten minste ene doorgaande opening van het vlakte substraat van de manipulatorinrichting.

30 24. Geladen-deeltjessysteem volgens een van de conclusies 1-23, waarbij:

- de manipulatorinrichting een eerste manipulatorinrichting is, die ingericht is voor het afbuigen van de een of meer geladen-deeltjesbundels in een x-richting;
- het geladen-deeltjessysteem verder een tweede manipulatorinrichting volgens een van conclusies 1-16 omvat, die ingericht is voor het afbuigen van de een of meer geladen-deeltjesbundels in een y-richting, waarbij de x-

richting loodrecht op de y-richting staat, waarbij de tweede manipulatorinrichting parallel met en naast de eerste manipulatorinrichting aangebracht is en de ten minste een doorgaande opening van de tweede manipulatorinrichting
5 uitgelijnd met de ten minste een doorgaande opening van de eerste manipulatorinrichting aangebracht is,

waarbij het systeem ingericht is voor het verschaffen van een spanningsverschil tussen het eerste vlakke lenssubstraat en het vlakke substraat van de eerste manipulatorinrichting en tussen het vlakke substraat van de tweede manipulatorinrichting en het tweede vlakke lenssubstraat voor het genereren van een Einzellens voor de bundels.

25. Geladen-deeltjessysteem volgens een van conclusies 21-24, waarbij het eerste en tweede vlakke lenssubstraat geaard zijn en het systeem ingericht is voor het verschaffen van een negatieve spanning aan het vlakke substraat van de manipulatorinrichting(en), waarbij de negatieve spanning bij voorkeur in het bereik van -1500 volt tot -500 volt ligt, of bij voorkeur ongeveer -1000 volt is.

26. Manipulatorinrichting voor het manipuleren van een geladen-deeltjesbundel in een geladen-deeltjessysteem zoals een multibundel lithografiesysteem, volgens een van conclusies 1-25.

27. Geladen-deeltjessysteem zoals multibundel lithografiesysteem, omvattende:

30 - een manipulatorinrichting voor het manipuleren van een of meer geladen-deeltjesbundels, omvattende een vlak substraat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat, waarbij elke opening ingericht is voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel;

35 - een eerste vlak lenssubstraat, dat ten minste een eerste-vlakke-lensopening omvat, waarbij de ten minste

ene eerste-vlakke-lensopening uitgelijnd met de ten minste
ene doorgaande opening van het vlakke substraat van de ma-
nipulatorinrichting aangebracht is en het eerste vlakke
lenssubstraat boven en parallel met het vlakke substraat
5 van de manipulatorinrichting aangebracht is; en,

- een tweede vlak lenssubstraat, dat ten minste
een tweede-vlakke-lensopening omvat, waarbij de ten minste
ene tweede-vlakke-lensopening uitgelijnd met de ten minste
ene doorgaande opening van het vlakke substraat van de ma-
nipulatorinrichting aangebracht is en het tweede vlakke
lenssubstraat onder en parallel met het vlakke substraat
10 van de manipulatorinrichting aangebracht is,

waarbij het systeem ingericht is voor het verschaffen
van een spanningsverschil tussen het eerste vlakke lens-
15 substraat en het vlakke substraat van de manipulatorin-
richting en tussen het vlakke substraat van de manipula-
torinrichting en het tweede vlakke lenssubstraat voor het
genereren van een Einzellens voor de bundels.

20 28. Geladen-deeltjessysteem volgens conclusie 27,
verder omvattende een vlak stroombegrenzerssubstraat, dat
ten minste een stroombegrenzersopening omvat, waarbij het
vlakke stroombegrenzerssubstraat boven het vlakke sub-
straat van de manipulatorinrichting aangebracht is en de
25 ten minste een stroombegrenzersopening uitgelijnd met de
ten minste een doorgaande opening van het vlakke substraat
van de manipulatorinrichting aangebracht is.

29. Geladen-deeltjessysteem volgens conclusie 28,
30 waarbij de ten minste een stroombegrenzersopening kleiner
is dan de ten minste een doorgaande opening van het vlakke
substraat van de manipulatorinrichting.

30. Geladen-deeltjessysteem volgens een van conclu-
35 sies 28-29, verder omvattende koelbuizen voor het trans-
porteren van een koelfluidum, waarbij de koelbuizen rond

de ten minste ene stroombegrenzersopening aangebracht zijn.

31. Geladen-deeltjessysteem volgens een van conclusies 28-30, waarbij:

- de manipulatorinrichting een eerste manipulatorinrichting is, die ingericht is voor het afbuigen van de een of meer geladen-deeltjesbundels in een x-richting;

- het geladen-deeltjessysteem verder een tweede manipulatorinrichting omvat, die ingericht is voor het af-

buigen van de een of meer geladen-deeltjesbundels in een y-richting, waarbij de x-richting loodrecht op de y-richting staat, waarbij de tweede manipulatorinrichting een vlak substraat omvat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat, waar-

bij elke doorgaande opening ingericht is voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel, waarbij de tweede manipulatorinrichting parallel met en naast de eerste manipulatorinrichting aangebracht is en de

ten minste ene doorgaande opening van de tweede manipulatorinrichting uitgelijnd met de ten minste ene doorgaande opening van de eerste manipulatorinrichting aangebracht is,

waarbij het systeem ingericht is voor het verschaffen van een spanningsverschil tussen het eerste vlakke lens-

substraat en het vlakke substraat van de eerste manipulatorinrichting en tussen het vlakke substraat van de tweede manipulatorinrichting en het tweede vlakke lenssubstraat voor het genereren van een Einzellens voor de bundels.

32. Geladen-deeltjessysteem volgens een van conclusies 27-31, waarbij het eerste en tweede vlakke lenssub-

straat geaard zijn en het systeem ingericht is voor het verschaffen van een negatieve spanning aan het vlakke substraat van de manipulatorinrichting(en), waarbij de negatieve spanning bij voorkeur in het bereik van -1500 volt

tot -500 volt ligt, of bij voorkeur ongeveer -1000 volt is.

33. Geladen-deeltjessysteem volgens een van conclusies 27-32, verder omvattende koelbuizen voor het transporteren van een koelfluidum, waarbij de koelbuizen tussen de eerste en de tweede manipulatorinrichting aangebracht zijn.

10 34. Geladen-deeltjessysteem volgens een van conclusies 1-29, waarbij de elektroden, die in een eerste set van meerdere eerste elektroden en in een tweede set van meerdere tweede elektroden aangebracht zijn, en de elektronische besturingsschakeling een enkele CMOS-inrichting 15 vormen.

35. Geladen-deeltjessysteem zoals een multibundel lithografiesysteem, omvattende:

- een eerste manipulatorinrichting, die ingericht 20 is voor het afbuigen van een of meer geladen-deeltjesbundels in een x-richting, waarbij de eerste manipulatorinrichting een vlak substraat omvat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat, waarbij elke doorgaande opening ingericht is 25 voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel;

- een tweede manipulatorinrichting, die ingericht 30 is voor het afbuigen van de een of meer geladen-deeltjesbundels in een y-richting, waarbij de x-richting loodrecht op de y-richting staat, waarbij de tweede manipulatorinrichting een vlak substraat omvat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat, waarbij elke doorgaande opening ingericht is 35 voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel, waarbij de tweede manipulatorinrichting parallel met en naast de eerste manipulatorinrichting aangebracht is en de ten minste ene doorgaande opening van de

tweede manipulatorinrichting uitgelijnd met de ten minste een doorgaande opening van de eerste manipulatorinrichting aangebracht is; en,

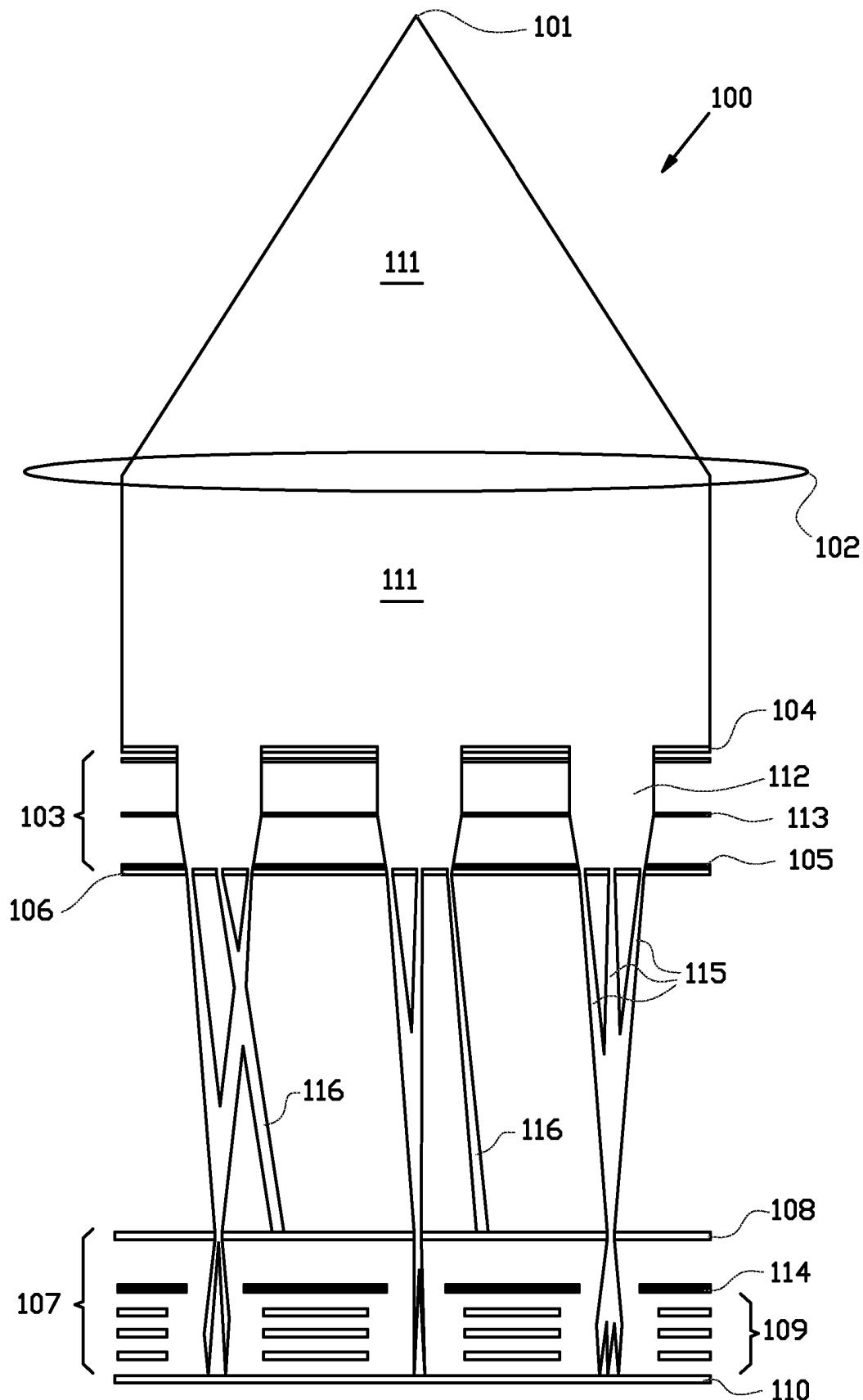
- koelbuizen, die ingericht zijn voor het trans-
- 5 porteren van een koelfluidum, waarbij de koelbuizen tussen de eerste en tweede manipulatorinrichting aangebracht zijn.

36. Geladen-deeltjessysteem zoals een multibundel
10 lithografiesysteem, omvattende een manipulatorinrichting voor het manipuleren van een of meer geladen-deeltjesbundels, waarbij de manipulatorinrichting omvat:

- een vlak substraat, dat ten minste een doorgaande opening in het vlak van het vlakke substraat omvat,
- 15 waarbij elke doorgaande opening ingericht is voor het daardoor laten gaan van ten minste een geladen-deeltjesbundel en elke doorgaande opening voorzien is van elektroden die aangebracht zijn in een eerste set van meerdere eerste elektroden langs een eerste deel van een 20 omtrek van de doorgaande opening en in tweede set van meerdere tweede elektroden langs een tweede deel van de omtrek; en,

- een elektronische besturingsschakeling, die ingericht is voor het verschaffen van verschillende spanningen aan ten minste twee eerste elektroden van de eerste set van meerdere eerste elektroden.

37. Geladen-deeltjessysteem volgens conclusie 37,
waarbij de elektronische besturingsschakeling ingericht is
30 voor het verschaffen van de verschillende spanningen om een elektrisch veld te verschaffen dat in hoofdzaak homogeen is over de doorgaande opening.



XY

FIG. 1

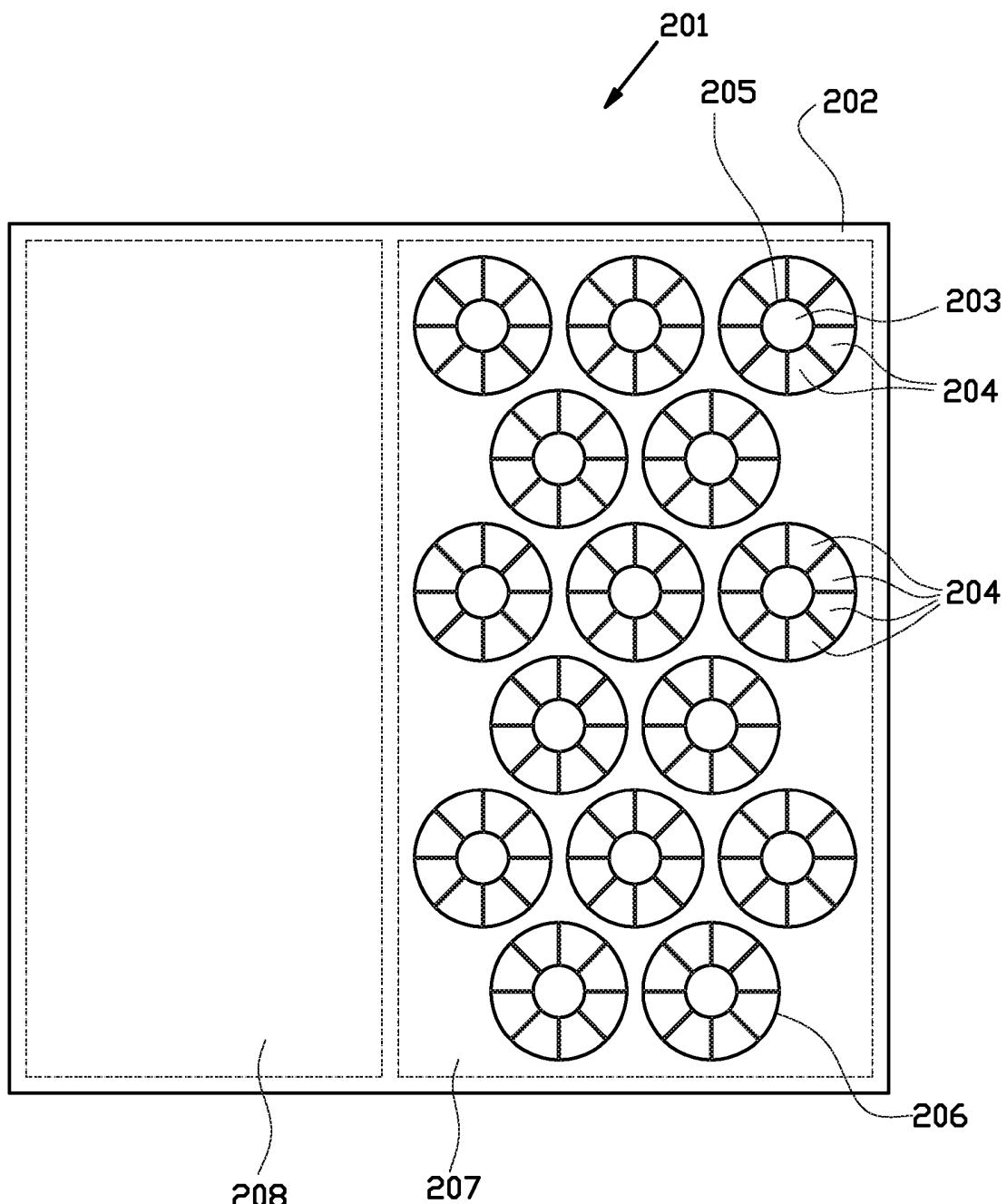


FIG. 2

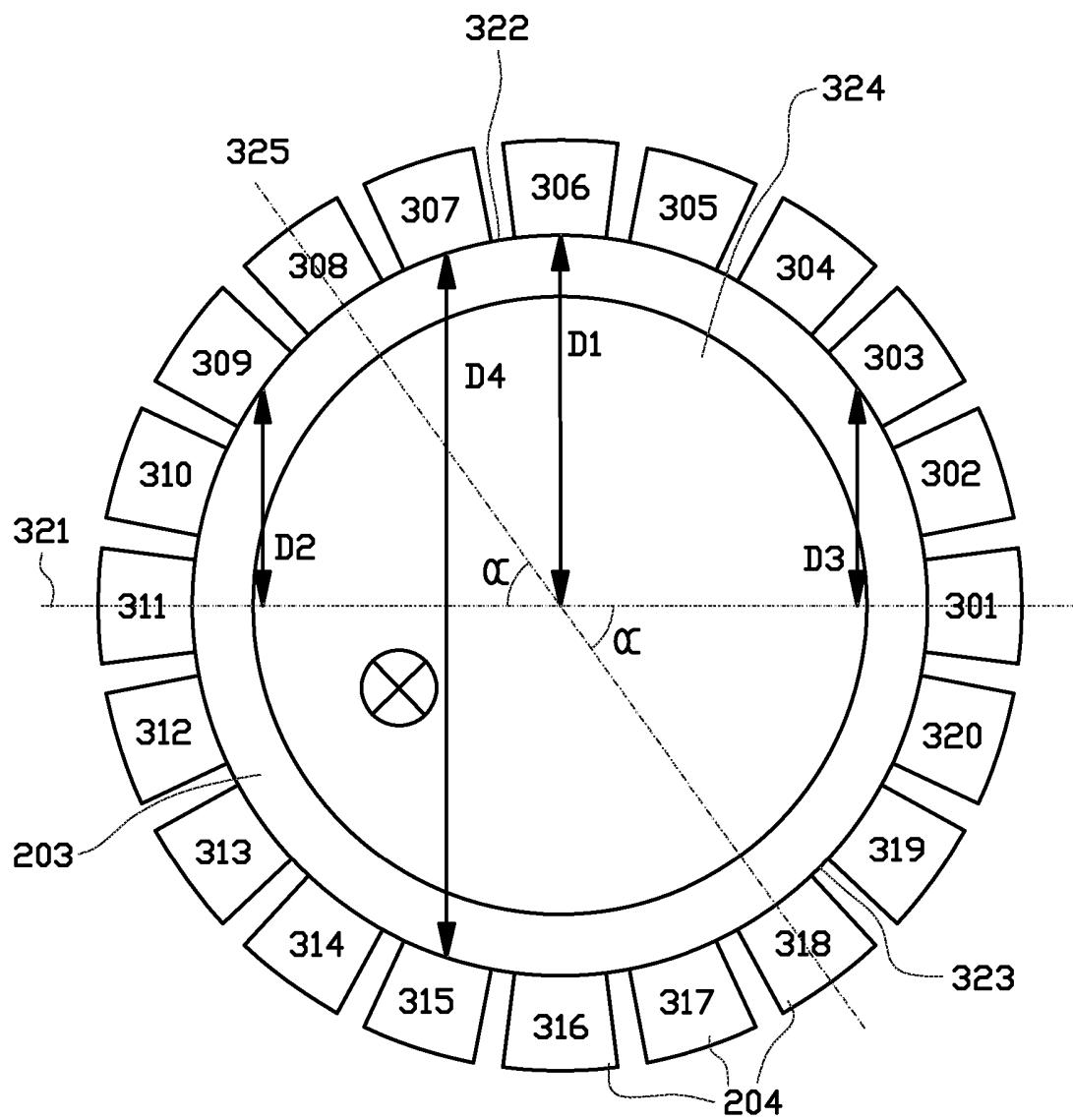


FIG. 3A

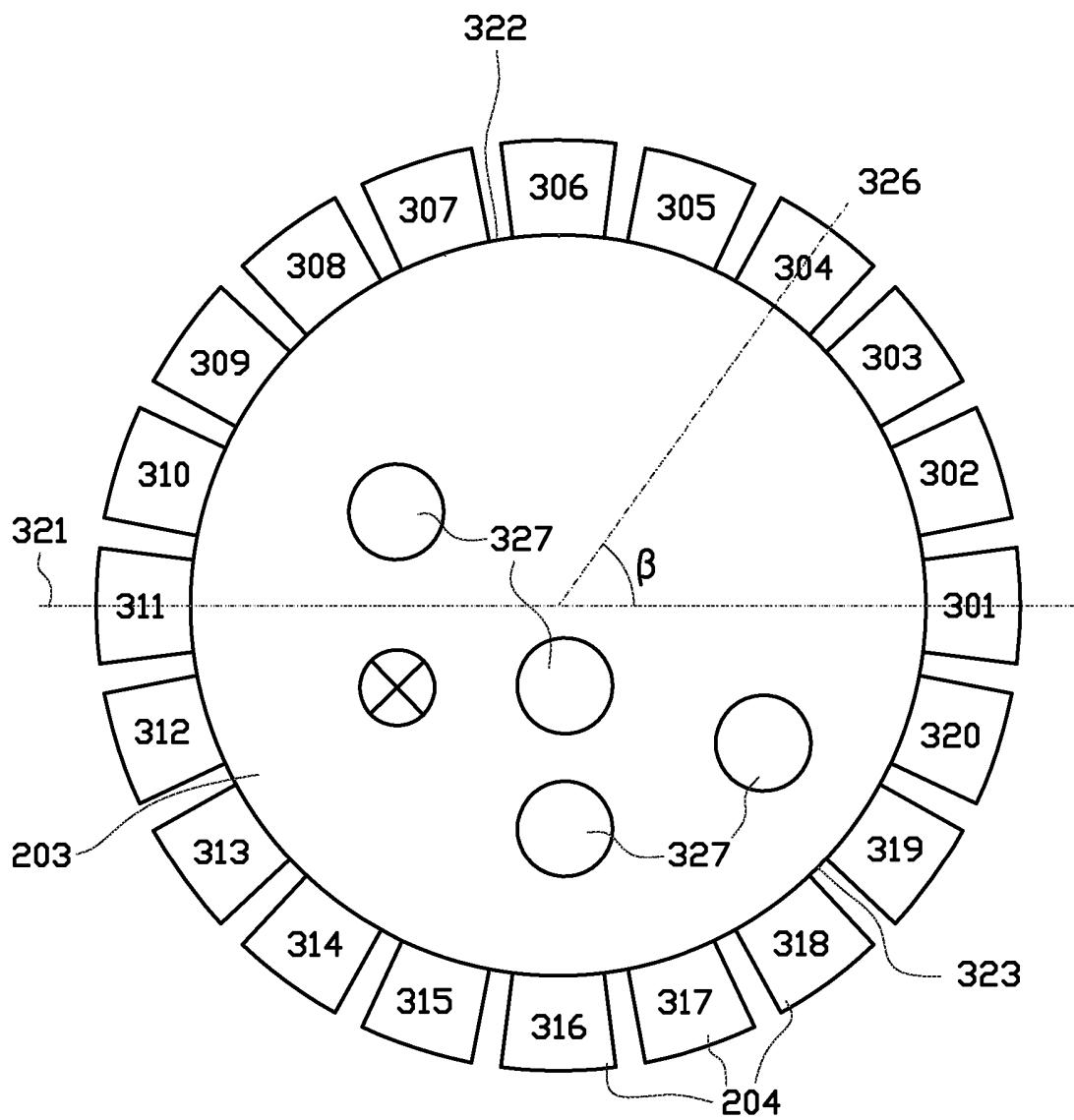


FIG. 3B

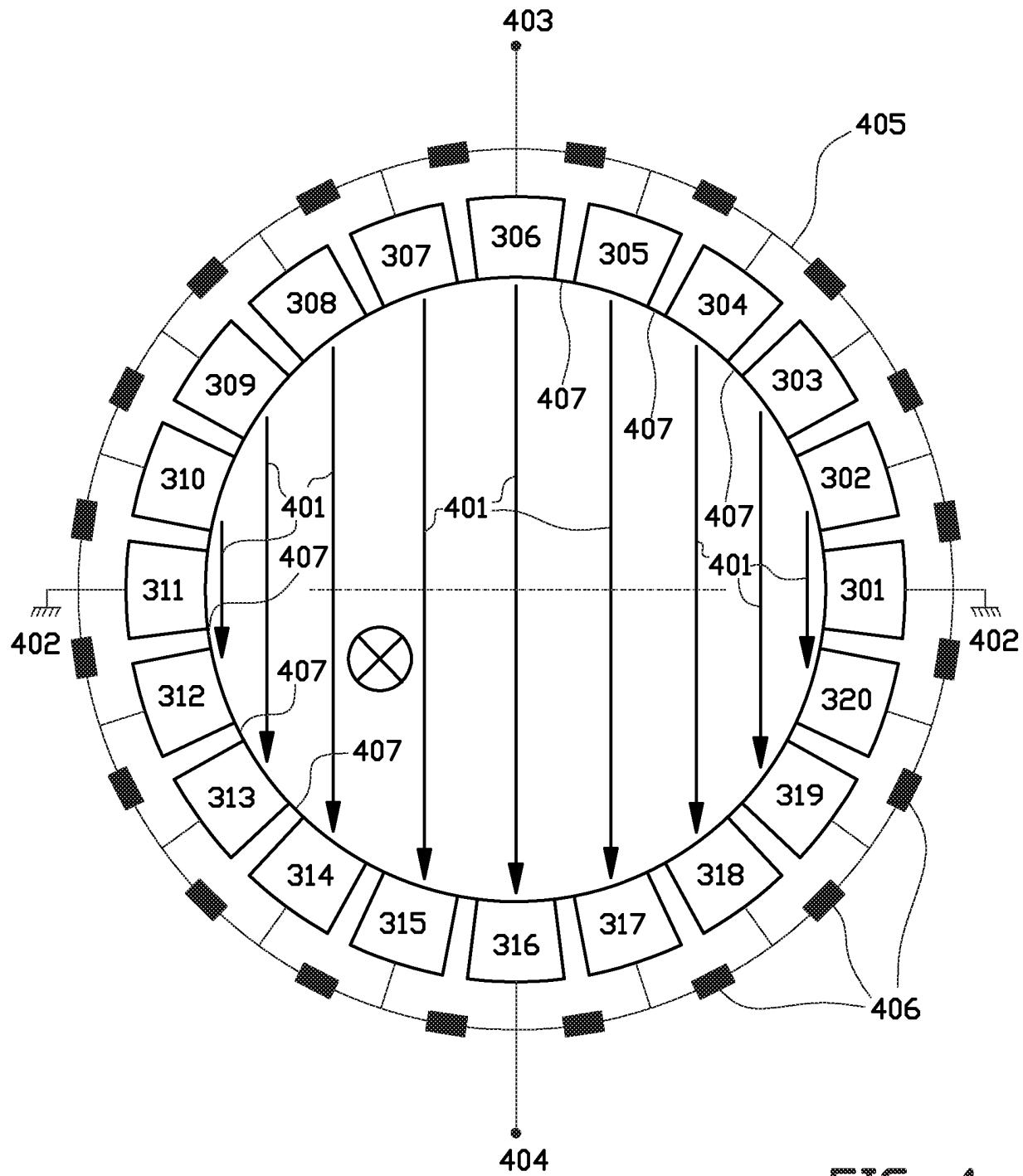


FIG. 4

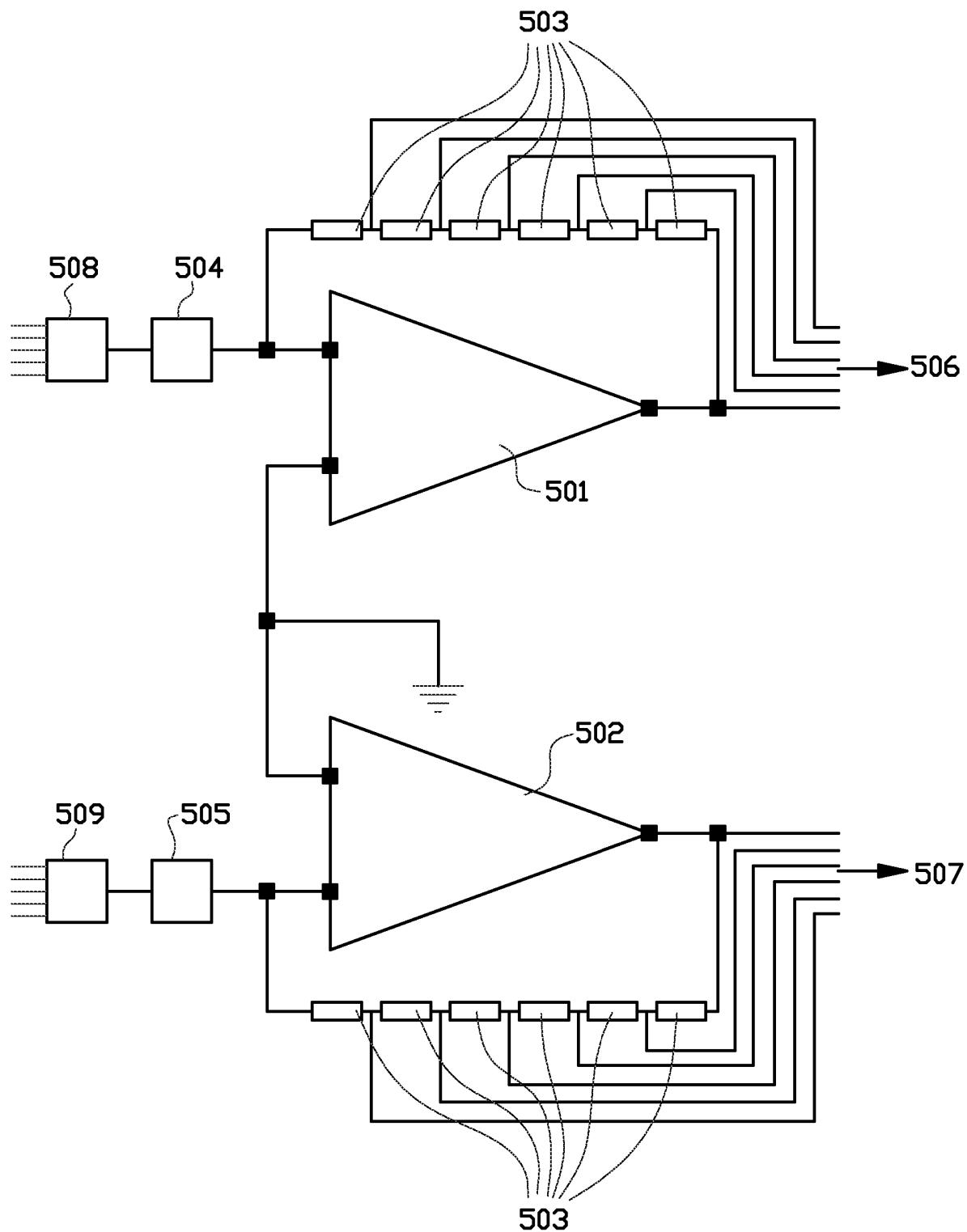


FIG. 5A

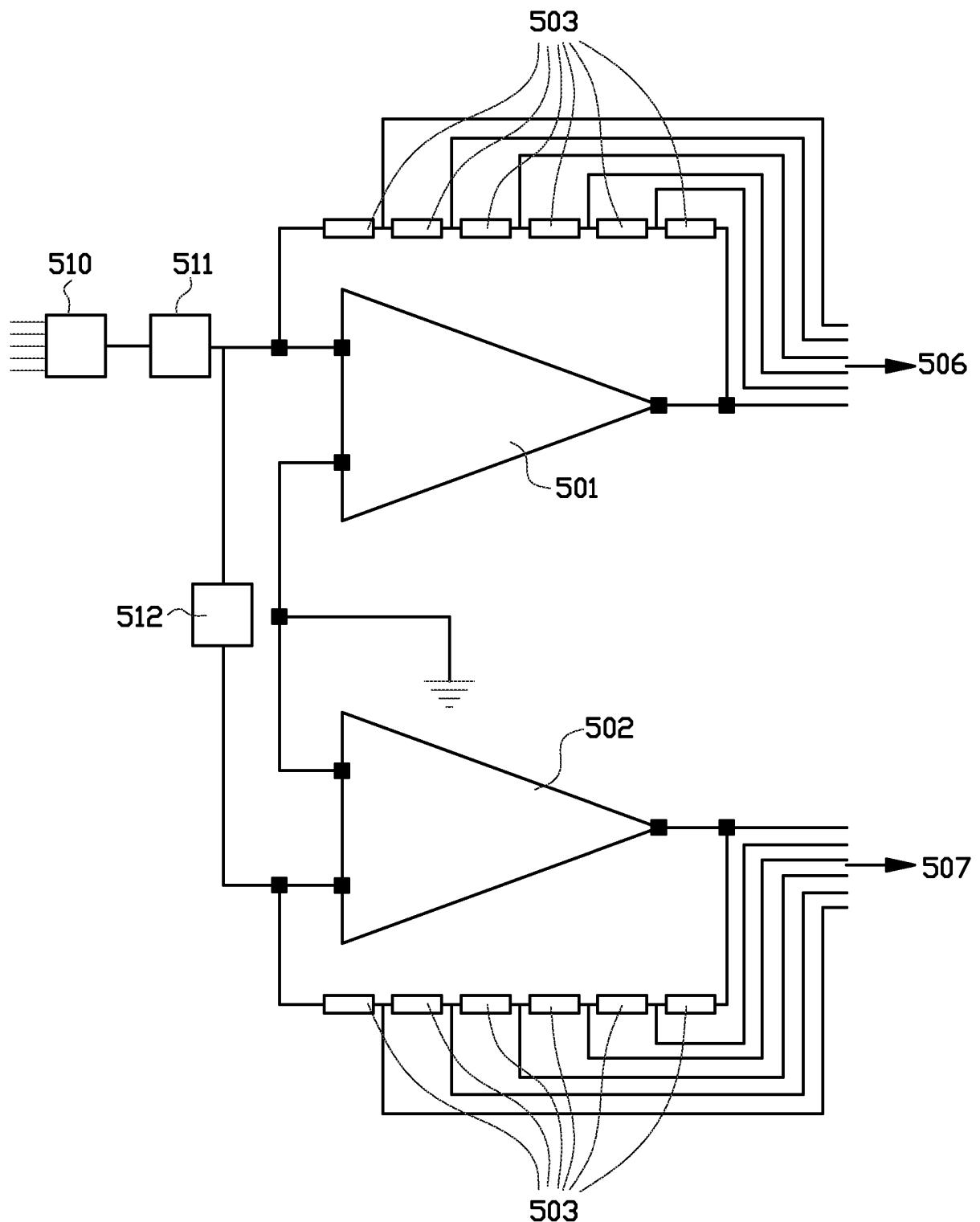


FIG. 5B

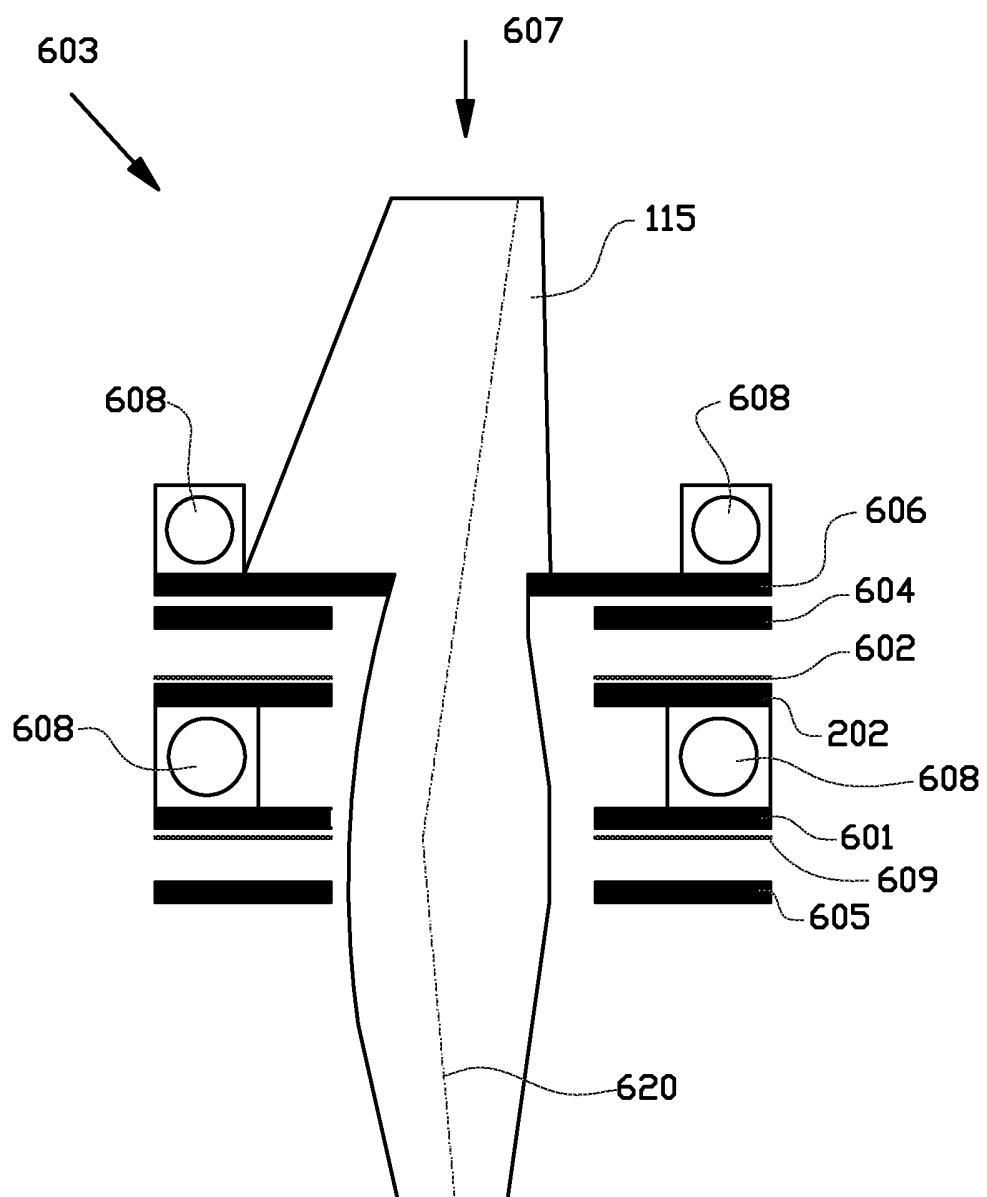


FIG. 6A

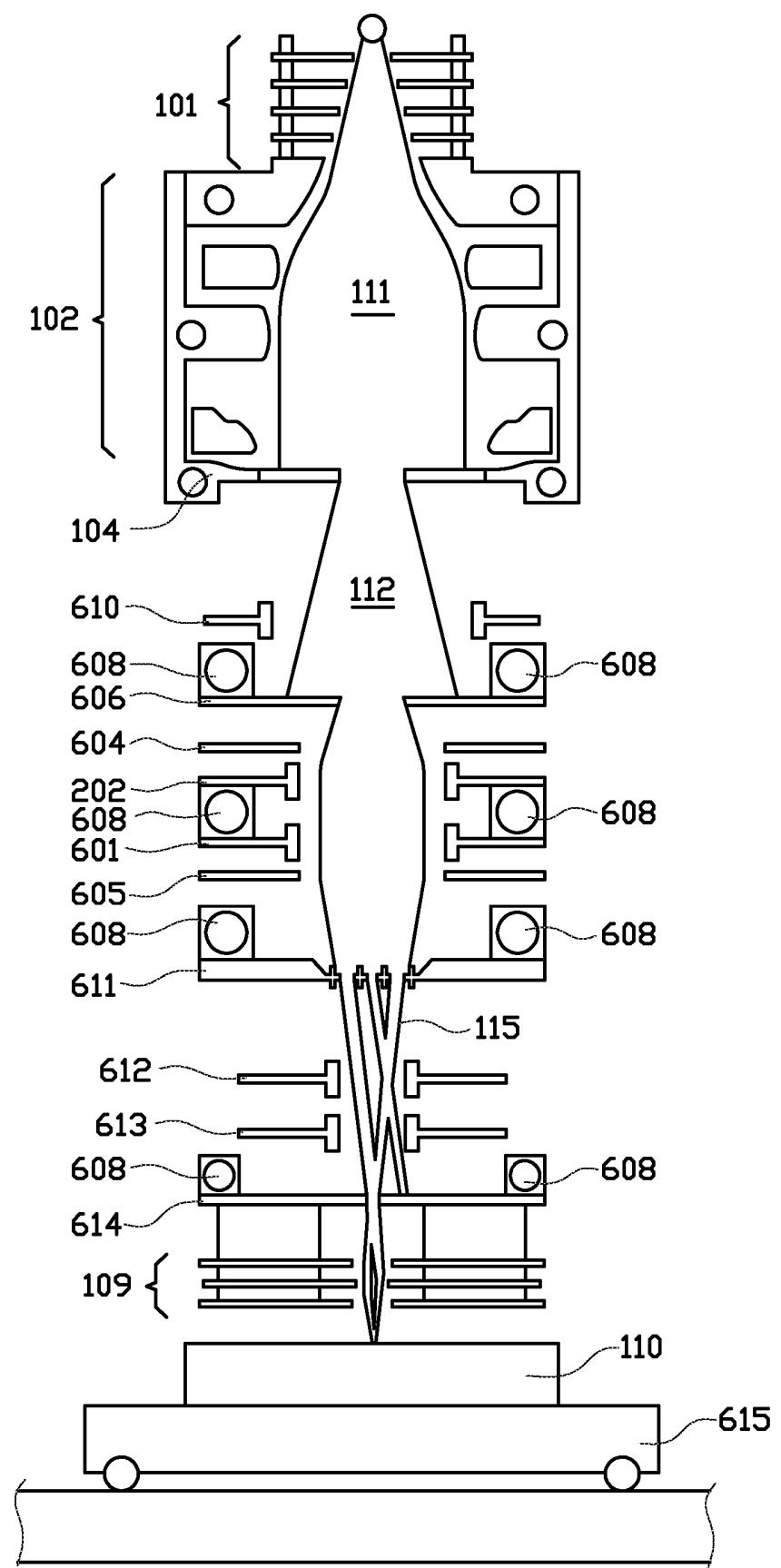


FIG. 6B

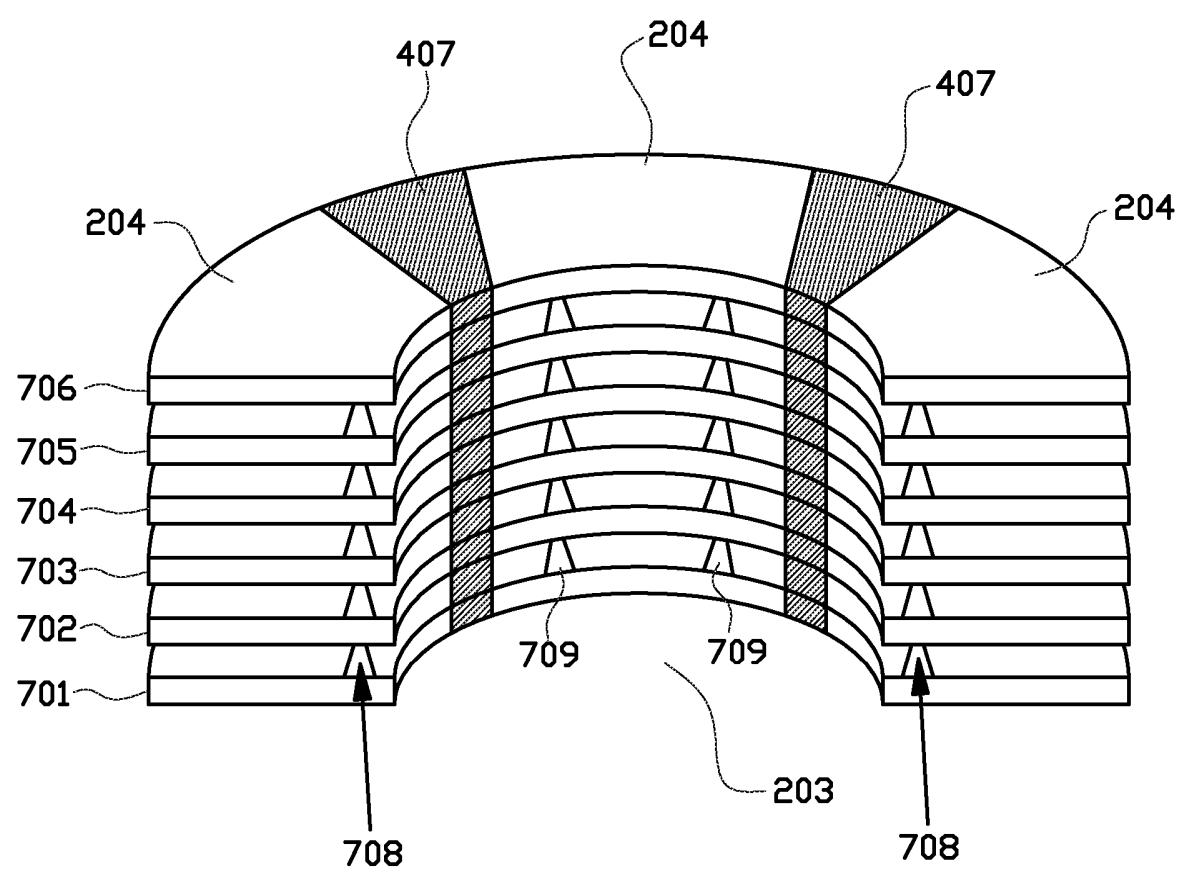


FIG. 7



Agentschap NL
Ministerie van Economische Zaken,
Landbouw en Innovatie

OCTROOIAANVRAAG NR.:
NO 137951
NL 2007604

ONDERZOEKSRAPPORT

BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK

RELEVANTE LITERATUUR			
Categorie ¹	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr:	Classificatie (IPC)
X	US 6 127 775 A (BERGEN RICHARD F [US]) 3 oktober 2000 (2000-10-03)	1-14,22, 33	INV. G21K1/087
Y	* kolom 4, regel 61 - kolom 5, regel 16;	15,30,31	H01J37/317
A	figuur 2 *	23-29,32	G03F7/20
	* kolom 6, regel 8 - regel 59; figuur 3 *		H01J29/46
	* kolom 9, regel 60 - kolom 10, regel 11; figuur 4 *		H01J37/09

X	US 5 617 129 A (CHIZUK JR JOSEPH A [US] ET AL) 1 april 1997 (1997-04-01)	1,33	
Y	* figuur 10 *	31	

X	US 2001/028046 A1 (HAMAGUCHI SHINICHI [JP] ET AL) 11 oktober 2001 (2001-10-11) * alinea [0115] - alinea [0118]; figuren 1,7A-C *	1,33	

X	EP 0 262 855 A2 (TRIALSITE LTD [GB]) 6 april 1988 (1988-04-06) * kolom 4, regel 48 - kolom 7, regel 4; figuren 1-4 *	1,33	

X	US 2003/209673 A1 (ONO HARUHITO [JP] ET AL) 13 november 2003 (2003-11-13) * alinea [0064] - alinea [0066]; figuren 11A-E *	23,28	G21K H01J
Y		15,24,	G03F
A		25,30	B41J
		16-21	G03G
		-/-	G06K
			G01N
Indien gewijzigde conclusies zijn ingediend, heeft dit rapport betrekking op de conclusies ingediend op:			
Plaats van onderzoek:	Datum waarop het onderzoek werd voltooid:	Bevoegd ambtenaar:	
München	7 september 2012	van Toledo, Wiebo	
¹ CATEGORIE VAN DE VERMELDE LITERATUUR			
2	X: de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur	T: na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding	
	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	E: eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven	D: in de octrooiaanvraag vermeld
	A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft	L: om andere redenen vermelde literatuur	
	O: niet-schriftelijke stand van de techniek	8: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie	
	P: tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur		

RELEVANTE LITERATUUR		
Categorie ¹	Literatuur met, voor zover nodig, aanduiding van speciaal van belang zijnde tekstgedeelten of figuren.	Van belang voor conclusie(s) nr:
Y	EP 2 019 415 A1 (IMS NANOFABRICATION AG [AT]) 28 januari 2009 (2009-01-28) * alinea [0051] - alinea [0059]; figuur 1 * * alinea [0063] - alinea [0078]; figuren 3,4a-c *	30,31
Y	US 2011/073782 A1 (WIELAND MARCO JAN-JACO [NL]) 31 maart 2011 (2011-03-31)	24,25
A	* alinea [0104] - alinea [0111]; figuur 5 *	18-21
A	----- US 2011/079731 A1 (KIM HO SEOB [KR]) 7 april 2011 (2011-04-07) * alinea [0004] - alinea [0011]; figuur 1 *	18-21,25
E	----- US 2012/145915 A1 (VAN VEEN ALEXANDER HENDRIK VINCENT [NL] ET AL) 14 juni 2012 (2012-06-14) * alinea [0063] *	32

2

¹ CATEGORIE VAN DE VERMELDE LITERATUUR

- 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
- A: niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
- 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 octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
- E: eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
- D: in de octrooiaanvraag vermeld
- L: om andere redenen vermelde literatuur
- &: lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

**AANHANGSEL BEHORENDE BIJ HET RAPPORT BETREFFENDE
HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK,
UITGEVOERD IN DE OCTROOIAANVRAGE NR.**

NO 137951
NL 2007604

Het aanhangsel bevat een opgave van elders gepubliceerde octrooiaanvragen of octrooien (zogenaamde leden van dezelfde octrooifamilie), die overeenkomen met octrooischriften genoemd in het rapport.

De opgave is samengesteld aan de hand van gegevens uit het computerbestand van het Europees Octrooibureau per
De juistheid en volledigheid van deze opgave wordt noch door het Europees Octrooibureau, noch door het Bureau voor de Industriële eigendom gegarandeerd; de gegevens worden verstrekt voor informatiedoeleinden.

07-09-2012

In het rapport genoemd octrooigeschrift		Datum van publicatie		Overeenkomend(e) geschrift(en)	Datum van publicatie
US 6127775	A	03-10-2000	JP US	2000057978 A 6127775 A	25-02-2000 03-10-2000
US 5617129	A	01-04-1997	JP JP US	3708186 B2 8207346 A 5617129 A	19-10-2005 13-08-1996 01-04-1997
US 2001028046	A1	11-10-2001	GEEN		
EP 0262855	A2	06-04-1988	EP GB JP US	0262855 A2 2196175 A 63211548 A 4839520 A	06-04-1988 20-04-1988 02-09-1988 13-06-1989
US 2003209673	A1	13-11-2003	JP JP US US US	4585661 B2 2001345259 A 6965153 B1 2003209673 A1 2005253082 A1	24-11-2010 14-12-2001 15-11-2005 13-11-2003 17-11-2005
EP 2019415	A1	28-01-2009	EP JP US	2019415 A1 2009032691 A 2009026389 A1	28-01-2009 12-02-2009 29-01-2009
US 2011073782	A1	31-03-2011	CN EP JP KR US WO	102113083 A 2297766 A1 2011523786 A 20110030537 A 2011073782 A1 2009147202 A1	29-06-2011 23-03-2011 18-08-2011 23-03-2011 31-03-2011 10-12-2009
US 2011079731	A1	07-04-2011	CN JP KR US WO	102047375 A 2011522373 A 20110014589 A 2011079731 A1 2009145556 A2	04-05-2011 28-07-2011 11-02-2011 07-04-2011 03-12-2009
US 2012145915	A1	14-06-2012	US WO	2012145915 A1 2012062854 A1	14-06-2012 18-05-2012



Agentschap NL
Ministerie van Economische Zaken,
Landbouw en Innovatie

SCHRIFTELIJKE OPINIE

DOSSIER NUMMER NO137951	INDIENINGSDATUM 14.10.2011	VOORRANGSDATUM	AANVRAAGNUMMER NL2007604
CLASSIFICATIE INV. G21K1/087 H01J37/317 G03F7/20 H01J29/46 H01J37/09			
AANVRAGER Mapper Lithography IP B.V.			

Deze schriftelijke opinie bevat een toelichting op de volgende onderdelen:

- Onderdeel I Basis van de schriftelijke opinie
- Onderdeel II Voorrang
- Onderdeel III Vaststelling nieuwheid, inventiviteit en industriële toepasbaarheid niet mogelijk
- Onderdeel IV De aanvraag heeft betrekking op meer dan één uitvinding
- Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid
- Onderdeel VI Andere geciteerde documenten
- Onderdeel VII Overige gebreken
- Onderdeel VIII Overige opmerkingen

DE BEVOEGDE AMBTENAAR
van Toledo, Wiebo

SCHRIFTELIJKE OPINIE**Onderdeel I Basis van de Schriftelijke Opinie**

1. Deze schriftelijke opinie is opgesteld op basis van de meest recente conclusies ingediend voor aanvang van het onderzoek.
2. Met betrekking tot **nucleotide en/of aminozuur sequenties** die genoemd worden in de aanvraag en relevant zijn voor de uitvinding zoals beschreven in de conclusies, is dit onderzoek gedaan op basis van:
 - a. type materiaal:
 - sequentie opsomming
 - tabel met betrekking tot de sequentie lijst
 - b. vorm van het materiaal:
 - op papier
 - in elektronische vorm
 - c. moment van indiening/aanlevering:
 - opgenomen in de aanvraag zoals ingediend
 - samen met de aanvraag elektronisch ingediend
 - later aangeleverd voor het onderzoek
3. In geval er meer dan één versie of kopie van een sequentie opsomming of tabel met betrekking op een sequentie is ingediend of aangeleverd, zijn de benodigde verklaringen ingediend dat de informatie in de latere of additionele kopieën identiek is aan de aanvraag zoals ingediend of niet meer informatie bevatten dan de aanvraag zoals oorspronkelijk werd ingediend.
4. Overige opmerkingen:

SCHRIJFTELIJKE OPINIE

Onderdeel V Gemotiveerde verklaring ten aanzien van nieuwheid, inventiviteit en industriële toepasbaarheid

1. Verklaring

Nieuwheid	Ja: Conclusies 8-21, 24-27, 29-32 Nee: Conclusies 1-7, 22, 23, 28, 33
Inventiviteit	Ja: Conclusies 16-21, 26, 27, 29, 32 Nee: Conclusies 1-15, 22-25, 28, 30, 31, 33
Industriële toepasbaarheid	Ja: Conclusies 1-33 Nee: Conclusies

2. Citaties en toelichting:

Zie aparte bladzijde

Onderdeel VI Andere geciteerde documenten

Andere geciteerde openbaarmakingen

Zie aparte bladzijde

Niet schriftelijke openbaarmakingen

Onderdeel VIII Overige opmerkingen

De volgende opmerkingen met betrekking tot de duidelijkheid van de conclusies, beschrijving, en figuren, of met betrekking tot de vraag of de conclusies nawerkbaar zijn, worden gemaakt:

Zie aparte bladzijde

Reference is made to the following documents:

- D1 US 6 127 775 A (BERGEN RICHARD F [US]) 3 oktober 2000
(2000-10-03)
- D2 US 5 617 129 A (CHIZUK JR JOSEPH A [US] ET AL) 1 april 1997
(1997-04-01)
- D3 US 2001/028046 A1 (HAMAGUCHI SHINICHI [JP] ET AL) 11 oktober
2001 (2001-10-11)
- D4 EP 0 262 855 A2 (TRIALSITE LTD [GB]) 6 april 1988 (1988-04-06)
- D5 US 2003/209673 A1 (ONO HARUHITO [JP] ET AL) 13 november 2003
(2003-11-13)
- D6 EP 2 019 415 A1 (IMS NANOFABRICATION AG [AT]) 28 januari 2009
(2009-01-28)
- D7 US 2011/073782 A1 (WIELAND MARCO JAN-JACO [NL]) 31 maart 2011
(2011-03-31)
- D8 US 2011/079731 A1 (KIM HO SEOB [KR]) 7 april 2011 (2011-04-07)

Re Item V

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

- 1 ----- [novelty] -----

The present application does not meet the criteria of patentability, because the subject-matter of claims 1, 23 and 33 is not new.

- 1.1 D1 discloses a charged particle system, comprising a manipulator which includes a planar substrate 102 with apertures 104, each aperture 104 being provided with electrodes 108, 109, 110, 111 (Fig. 4) or electrodes 108, 110, 150, 152 (Fig. 6).

A first set of electrodes 108, 109 and a second set of electrodes 110, 111 can be defined in dependence of a target position of the ion beam (indicated with S), the first set and the second set being provided at respective parts of the perimeter.

In dependence of desired target positions of the ion beam, an electronic control circuit 200 provides a different voltage to the pair of electrodes 108 and 110, belonging to the first set, respectively to the second set of electrodes, and a different voltage to the pair of electrodes 109 and 111, belonging to the first set, respectively to the second set of electrodes, and/or the electronic control circuit 200 provides a different voltage to the two electrodes 108 and 109 belonging to the first set of electrodes. D2, cited in D1, discloses essentially the same features.

Consequently, D1 and D2 disclose all the features of claims 1 and 33.

- 1.2 D3 discloses (Pars. 0115-0118; Figs. 1, 7A-C) a charged particle system, comprising a manipulator 18 which includes a planar substrate 186 with apertures 194, each aperture 194 being provided with electrodes 190 placed around the perimeter of the aperture. The electrodes are organised in pairs of electrodes so that the same reasoning applies with respect to applying voltage to the electrodes for the purpose of deflection a charged particle beam as given for D1.

Consequently, D3 discloses all the features of claims 1 and 33.

- 1.3 D4 discloses (Figs. 2, 3) a charged particle system, comprising a manipulator 36 which includes a planar substrate with an aperture 34 provided with electrodes 38 placed around the perimeter of the aperture. The electrodes of D4 serve the purpose of temporarily deflecting a circulating beam of charged particles so that the beam current onto the target is interrupted. An electronic circuit (Fig. 5) will apply a deflecting voltage to at least one electrode, whereas other electrodes will receive another voltage or be grounded. The subject-matter of claims 1 and 33 does not prescribe how the sets of electrodes are to be chosen, or which ones of the first and second set are selected to be the first and second electrode.

Consequently, D4 discloses all the features of claims 1 and 33.

- 1.4 D5 discloses (Pars. 0064-0066; Figs. 11A-E) a multi-beam planar lens substrate 1, manipulator device substrate 2 and planar lens substrate 3, each substrate comprising apertures to pass an electron beam therethrough, voltage being applied to the three substrates so as to form an Einzel lens for the beams.

Consequently, claim 23 is not new.

- 1.5 According to Col.6, lines 58-59 of D1, 'different pairs [of deflection electrodes] can be placed on opposite sides of a substrate [such as 102]'. In such a case, one planar substrate accommodates two manipulator devices, a first one for deflection in the x direction, and the second one for deflection in the y direction. The first and second manipulator form respective apertures which have been aligned (see Fig. 7 for how electrode layers define an aperture; Fig. 10 of D2, cited in D1, to be compared with present Figs. 6 and 7). Here, the wording of claims 31 and 32 with respect to aligned apertures is interpreted according to p.34, lines 1-5 of the present description.

D1 does neither disclose planar lenses (claim 23), nor explicit mention of the two manipulator devices being a single CMOS device (claim 31), nor cooling tubes provided between the two manipulator devices (claim 32).

- 1.6 D3 discloses (Par. 0176; Fig. 1) various manipulating devices for deflecting a charged particle beam directions (e.g. nos. 18, 20, 60), including x and y directions, but does not disclose that the planar deflectors are manufactured using CMOS techniques. Between the deflectors 18 and 60, the shaping member 22 is provided with a cooling unit. Cooling tubes have not been disclosed.
- 1.7 D4 does neither disclose an electronic circuit arranged for providing differences to pairs of first and second electrodes (claim 1), nor planar lenses (claim 23), nor first and second manipulating devices comprising a planar substrate (claims 31, 32).
- 1.8 D5 does not disclose two manipulator devices for deflection in x and y direction, comprising a planar substrate.
- 1.9 Consequently, claims 31 and 32 are new.

2 ----- [inventive step] -----

- 2.1 The present application does not meet the criteria of patentability, because the subject-matter of claims 1, 23 and 33, since not being new, and of claim 31, does not involve an inventive step.

2.2 From the differences with the closest prior art D1, the problem to be solved by the present invention may be regarded as providing an alternative manufacturing technique of the manipulating device. A skilled person knows that CMOS technique is commonly used in the art, as illustrated in D6 (Par. 0076) and that it serves e.g. to reduce power consumption.

Consequently, claim 31 does not rely on inventive merit.

2.3 From the differences with the closest prior art D3, the problem to be solved by the present invention may be regarded as what kind of cooling unit is to be selected. The prior art does not disclose or suggest the use of cooling tubes, and therefore will no lead to the solution according to claim 21.

Consequently, claim 32 is inventive.

3 ----- [dependent claims] -----

3.1 The following dependent claims 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:

Claim 2	D1: the electric field applied to deflect a charged particle beam is proportional to the voltage applied to the electrodes and the distance between the electrodes;
Claims 3, 4	D1: such an angle is to be considered when establishing a voltage difference in dependence of a desired target position of a beam, wherein the angle is determined by said desired position and the centre of the aperture lying on a plane defined between the first part and the second part of the perimeter;
Claim 5	D1: the electrodes are uniformly distributed along the perimeter, in the sense of symmetrically distributed;
Claim 6	D1: the point of symmetry is the centre of the aperture;
Claim 7	D1, see Fig. 4;

Claims 8, 9	such a scheme should normally be contemplated, when executing the deflection according to D1; the denomination of first and second electrodes has not been precisely defined in the claimed subject-matter and thus depends on custom;
Claim 10	D1, see Fig. 4: such a scheme should be contemplated for a desired target position in the centre or on a horizontal line;
Claims 11-13	the use of the claimed components cannot be considered inventive;
Claim 14	although from Fig. 4 of D1, no such ratio is deducible, the gap ratio appears to be within a range in which desired deflection ranges should normally be achievable;
Claim 15	cross-talk is a general problem. A solution is proposed by D5 (Pars. 0062-0066) and consists of placing a planar shield substrate ('shield electrode') adjacent the middle electrode;
Claim 22	see D1;
Claim 24	a substrate acting as a current limiter in an Einzel lens has been disclosed in D8; also D7 discloses a current limiter aperture;
Claim 25	a substrate acting as a current limiter in an Einzel lens is known per se from D7 and D8: the apertures of plate 8 of D7 are seen to be smaller than those of the manipulator device;
Claim 28	D5, Par. 0064;
Claim 30	D6, Par. 0076: CMOS technique is commonly used (see claim 31).

3.2 The combination of the features of the following dependent claims is neither known from, nor rendered obvious by, the available prior art. The reasons are as follows:

Claim 16	D5 mentions a distance between a shield electrode and an electrode to be shielded of 1 micron (Par. 0042), but does not disclose or suggest the claimed thickness condition;
Claim 17	Although the subject-matter is known per se from D5, the electrodes of the middle electrode are not in accordance with present claim 1;
Claims 18-21	Although D5 and D8 disclose an Einzel lens comprising a middle electrode as manipulator device, the electrodes of the middle electrode are not in accordance with present claim 1;
Claim 26	the prior art does not disclose such cooling means in combination with the subject-matter of claim 23;
Claim 27, 29	the combined subject-matter of claims 23 and 27 is neither disclosed in D1 (x-y deflection but no Einzel lens) nor in D5 (Einzel lens but no x-y deflection).

Re Item VI

Certain documents cited

Application No	Publication date (day/month/year)	Filing date (day/month/year)	Priority date (<i>valid claim</i>) (day/month/year)
Patent No			
US2012145915	14/06/2012	14/11/2011	14/11/2011

Re Item VIII

Certain observations on the application

In claim 1, the expression 'pairs of a first electrode and a second electrode' is not clear in view of the preceding text, and has been construed as 'pairs of electrodes, each pair consisting of an electrode from the first set and an electrode from the second set of electrodes'.

In claim 4, the term 'though opening' has been construed as 'through opening'.

Claims 3 and 4 appear redundant, when comparing Figs. 3A and 3B to which said claims correspond.

In claim 10, the expression 'one voltage' has been construed as 'same voltage'.

In claim 14, the term 'ration' has been construed as 'ration'.

Claim 29 cannot refer to claim 23-26, since in these claims, a second manipulator device has not been mentioned. Therefore, the back reference has been construed as 'according to claims 27 or 28'.

Claim 30 cannot refer to claims 23-25, since in these claims, a first and second set of electrodes have not been mentioned. Therefore, the back reference has been construed as 'according to claims 1-22'.