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INVENTOR(S):	Kagarice et al.	§	ART UNIT:	2881
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FILING DATE:	September 30, 2014	§	EXAMINER:	Logie, Michael J.

TITLE: Chicane Blanker Assemblies for Charged Particle Beam Systems and Methods of Using the Same

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AMENDMENTS AND RESPONSE PURSUANT TO REQUEST FOR CONTINUED EXAMINATION

Dear Sir:

In response to the Final Office Action dated August 12, 2016, Applicant respectfully requests the following amendments in the above-identified application. Applicant requests that the unentered amendment filed November 14, 2016 **not** be entered. The changes made are shown by underlining the added text and striking through the deleted text in bold.

Amendments to the Claims begin on page 2 of this paper.

Remarks/Arguments begin on page 9 of this paper.

Technical arguments are provided in Sections II-III (pages 9-13).

The purpose of this "Response" is to convince a patent examiner that the "claimed invention" is patentable over the devices described in certain "references" published before the patent application was filed. These references are cited in rejections against Applicant's "claims" as part of an "Office Action" written by the Examiner. To overcome the Office Action, the Response includes claim amendments and rebuttal arguments that Applicant's attorney believes will be effective in distinguishing the claims over the references.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application.

Listing of Claims

1. (Currently Amended) A chicane blanker assembly for a focused ion beam column of a charged particle beam system, comprising:

an entrance and an exit, wherein the entrance is configured to accept a focused ion beam propagating along ~~an~~ a first axis;

a neutrals blocking structure intersecting the first axis;

a plurality of electrostatic chicane deflectors comprising a first chicane deflector, a second chicane deflector, a third chicane deflector, and a fourth chicane deflector sequentially arranged in series between the entrance and the exit and configured to deflect the focused ion beam along a path that bypasses the neutrals blocking structure and exits the chicane blanker assembly through the exit along a second axis parallel to the first axis, wherein:

the first chicane deflector is configured to deflect the focused ion beam off of the first axis at a point before the first axis intersects the neutrals blocking structure and onto the portion of the path that bypasses the neutrals blocking structure, and

the fourth chicane deflector is configured to deflect the focused ion beam onto the second axis; and

a beam blocking structure different from the neutrals blocking structure and arranged between the third chicane deflector and the fourth chicane deflector, the beam blocking structure configured to prevent the focused ion beam from passing through the exit during operation of the chicane blanker assembly in a blanking mode,

a beam blanking deflector configured to prevent the focused ion beam from passing through the exit by deflecting the focused ion beam into the beam blocking structure;

wherein the chicane blanker assembly does not comprise an aperture for shaping the beam.

2. (Cancelled)

3. (Currently Amended) The chicane blanker assembly of ~~claim 2~~ claim 1, wherein the beam blanking deflector is disposed between the first chicane deflector and the second chicane deflector.

4. (Currently Amended) The chicane blanker assembly of ~~claim 2~~ claim 1, further comprising a quadrupole deflector, wherein the first chicane deflector comprises two oppositely opposed electrodes of the quadrupole deflector and the beam blanking deflector comprises another two oppositely opposed electrodes of the quadrupole deflector.

5. (Currently Amended) The chicane blanker assembly of ~~claim 2~~ claim 1, wherein the first chicane deflector and the beam blanking deflector are a same deflector and further comprising a voltage source configured to:

apply a first voltage to the same deflector sufficient to deflect the focused ion beam along a path bypassing the neutrals blocking structure, and

apply a second voltage to the same deflector sufficient to deflect the focused ion beam along a path that terminates in the beam blocking structure.

6. (Currently Amended) The chicane blanker assembly of ~~claim 2~~ claim 1, wherein:

the first chicane deflector is configured to apply a first deflective force to the focused ion beam in a first direction, the first direction being perpendicular to the first axis; and

the beam blanking deflector is configured to apply a second deflective force to the focused ion beam in the first direction,

wherein the first deflective force and the second deflective force are electrostatic forces.

7. (Currently Amended) The chicane blanker assembly of ~~claim 2~~ claim 1, wherein:

the first chicane deflector is configured to apply a first deflective force to the focused ion beam in a first direction, the first direction being perpendicular to the first axis; and

the beam blanking deflector is configured to apply a second deflective force to the focused ion beam in a second direction, the second direction being perpendicular to the first axis and to the first direction,

wherein the first deflective force and the second deflective force are electrostatic forces.

8. (Original) The chicane blanker assembly of claim 1, wherein the neutrals blocking structure is disposed upstream of the fourth chicane deflector.

9. (Original) The chicane blanker assembly of claim 8, wherein the neutrals blocking structure is a first neutrals blocking structure,

further comprising a second neutrals blocking structure disposed upstream of the fourth chicane deflector,

wherein the path that bypasses the first neutrals blocking structure bypasses the second neutrals blocking structure, and

wherein the second neutrals blocking structure is configured to block charged particles neutralized along the path that bypasses the first neutrals blocking structure and the second neutrals blocking structure that are not blocked by the first neutrals blocking structure.

10. (Original) The chicane blanker assembly of claim 1, wherein the beam blocking structure comprises a Faraday cup.

11. (Previously Presented) The chicane blanker assembly of claim 1, wherein the focused ion beam column comprises a plasma-focused ion beam column and the focused ion beam comprises a plasma-focused ion beam.

12. (Withdrawn) A method for preventing neutrals from impacting a sample while processing the sample with a charged particle system, wherein:

the charged particle system comprises:

a charged particle source; and

a chicane blanker assembly comprising first, second, third, and fourth chicane deflectors arranged in series, a first neutrals blocking structure, a second neutrals blocking structure, and a beam blocking structure disposed between the third and fourth chicane deflectors, and

the method comprises:

irradiating a sample with a charged particle apparatus by:

emitting charged particles from a charged particle source,

focusing the charged particles into a charged particle beam propagating towards the sample along a first axis,

using the chicane deflectors to deflect the charged particle beam around the first neutrals blocking structure and the second neutrals blocking structure and then onto a second axis, the second axis being parallel to or the same as the first axis, and

propagating the charged particle beam along the second axis such that the charged particle beam irradiates a surface of the sample; and

preventing neutrals from impacting the sample using the chicane blanker assembly.

13. (Withdrawn) The method of claim 12, wherein the second neutrals blocking structure comprises a plate overlapping a portion of a cross-section of the chicane blanker assembly normal to the first axis and blocking a portion of the chicane blanker assembly between the first axis and the second axis.

14. (Withdrawn) The method of claim 13, wherein preventing neutrals from impacting the sample comprises blocking neutrals with at least one of the first neutrals blocking structure and the second neutrals blocking structure while the charged particle beam irradiates the sample such that the neutrals are prevented from staining the sample.

15. (Withdrawn) The method of claim 13, wherein:

the charged particle apparatus comprises a focused ion beam column, the charged particle source comprises an ion source, and the charged particle beam comprises a focused ion beam;

the chicane blanker assembly further comprises a beam blanking deflector disposed at or downstream of a point where the focused ion beam enters the first chicane deflector and upstream of the beam blocking structure; and

the charged particle system further comprises a scanning electron microscope; and

further comprising simultaneously:

blanking the focused ion beam, wherein blanking the focused ion beam comprises applying a first deflective force to the focused ion beam with the first chicane deflector and applying a second deflective force to the focused ion beam with the beam blanking deflector;

blocking neutrals with at least one of the first neutrals blocking structure and the second neutrals blocking structure during the blanking of the focused ion beam such that the neutrals are prevented from generating secondary electrons at the surface of the sample; and

imaging the sample with the scanning electron microscope.

16. (Withdrawn) The method of claim 15, wherein blanking the focused ion beam comprises deflecting the focused ion beam with electrostatic fields generated by the first chicane deflector, the second chicane deflector, the third chicane deflector, and the beam blanking deflector.

17. (Withdrawn) The method of claim 15, wherein a direction of the first deflective force is perpendicular to the first axis and a direction of the second deflective force is the same as the direction of the first deflective force.

18. (Withdrawn) The method of claim 15, wherein a direction of the first deflective force is perpendicular to the first axis and a direction of the second deflective force is perpendicular to the first axis and to the direction of the first deflective force.

19. (Withdrawn) The method of claim 12, wherein the charged particle apparatus comprises a plasma focused ion beam column, the charged particle source comprises a plasma ion source, and the charged particle beam comprises a focused ion beam.

20. (Withdrawn) The method of claim 19, wherein a current of the focused ion beam is less than or equal to about 1.3 μA.

21. (Withdrawn) The method of claim 19, wherein the neutrals comprise gas molecules emitted from the plasma source, ions of the focused ion beam neutralized in the plasma focused ion beam column, or a combination thereof.

22. (Withdrawn) A charged particle beam system for processing a workpiece, comprising a focused ion beam column configured to generate, focus, and direct an ion beam, wherein the focused ion beam column includes:

an ion source;

an optical axis for propagating the ion beam from the ion source towards a workpiece; and

a chicane blanker assembly comprising four chicane deflectors arranged in series, a blanking deflector, a first neutrals blocking structure, a second neutrals blocking structure, and a beam blocking structure, wherein:

the first neutrals blocking structure is configured to block neutrals propagating towards a workpiece along the optical axis;

the four chicane deflectors are configured to direct the beam onto the workpiece by deflecting the ion beam from the optical axis, onto a path bypassing the first neutrals blocking structure and the second neutrals blocking structure, and back onto the optical axis or an axis parallel to the optical axis;

the four chicane deflectors and the blanking deflector are configured to blank the ion beam by deflecting the ion beam into the beam blocking structure; and

the second neutrals blocking structure is configured to block ions neutralized after being deflected from the optical axis.

23. (Withdrawn) The charged particle beam system of claim 22, wherein:

the chicane deflector closest to the ion source is configured to apply a first electrostatic field to the ion beam in a first direction perpendicular to the optical axis, and

the blanking deflector is configured to apply a second electrostatic field to the ion beam in a second direction while the chicane deflector closest to the ion source applies the first electrostatic field.

24. (Withdrawn) The charged particle beam system of claim 23, wherein the second direction is parallel to or perpendicular to the first direction.

25. (Withdrawn) The charged particle beam system of claim 22, wherein the beam blocking structure comprises a faraday cup, and the ion source comprises a plasma source having:

a plasma chamber for containing a plasma;

a source electrode for electrically biasing the plasma; and

an extractor electrode for extracting ions from the plasma chamber.

26. (Withdrawn) The charged particle beam system of claim 25, further comprising a scanning electron microscope configured to image the workpiece while the chicane blanker assembly blanks the ion beam.

27. (Withdrawn) The charged particle beam system of claim 22, wherein there is no crossover of the beam in the chicane blanker assembly.

28. (Withdrawn) The charged particle beam system of claim 22, wherein the chicane blanker assembly does not comprise an aperture for shaping the beam.

29. (Withdrawn) The charged particle beam system of claim 22, wherein there are no focusing elements exerting any shaping of the beam into a round or line focus.

30. (New) The chicane blanker assembly of claim 1, wherein the second axis overlaps the first axis.

REMARKS/ARGUMENTS

Claims 1, 12 and 22 are in independent form. Claims 1 and 3-7 are amended. Claim 2 is cancelled. Claim 30 is added. Claims 12-29 were previously withdrawn. Thus, claims 1-30 are pending, and claims 1, 3-11 and 30 are under consideration.

I. Support for Claim Amendments

Applicant respectfully submits that no new matter has been introduced by the amendments to claim 1 or by the addition of new claim 30. Claim 1 is amended to recite that the plurality of electrostatic chicane deflectors are:

> configured to deflect the focused ion beam along a path that bypasses the neutrals blocking structure and exits the chicane blanker assembly through the exit along a second axis parallel to the first axis, wherein
>
> the first chicane deflector is configured to deflect the focused ion beam off of the first axis at a point before the first axis intersects the neutrals blocking structure and onto the portion of the path that bypasses the neutrals blocking structure, and
>
> the fourth chicane deflector is configured to deflect the focused ion beam onto the second axis

The amendment is supported in the originally filed disclosure, for example, at paragraphs [0063] and [0081]. Claim 1 is also amended to additionally recite the feature of "wherein the chicane blanker assembly does not comprise an aperture for shaping the beam." The amendment is supported by paragraph [00133]. Claim 1 is further amended to recite "a beam blanking deflector configured to prevent the focused ion beam from passing through the exit by deflecting the focused ion beam into the beam blocking structure," which is the subject matter of originally filed claim 2. New claim 30 is supported in the originally filed disclosure at paragraph [0063] ("In an embodiment, the third axis overlaps the Z-axis . . .).

II. Claim Rejections Under 35 U.S.C. § 102

Claims 1, 2, 4, 6-11 stand rejected under 35 U.S.C. § 102(a)(1) as being anticipated by U.S. Patent Publication No. 2013/0112890 to Parker et al., ("Parker") (first interpretation). Claims 1-3 stand rejected under 35 U.S.C. § 102(a)(1) as being anticipated by U.S. Patent Publication No. 2013/0112890 to Parker et al., ("Parker") (second interpretation). Claims 1-3 stand rejected under

35 U.S.C. § 102(a)(1) as being anticipated by U.S. Patent Publication No. 2013/0112890 to Parker et al., ("Parker") (third interpretation).

In the Applicant Initiated Interview Summary issued by the Examiner on October 28, 2016, the Examiner states:

> Parker fails to disclose 'the first chicane deflector is configured to deflect the focused ion beam off of the first axis, and the fourth chicane deflector is configured to deflect the focused ion beam onto the second axis' (i.e. in Parker the fourth Chicane deflector does not function to deflect onto a second axis).

To this, Applicant makes a point of clarification. Each of the three 35 U.S.C. § 102 rejections in the Office Action cites octupole 2030 as disclosing the fourth chicane deflector of previously presented claim 1. While Applicant agrees that octupole 2030 does not disclose the requisite functionality of the fourth chicane deflector recited in claim 1, Applicant notes that octupole 2024 shown in Parker Fig. 20 appears to function as a fourth chicane deflector in the way described by amended claim 1.

However, even if octupole 2024 were considered to read upon the claimed fourth chicane deflector, Parker would still fail to anticipate amended claim 1. In particular, Parker does not anticipate amended claim 1 because Parker fails to disclose the feature of "a beam blocking structure different from the neutrals blocking structure and *arranged between the third chicane deflector and the fourth chicane deflector*" required by amended claim 1. In each of the rejections, faraday cup 2028 is considered to disclose the claimed beam blocking structure. However, FIG. 20 shows faraday cup 2028 to be located downstream of octupole 2024, and not between deflectors 2016 and 2024. Thus, faraday cup 2028 is not "*arranged between the third chicane deflector and the fourth chicane deflector.*"

Parker also does not anticipate amended claim 1 because Parker does not disclose the feature of "wherein the chicane blanker assembly does not comprise an aperture for shaping the beam." Instead, each of the Parker chicane apparatuses have beam-defining apertures. Thus, Applicant respectfully submits that amended claim 1, and claims 2-11 by virtue of dependency from amended claim 1, have novelty over Parker, and Applicant respectfully requests withdrawal of the 35 U.S.C. § 102 rejection rejections based on Parker

III. Non-obviousness

The degree to which a charged particle beam is electrostatically deflected off-axis in a chicane deflector arrangement is a function of the deflection voltage and the length of the chicane along its longitudinal axis over which the deflection occurs. The greater the length of a chicane assembly, the less voltage required to achieve a desired beam deflection, and vice versa. Similarly, the distance a charged particle beam must be deflected off-axis for blanking (i.e., the "throw distance") is a function of the blanking deflection distance and blanking deflection voltage, wherein the voltage requirement for achieving the throw distance decreases as the blanking deflection distance increases.

Claim 1

Amended **claim 1** is directed to "[a] chicane blanker assembly for a focused ion beam column of a charged particle beam system . . . wherein the chicane blanker assembly does not comprise an aperture for shaping the beam." In such an arrangement, effective elimination of neutrals may be achieved by an electrostatic chicane deflection slightly larger than the diameter of the charged particle beam. In amended claim 1, the beam blanking deflector is positioned between the first and second chicane deflectors, expanding the distance between the first and second chicane deflectors over which deflection off the first axis can occur, and the beam blocking structure is arranged between the third and fourth chicane deflectors, expanding the distance between the third and fourth chicane deflectors over which deflection onto the second axis can occur. *The presence of the beam blanking deflector and the beam blocking structure between different chicane deflectors of the chicane assembly rather than in the column above or below the chicane allows a longer chicane assembly to be used inside a charged particle beam column without lengthening the column, which lowers the voltage necessary to produce a deflection that clears the neutrals blocking structure and also successfully filters out neutral particles from the beam.*

In view of the above, Applicant respectfully submits that the integrated blanking deflector and beam blocking structure recited by amended claim 1 would not have been obvious for two reasons. First, all of the chicane energy filters of Parker include a beam-shaping aperture. It would not have been obvious to persons skilled in the art to remove the aperture because shaping of the charged particle beam is integral to the principal of operation of the Parker energy filters. *See*

Parker at paragraph [0014] ("[T]he addition of electrostatic quadrupole and hexapole excitations to the dipole elements in a chicane energy filters form the beam into a line focus at an aperture positioned between the second and third elements of the chicane. Applicants have found that this addition further improves the energy resolution by making the line focus both sharper and straighter at the aperture plane.").

Second, the Parker energy filters would not have significantly benefited from integrating a beam blanking deflector and beam blocking structure into the chicane because the charged particle beam in FIG. 20 has been shaped to have a line focus where the beam blanking deflection takes place. *See* Parker at [0076] ("An alternative operating mode allows the beam current passing through the slit aperture to be measured . . . . In this alternative mode, *the deflections and line focusing performed by octupoles 2002 and 2010 are unchanged*, but octupole 2016 functions only as a weak deflector to steer the beam along axis 2042 into a lower Faraday cup 2028 located between octupoles 2024 and 2030 in block 2046."). Because of the line focus, the beam is thin and only a small additional deflection in the same direction as the chicane deflection is needed to blank the beam. Id. (" . . . but octupole 2016 functions only as a *weak deflector* to steer the beam along axis 2042 into a lower Faraday cup")

Claim 7

Claim 7 recites the following features:

> the first chicane deflector is configured to apply a first deflective force to the focused ion beam in a first direction, the first direction being perpendicular to the first axis; and
>
> the beam blanking deflector is configured to apply a second deflective force to the focused ion beam in a second direction, the second direction being perpendicular to the first axis and to the first direction

To facilitate the discussion of claim 7, Applicant refers the Examiner to the embodiment of FIG. 7 (for illustrative purposes only[1]). Referring to FIG. 7 (which can be visualized in three dimensions by referring to FIGS. 2a-2c), the use of first chicane deflector 610 to carry out first blanking deflection 660 and the use of blanking deflector 620 to carry out a second deflection 750

[1] It should be noted that FIGS. 5a-5b illustrate a second embodiment in accordance with claim 7. The configuration of FIGS. 5a-66b differs from FIG. 7 in that blanking deflector 520 and the first chicane deflector 510 share the same position along the beam axis whereas blanking deflector 620 is down stream of first chicane deflector 610 in FIG. 7. *See* Application at [0079]-[0080].

perpendicular to beam 645 and first deflection 660, the throw distance required for beam blanking can be achieved:

(1) using two voltage deflections that are each lower than could be achieved by a single unidirectional deflection 730; and/or

(2) over a shorter distance along the beam axis than could be achieved by a single unidirectional deflection 730.

These results can be explained by Pythagorean theorem, i.e., the two perpendicular deflections 660 and 750 are individually shorter than the overall throw distance 730 according to the relationship $d_{730} = (d_{660}^2 + d_{750}^2)^{½}$.

Lower deflection voltages are advantageous in that they enable faster blanking since typically a bottleneck of blanking speed is the voltage slew rate (in V/μs) driving the blanker plates. *See* Application at [0068]. A lower blanking voltage also reduces the time it takes to reach the required blanking voltage, which improves system responsiveness. *Id.*

Additionally, or alternatively, instead of lowering the operating voltages, the longer throw distance can allow the chicane assembly to be constructed with a shortened overall length and/or with shorter beam blanking plates (electrodes). *Id.* at [0069]. Shorter beam blanking plates may allow for faster blanking speed because shorter plates will generally have less capacitance, less capacitance being another limitation on the slew rate of the voltages on the blanking plates. *Id.* Shorter blanking plates may also make blanking "sharper" since the transit time through the blanker is less for shorter plates. *Id.*

Thus, the integration of blanking and chicane deflection embodied in claim 7 presents several advantages in cases involving chicane assemblies for blocking neutrals in which a full-beam width and/or an unshaped charged particle beam is utilized. Similar to the discussion for claim 1, such advantages would not be obvious from Parker because Parker flattens the charged particle beam at a slit aperture in the middle of the Parker chicane and the flattened beam requires a much smaller throw distance than a circular beam. Claim 7 would not have been obvious from Parker because the benefits achieved are for problems that are not suggested by Parker and likely would not have been apparent in working with the chicane energy filters of Parker.

IV. New Claim 30

New claim 20 depends from amended claim 1 and is not anticipated by Parker at least for the same reasons as amended claim 1.

V. Conclusion

It is believed that all of the pending issues have been addressed. However, the absence of a reply to a specific objection, issue or comment does not signify agreement with or concession of the rejection, issue or comment. In addition, because the arguments made above may not be exhaustive, there may be reasons for patentability of any or all pending claims (or other claims) that have not been expressed. Finally, nothing in this reply should be construed as an intent to concede any issue with regard to any claim, except as specifically stated in this reply, and the amendment of any claim does not necessarily signify concession of unpatentability of the claim prior to its amendment.

Applicant submits that all claims in the application are now in condition for allowance, and Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

If the Commissioner determines that any additional fees or extensions are required, Applicant requests that such extensions be granted and any fees be charged to Deposit Account 50-1635.

Respectfully submitted,

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