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(71) Applicant *(for all designated States except US)*: **MAPPER LITHOGRAPHY IP B.V.** [NL/NL]; Computerlaan 15, NL-2628 XK Delft (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **ZONNEVYLLE, Aernout Christiaan** [NL/NL]; Ahornstraat 16-2, NL-3552 CG Utrecht (NL). **KRUIT, Pieter** [NL/NL]; Koornmarkt 49, NL-2611 EB Delft (NL).

(74) Agent: **DE HOOP, Eric**; Octrooibureau Vriesendorp & Gaade B.V., Dr. Kuyperstraat 6, NL-2514 BB Den Haag (NL).

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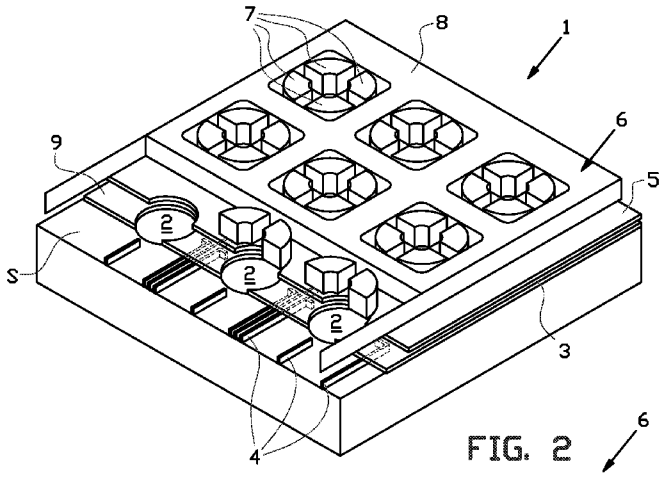

FIG. 2

(57) Abstract: The invention relates to a method and a device for manipulation of one or more charged particle beams of a plurality of charged particle beamlets in a charged particle multi-beamlet apparatus. The manipulator device comprises a planar substrate comprising an array of through openings in the plane of the substrate, each of these through openings is arranged for passing the at least one charged particle beamlet there through, wherein each of the through openings is provided with one or more electrodes arranged around the through opening, and a electronic control circuit for providing control signals to the one or more electrodes of each through opening, wherein the electronic control circuit is arranged for providing the one or more electrodes of each individual through opening with an at least substantially analog adjustable voltage.

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AMENDED CLAIMS
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1. Method for influencing and/or controlling the trajectory of one or more charged particle beamlets in a charged particle multi-beamlet apparatus, wherein said apparatus comprises a manipulator device for manipulation of one or more charged particle beams of a plurality of charged particle beamlets in the charged particle multi-beamlet apparatus, wherein the manipulator device comprises:

a planar substrate comprising an array of through openings in the plane of the substrate, each of these through openings is arranged for passing at least one charged particle beamlet there through, wherein each of the through openings is provided with one or more electrodes arranged around the through opening, and wherein the one or more electrodes are arranged in and/or on said substrate, and

an electronic control circuit for providing control signals to the one or more electrodes of each through opening of the array of through openings,

wherein the method comprises the step of providing individual adjustment control for each through opening by providing the one or more electrodes of each individual through opening with an at least substantially analog adjustable voltage, wherein the charged particle multi-beamlet apparatus comprises a sensor for determining at least one characteristic of said charged particle beamlets, wherein the sensor is connected to said electronic control circuit, wherein the method comprises the step of providing individual adjustment control for each through opening based on a feedback signal provided by the sensor to the electronic control circuit.

2. Method according to claim 1, wherein said manipulator device comprises an array of electrostatic

lenses, wherein each of said electrostatic lenses comprises one through opening of said array of through openings, wherein each of the through openings comprises one electrode arranged around the corresponding through opening, and wherein the electronic control circuit is arranged for individually adjusting a strength of each of said electrostatic lenses by providing the one electrode of each individual through opening of a lens of said array of electrostatic lenses with an at least substantially analog adjustable voltage.

3. Method according to claim 1, wherein said manipulator device comprises an array of electrostatic deflectors, wherein each of said electrostatic deflectors comprises one through opening of said array of through openings, wherein each of the through openings comprises two or more electrodes arranged around the corresponding through opening, and wherein the electronic control circuit is arranged for individually adjusting an amount of deflection of a charged particle beamlet induced by said deflector by providing the two or more electrodes of each individual through opening of a deflector of said array of electrostatic deflectors with an at least substantially analog adjustable voltage.

4. Method according to claim 1, wherein said manipulator device comprises an array of electrostatic astigmatism correctors, wherein each of said electrostatic astigmatism correctors comprises one through opening of said array of through openings, wherein each of the through openings comprises eight electrodes arranged around the corresponding through opening, and wherein the electronic control circuit is arranged for individually adjusting an amount of astigmatism correction of a charged particle beamlet induced by said astigmatism corrector by providing the eight electrodes of each individual through opening of an astigmatism corrector of said array of electrostatic astigmatism correctors with an at least substantially analog adjustable voltage.

5. method according to any one of the previous claims, wherein the charged particle multi-beamlet apparatus comprises an optical column for:

producing an expanding charged particle beam using a charge particle source,

collimating the charged particle beam using a collimator,

creating multiple beamlets using an aperture array,

deflecting individual beamlets in a group of beamlets at certain times in order to blank them using a beamlet blanker array,

stopping the deflected individual beamlets using a beam stop array, and

projecting the non-stopped beamlets onto a target using a projection lens system.

6. Method according to claim 5, wherein the manipulator device is arranged behind the collimator for:

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

- correcting one or more of said one or more charged particle beamlets for astigmatism.

7. Method according to claim 5 or 6, wherein the manipulator device is provided as part of the projection lens system for providing a deflection and/or a focusing or defocusing of one or more of said one or more charged particle beamlets in the projection lens system.

8. Charged particle multi-beamlet apparatus comprising a manipulator device for manipulation of one or more charged particle beams of a plurality of charged particle beamlets in the charged particle multi-beamlet apparatus, wherein the manipulator device comprises:

a planar substrate comprising an array of through

openings in the plane of the substrate, each of these through openings is arranged for passing at least one charged particle beamlet there through, wherein each of the through openings is provided with one or more electrodes arranged around the through opening, and wherein the one or more electrodes are arranged in and/or on said substrate, and

an electronic control circuit for providing control signals to the one or more electrodes of each through opening, wherein the electronic control circuit is arranged for providing the one or more electrodes of each individual through opening with an at least substantially analog adjustable voltage, wherein the charged particle multi-beamlet apparatus further comprises:

a sensor for determining at least one characteristic of said charged particle beamlets, wherein the sensor is connected to said electronic control circuit for providing individual adjustment control for each through opening based on a feedback signal provided by the sensor to the electronic control circuit.

9. Charged particle multi-beamlet apparatus according to claim 8, wherein the voltage is individual adjustable for each electrode of said manipulator.

10. Charged particle multi-beamlet apparatus according to claim 8 or 9, wherein said manipulator device is arranged for focusing, deflection or stigmation of individual beamlets of said plurality of beamlets.

11. Charged particle multi-beamlet apparatus according to claim 8, 9 or 10, wherein the planar substrate of said manipulator device is a wafer, and wherein the electronic control circuit comprises an integrated circuit on said planar substrate.

12. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 11, wherein the electronic control circuit is, at least partially, arranged in-between two through openings on said manipulator device.

13. Charged particle multi-beamlet apparatus

according to claim 12, wherein the electronic control circuit is arranged in non-beam areas between two through openings or between two groups of through openings on said manipulator device.

14. Charged particle multi-beamlet apparatus according to any one or the claims 8 to 13, wherein the electronic control circuit comprises a memory for storing control data for the one or more electrodes of one or more individual through openings, which memory is arranged on the planar substrate of said manipulator device and adjacent to said through openings.

15. Charged particle multi-beamlet apparatus according to claim 14, wherein the memory is arranged for storing control data for the one or more electrodes of one individual through opening, which memory is arranged on the planar substrate of said manipulator device and adjacent to said individual through opening.

16. Charged particle multi-beamlet apparatus according to claim 14 or 15, wherein the memory is arranged in-between two through openings.

17. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 16, wherein the one or more electrodes of said manipulator device comprises a metal that is deposited on the planar substrate.

18. Charged particle multi-beamlet apparatus according to claim 17, wherein the metal comprises Molybdenum.

19. Charged particle multi-beamlet apparatus according to claim 17 or 18, wherein the one or more electrodes of a through opening in said manipulator device are at least partially arranged against an inwards facing wall of said through opening.

20. Charged particle multi-beamlet apparatus according to claim 19, wherein said one or more electrodes extend into the trough opening in a direction substantially parallel a centre line of said through opening.

21. Charged particle multi-beamlet apparatus

according to any one of the claims 8 to 20, wherein the one or more electrodes of each through opening of said manipulator device are at least substantially surrounded by an earthed electrode.

22. Charged particle multi-beamlet apparatus according to claim 21, wherein the earthed electrode comprises a metal that is deposited on the planar substrate.

23. Charged particle multi-beamlet apparatus according to claim 22, wherein the metal comprises Molybdenum.

24. Charged particle multi-beamlet apparatus according to claim 21, 22 or 23, wherein a surface of the one or more electrodes of said manipulator device that faces away from the planar substrate, is arranged at a height between the planar substrate and a surface of the earthed electrode that faces away from said planar substrate.

25. Charged particle multi-beamlet apparatus according to claim 24, wherein a thickness of the earthed electrode on the planar substrate of said manipulator device is larger than a thickness of the one or more electrodes on the planar substrate.

26. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 25, wherein the electronic control circuit comprises connecting leads for connecting the electronic control circuit with the one or more electrodes of said manipulator device, wherein at least one of said connecting leads is at least partially arranged between two earthed electrically conducting layers.

27. Charged particle multi-beamlet apparatus according to claim 26, wherein the at least one of said connecting leads is at least partially arranged between two earthed leads.

28. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 27, wherein the

electronic control circuit comprises a demultiplexer for extracting control data for one or more individual through openings from a multiplexed signal, which demultiplexer is arranged on the planar substrate of said manipulator device and adjacent to said through openings.

29. Charged particle multi-beamlet apparatus according to claim 28, wherein the demultiplexer is arranged for extracting control data for the one or more electrodes of one individual through opening, which demultiplexer is arranged on the planar substrate of said manipulator device and adjacent to said individual through opening.

30. Charged particle multi-beamlet apparatus according to claim 28 or 29, wherein the demultiplexer is arranged in-between adjacent through openings.

31. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 30, wherein the number of connecting leads to the manipulator device is substantially smaller than the number of electrodes.

32. Charged particle multi-beamlet apparatus according to any one of the claims 8 to 31, wherein the number of connecting leads to a through opening of the manipulator device is smaller than the number of electrodes of said through opening.

33. The charged particle multi-beamlet apparatus according to any one of the claims 8 to 32,

wherein the manipulator device is a first manipulator device having a first planar substrate comprising a first array of through openings in the plane of the first planar substrate,

wherein the charged particle multi-beam apparatus comprises a second manipulator device having a second planar substrate comprising a second array of through openings in the plane of the second planar substrate, wherein each of the through openings comprises one or more electrodes arranged around the corresponding through opening, and wherein the one or more electrodes are

arranged in and/or on said substrate,

wherein the second planar substrate is arranged at a distance and substantially parallel to the first planar substrate, wherein each through opening of the second array of through openings are at least substantially in line with a through opening of the first array of through openings.

34. Charged particle multi-beamlet apparatus according to claim 33, wherein the through openings have a radius r, and wherein the distance d between the first and second planar substrate is equal or smaller than the radius r.

35. Charged particle multi-beamlet apparatus according to claim 33 or 34, wherein the one or more electrodes of the first and second manipulator device are arranged on said first and second substrate, respectively, and wherein the one or more electrodes on the first substrate and the one or more electrodes on the second substrate face each other.

36. Charged particle multi-beamlet apparatus according to claim 33, 34 or 35, wherein the second manipulator device is at least substantially mirror symmetrical to the first manipulator device, at least with respect to a centre plane between the first and second manipulator device.

37. A charged particle multi-beamlet maskless lithography device comprising a manipulator device for manipulation of one or more charged particle beams of a plurality of charged particle beamlets in the charged particle multi-beamlet maskless lithography device, wherein the manipulator device comprises:

a planar substrate comprising an array of through openings in the plane of the substrate, each of these through openings is arranged for passing at least one charged particle beamlet there through, wherein each of the through openings is provided with one or more electrodes arranged around the through opening, and wherein the one or

more electrodes are arranged in and/or on said substrate, and

an electronic control circuit for providing control signals to the one or more electrodes of each through opening, wherein the electronic control circuit is arranged for providing the one or more electrodes of each individual through opening with an at least substantially analog adjustable voltage, wherein the charged particle maskless multi-beamlet apparatus further comprises:

a sensor for determining at least one characteristic of said charged particle beamlets, wherein the sensor is connected to said electronic control circuit for providing individual adjustment control for each through opening based on a feedback signal provided by the sensor to the electronic control circuit.

38. A charged particle multi-beamlet maskless lithography device according to claim 37, further comprising one or more of the measures described in any one of the claims 9 to 36.

STATEMENT UNDER ARTICLE 19 (1)

The invention relates to a method and system for influencing and/or controlling the trajectory of one or more charged particle beamlets in a charged particle multi-beamlet apparatus, wherein said apparatus comprises a manipulator device for manipulation of one or more charged particle beams of a plurality of charged particle beamlets in the charged particle multi-beamlet apparatus. Such manipulator device comprises: i)a planar substrate comprising an array of through openings with electrodes formed therearound and ii)an electronic control circuit for providing control signals to the one or more electrodes of each through opening. Furthermore, there is a sensor for determining at least one characteristic (beam, trajectory, beam astigmatism or beam focus) of the beamlets. The sensor is connected to said control circuit. The method comprises the step of providing individual (dynamic! see P4,L29-31) adjustment control for each through opening by providing the one or more electrodes of each individual through opening with an at least substantially analog adjustable voltage based on a feedback signal provided by the sensor to the electronic control circuit.

US6,175,122B1 (D1) discloses a multibeam e-beam system, which is based upon a beam-shaping plus projection approach. D1 does not disclose *a sensor for determining at least one characteristic of said beamlets and is coupled to an electronic control circuit.* D1 does further not disclose individual adjustment control for each through opening with an at least substantially analog adjustable voltage *based on a feedback signal provided by the sensor to the electronic control circuit.*

JP2004165076 (D3) discloses a deflector for a charged particle beam lithography machine, which comprises of multiple layers that are mounted in a stack. D3 does not disclose *a sensor for determining at least one characteristic of said beamlets and is coupled to an electronic control circuit.* D3 does further not disclose *individual adjustment control for each through opening with an at least substantially analog adjustable voltage based on a feedback signal provided by the sensor to the electronic control circuit.*

WO2010/134026A2 (D2) discloses a method for exposing a wafer using a plurality of charged particle beamlets. The method comprises identifying non-functional beamlets among the beamlets, wherein such non-functional beamlets are subsequently deactivated. D2 does not disclose individual adjustment control for each through opening *with an at least substantially analog adjustable voltage* based on a feedback signal provided by the sensor to the electronic circuit. In D2 such beamlets are deactivated in case such beamlets are not functioning. It is submitted that the teaching of D2 would not be applied to the teaching of D1 or D3, because the machines are fundamentally different (maskless direct writing system versus maskless projection system). Furthermore, if the teaching of D2 would be applied to D1 or D3, the person skilled in the art would not arrive at something falling within the scope of the independent claims. Instead, he would arrive at the system of D2, lacking the analog individual control of the beamlets as mentioned in the claims. D2 deals with deactivating faulty beamlets, whereas the invention deals with correcting deviating beamlets.