CLAIMS

What is claimed is:

1. An apparatus for ion accumulation, comprising:

a first region configured to receive ions and generate a first drive potential configured to guide the ions across the first region in a first direction; and

a second region configured to receive the ions from the first region, switch between a first state and a second state, generate a first electric field when in the first state, and generate a second electric field when in the second state;

wherein the first electric field is configured to prevent the ions from moving in the first direction and entering a third region, and the second electric field is configured to guide the ions in the first direction toward the third region, and

wherein when the second region is in the first state the first drive potential and the first electric field prevent ions in the second region from exiting the second region and causes the ions to accumulate in the second region, and when the second region is in the second state the second electric field causes the ions to move in the first direction toward the third region.

2. The apparatus of claim 1, wherein the first electric field is a DC voltage.

3. The apparatus of claim 2, wherein a magnitude of the DC voltage is greater than a voltage bias of the first drive potential.

4. The apparatus of claim 2, wherein the second electric field is a traveling wave.

5. The apparatus of claim 2, wherein a magnitude of the DC voltage is less than a voltage bias of the first drive potential, the DC voltage creating a potential well.

6. The apparatus of claim 5, wherein the second electric field is a DC potential gradient or a traveling wave.

7. The apparatus of claim 2, wherein the first electric field is a traveling wave that travels in a second direction that is opposite to the first direction, and the second electric field is a second traveling wave that travels in the first direction.

8. The apparatus of claim 1, wherein the third region is configured to receive the ions from the second region and generate a second drive potential configured to separate the ions based on mobility.

9. The apparatus of claim 1, wherein

the first region includes a plurality of electrodes disposed on a first surface, arranged along the first direction, and configured to generate the first drive potential, and

the second region includes one or more electrodes disposed on the first surface, arranged along the first direction, and configured to generate the first electric field when in the first state and generate the second electric field when in the second state.

10. The apparatus of claim 9, comprising:

a controller configured to:

apply a first voltage signal to the plurality of electrodes of the first region, the plurality of electrodes configured to generate the first drive potential based on the first voltage signal,

apply a second voltage signal to at least one electrode of the one or more electrodes of the second region, the at least one electrode configured to generate the first electric field based on the second voltage signal, and

apply a third voltage signal to the at least one electrode of the one or more electrodes of the second region, the at least one electrode configured to generate the second electric field based on the third voltage signal,

wherein when the apparatus is in a first mode of operation the controller applies the second voltage signal to the second plurality of electrodes placing the second region in the

first state, and when the apparatus is in a second mode of operation the controller applies the third voltage signal to the second plurality of electrodes placing the second region in the second state.

11. The apparatus of claim 1, wherein a first portion of the second region generates the first electric field when the second region is in the first state, the first portion of the second region generates the second electric field when the second region is in the second state, and a second portion of the second region generates a fourth electric field that is different than the first electric field.

12. The apparatus of claim 1, wherein the second region includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

13. The apparatus of claim 12, wherein the first electric field is generated by at least one of the individual electrodes of each of the plurality of TW electrode arrays when the second region is in the first state.

14. A method of ion accumulation, comprising:

introducing ions into an apparatus for ion accumulation having a first region, a second region, and a third region;

generating a drive potential within the first region for guiding the ions across the first region in a first direction;

transferring the ions from the first region to the second region with the drive potential;

generating a first electric field within the second region for preventing the ions from moving in the first direction and entering the third region;

accumulating ions in the second region; and

switching the first electric field generated within the second region to a second electric field for guiding the accumulated ions in the first direction toward the third region.

15. The method of claim 14, wherein the first electric field is a DC voltage.

16. The method claim 15, wherein a magnitude of the DC voltage is greater than a voltage bias of the drive potential.

17. The method of claim 15, wherein the second electric field is a traveling wave.

18. The method of claim 15, wherein a magnitude of the DC voltage is less than a voltage bias of the drive potential, the DC voltage creating a potential well.

19. The method of claim 18, wherein the second electric field is a DC potential gradient or a traveling wave.

20. The method of claim 15, wherein the first electric field is a first traveling wave that travels in a second direction that is opposite to the first direction, and the second electric field is a second traveling wave that travels in the first direction.

21. The method of claim 14, further comprising:

transferring the ions accumulated in the second region to the third region;

generating a second drive potential within the third region; and

separating the ions based on mobility with the second drive potential.

22. The method of claim 14, wherein

the first region includes a plurality of electrodes disposed on a first surface, arranged along the first direction, and configured to generate the first drive potential,

the second region includes one or more electrodes disposed on the first surface and arranged along the first direction, and

at least one of the one or more electrodes of the second region generates the first electric field and the second electric field.

23. The method of claim 14, wherein a first portion of the second region generates the first electric field and the second electric field, and a second portion of the second region generates a fourth electric field that is different than the first electric field.

24. The method of claim 14, wherein the second region includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

25. The method of claim 24, wherein the first electric field is generated by at least one of the individual electrodes of each of the plurality of TW electrode arrays when the second region is in the first state.

26. An ion accumulation device, comprising:

an ion accumulation section having a first width and being configured to receive ions, switch between a first state and a second state, generate a first electric field when in the first state, and generate a second electric field when in the second state;

an outlet section having a second width less than the first width, the outlet section being configured to generate a third electric field configured to guide the ions across the outlet section; and

an outlet transition section extending between the ion accumulation section and the outlet section, and having a tapering width that reduces from the first width adjacent the ion accumulation section to the second width adjacent the outlet section, the outlet transition section being configured to generate the third electric field to guide the ions across the outlet transition section to the outlet section;

wherein the first electric field is configured to prevent the ions from moving in a first direction and entering the outlet transition section, and the second electric field is configured to guide the ions in the first direction toward the outlet transition section, and

wherein when the ion accumulation section is in the first state the first electric field prevents ions in the ion accumulation section from exiting the ion accumulation section and causes the ions to accumulate in the ion accumulation section, and when the ion accumulation

section is in the second state the second electric field causes the ions to move in the first direction toward the outlet transition section.

27. The ion accumulation device of claim 26, comprising:

an inlet section having a third width less than the first width; and

an inlet transition section extending between the inlet section and the ion accumulation section, and having a tapering width that increases from the third width adjacent the inlet section to the first width adjacent the ion accumulation section,

wherein the inlet section and the outlet transition section are configured to generate a fourth electric field to guide the ions across the inlet section and the inlet transition section to the ion accumulation section.

28. The ion accumulation device of claim 26, wherein the second electric field is a traveling wave that travels in the first direction, and the ion accumulation section is configured to be switched from generating the second electric field to generating a fourth electric field that is a traveling wave that travels in a second direction opposite the first direction.

29. The ion accumulation device of claim 26, wherein the first electric field is a DC voltage.

30. The ion accumulation device of claim 26, wherein a first portion of the ion accumulation section generates the first electric field and a second portion of the ion accumulation section generates a fourth electric field that is different than the first electric field.

31. The ion accumulation device of claim 26, wherein the ion accumulation section includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

32. The ion accumulation device of claim 31, wherein the first electric field is generated by at least one of the individual electrodes of each of the plurality of TW electrode arrays.

33. The ion accumulation device of claim 26, comprising an inlet section positioned at a lateral side of the ion accumulation section and configured to provide ions to the ion accumulation section.

CLAIMS

1. An apparatus for ion accumulation, comprising:

a first region configured to receive ions and generate a first drive potential configured to guide the ions across the first region in a first direction; and

a second region configured to receive the ions from the first region, switch between a first state and a second state, generate a first electric field when in the first state, and generate a second electric field when in the second state;

in which the first electric field is configured to prevent the ions from moving in the first direction and entering a third region, and the second electric field is configured to guide the ions in the first direction toward the third region,

in which when the second region is in the first state the first drive potential and the first electric field prevent ions in the second region from exiting the second region and causes the ions to accumulate in the second region, and when the second region is in the second state the second electric field causes the ions to move in the first direction toward the third region; and

in which a first portion of the second region generates the first electric field when the second region is in the first state, the first portion of the second region generates the second electric field when the second region is in the second state, and a second portion of the second region generates a fourth electric field that is different from the first electric field.

2. An apparatus according to Claim 1, in which the first electric field is a DC voltage.

3. An apparatus according to Claim 2, in which a magnitude of the DC voltage is greater than a voltage bias of the first drive potential.

4. An apparatus according to Claim 2, in which the second electric field is a traveling wave.

5. An apparatus according to Claim 2, in which a magnitude of the DC voltage is less than a voltage bias of the first drive potential, the DC voltage creating a potential well.

6. An apparatus according to Claim 2, in which the first electric field is a traveling wave that travels in a second direction that is opposite to the first direction, and the second electric field is a second traveling wave that travels in the first direction.

7. An apparatus according to Claim 1, in which the third region is configured to receive the ions from the second region and generate a second drive potential configured to separate the ions based on mobility.

8. An apparatus according to Claim 1, in which

the first region includes a plurality of electrodes disposed on a first surface, arranged along the first direction, and configured to generate the first drive potential, and

the second region includes one or more electrodes disposed on the first surface, arranged along the first direction, and configured to generate the first electric field when in the first state and generate the second electric field when in the second state.

9. An apparatus according to Claim 1, in which the second region includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

10. A method of ion accumulation, comprising:

introducing ions into an apparatus for ion accumulation having a first region, a second region, and a third region;

generating a drive potential within the first region for guiding the ions across the first region in a first direction;

transferring the ions from the first region to the second region with the drive potential;

generating a first electric field within the second region for preventing the ions from moving in the first direction and entering the third region;

accumulating ions in the second region; and

switching the first electric field generated within the second region to a second electric field for guiding the accumulated ions in the first direction toward the third region; and

in which a first portion of the second region generates the first electric field and the second electric field, and a second portion of the second region generates a fourth electric field that is different from the first electric field.

11. A method according to Claim 10, in which the first electric field is a DC voltage.

12. A method according to Claim 11, in which a magnitude of the DC voltage is greater than a voltage bias of the drive potential.

13. A method according to Claim 11, in which the second electric field is a traveling wave.

14. A method according to Claim 11, in which a magnitude of the DC voltage is less than a voltage bias of the drive potential, the DC voltage creating a potential well.

15. A method according to Claim 11, in which the first electric field is a first traveling wave that travels in a second direction that is opposite to the first direction, and the second electric field is a second traveling wave that travels in the first direction.

16. A method according to Claim 10, further comprising:

transferring the ions accumulated in the second region to the third region;

generating a second drive potential within the third region; and

separating the ions based on mobility with the second drive potential.

17. A method according to Claim 10, in which

the first region includes a plurality of electrodes disposed on a first surface, arranged along the first direction, and configured to generate the first drive potential,

the second region includes one or more electrodes disposed on the first surface and arranged along the first direction, and

at least one of the one or more electrodes of the second region generates the first electric field and the second electric field.

2418. A method according to Claim 10, in which the second region includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

19. An ion accumulation device, comprising:

an ion accumulation section having a first width and being configured to receive ions, switch between a first state and a second state, generate a first electric field when in the first state, and generate a second electric field when in the second state;

an outlet section having a second width less than the first width, the outlet section being configured to generate a third electric field configured to guide the ions across the outlet section; and

an outlet transition section extending between the ion accumulation section and the outlet section, and having a tapering width that reduces from the first width adjacent the ion accumulation section to the second width adjacent the outlet section, the outlet transition section being configured to generate the third electric field to guide the ions across the outlet transition section to the outlet section;

in which the first electric field is configured to prevent the ions from moving in a first direction and entering the outlet transition section, and the second electric field is configured to guide the ions in the first direction toward the outlet transition section, and

in which when the ion accumulation section is in the first state the first electric field prevents ions in the ion accumulation section from exiting the ion accumulation section and causes the ions to accumulate in the ion accumulation section, and when the ion accumulation section is in the second state the second electric field causes the ions to move in the first direction toward the outlet transition section.

20. An ion accumulation device according to Claim 19, comprising:

an inlet section having a third width less than the first width; and

an inlet transition section extending between the inlet section and the ion accumulation section, and having a tapering width that increases from the third width adjacent the inlet section to the first width adjacent the ion accumulation section,

in which the inlet section and the outlet transition section are configured to generate a fourth electric field to guide the ions across the inlet section and the inlet transition section to the ion accumulation section.

21. An ion accumulation device according to Claim 19, in which the second electric field is a traveling wave that travels in the first direction, and the ion accumulation section is

configured to be switched from generating the second electric field to generating a fourth electric field that is a traveling wave that travels in a second direction opposite the first direction.

22. An ion accumulation device according to Claim 19, in which the first electric field is a DC voltage.

23. An ion accumulation device according to Claim 19, in which a first portion of the ion accumulation section generates the first electric field and a second portion of the ion accumulation section generates a fourth electric field that is different from the first electric field.

24. An ion accumulation device according to Claim 19, in which the ion accumulation section includes a plurality of rows of radio frequency (RF) electrodes and a plurality of traveling wave (TW) electrode arrays, each of the plurality of TW electrode arrays including at least three individual electrodes.

25. An ion accumulation device according to Claim 19, comprising an inlet section positioned at a lateral side of the ion accumulation section and configured to provide ions to the ion accumulation section.