CLAIMS

1. An ion manipulation device comprising:

a pair of substantially parallel surfaces extending along a longitudinal axis, and defining a space therebetween dimensioned to receive ions;

an array of inner electrodes contained within each parallel surface, and arranged substantially along the longitudinal axis, in which at least two electrodes of the inner array of electrodes are positioned directly adjacent to one another along the longitudinal axis, in which the array of inner electrodes are configured to receive a radiofrequency (RF) voltage and generate a pseudopotential and receive a first DC voltage and generate a first DC potential;

a first outer array of electrodes and a second outer array of electrodes, each positioned on either side of the array of inner electrodes, contained within each parallel surface, and arranged substantially along the longitudinal axis, in which the first and second outer array of electrodes are configured to receive a second DC voltage and generate a second DC potential;

in which the pseudopotential and the second DC potential are configured to manipulate movement of ions between the parallel surfaces, and the first DC potential is configured to drive ions along the longitudinal axis.

2. A device according to Claim 1, in which adjacent inner electrodes are configured to receive RF voltages that are phase shifted with respect to one another.

3. A device according to Claim 1, in which the array of inner electrodes, the first outer array of electrodes, and the second outer array of electrodes each comprise at least two electrodes on each of the pair of parallel surfaces.

4. A device according to Claim 1, in which the RF frequency applied to the electrodes is between 0.1 kHz and 50 MHz, RF peak-to-peak voltage is 10 to 2000 volts and pressure is between 10^{-3} torr and atmospheric pressure.

5. A device according to Claim 1, in which one or more electrodes of the array of inner electrodes, the first outer array of electrodes and the second outer array of electrodes are perpendicular to at least one of the surfaces.

6. A device according to Claim 1, in which one or more electrodes of the array of inner electrodes, the first outer array of electrodes, and the second outer array of electrodes comprise a thin conductive layer on the surfaces.

7. A device according to Claim 1, in which the pair of surfaces forms at least one of the following configurations:

a substantially T-shaped configuration, allowing ions to be switched at a junction of the T-shaped configuration;

a substantially Y-shaped configuration, allowing ions to be switched at a junction of the Y-shaped configuration;

a substantially X-shaped or cross-shaped configuration, allowing ions to be switched at a junction of one or more sides of the X-shaped or cross-shaped configuration; and

a substantially multidirectional shape, such as an asterisk (*)-shaped configuration, with multiple junction points, allowing ions to be switched at a junction to one or more sides of the configuration.

8. A device according to Claim 1, in which the electric field generated by the array of inner electrodes, the first outer array and the second outer array allows the ions to move in a circular shaped path, a rectangle-shaped path or irregular path, to allow the ions to make more than one transit.

9. A device according to Claim 1, in which the space between the pair of parallel surfaces includes a gas that ions react with.

10. A device according to Claim 1, further comprising multiple cyclotron stages.

11. A device according to Claim 10, in which the multiple cyclotron stages are arranged in a stack.

12. A device according to Claim 1, in which the device is coupled to at least one of the following: a charge detector, an optical detector and a mass spectrometer.

13. A device according to Claim 1, in which the device is used to perform ion mobility separations.

14. A device according to Claim 1, in which the device is fabricated using printed circuit board technology.

15. A device according to Claim 1, in which the ions are formed inside the device using at least one of the following: photoionization, Corona discharge, laser ionization, electron impact, field ionization, chemical ionization and electrospray.

16. A device according to Claim 1, in which the ions are introduced from outside the device.

17. A device according to Claim 1, in which the ions are introduced from outside the device and are formed using at least one of the following: photoionization, Corona discharge, laser ionization, electron impact, field ionization, chemical ionization and electrospray.

18. A device according to Claim 1, in which the device is used for at least one of the following: ion mobility separations, differential ion mobility separations (FAIMS), ion-molecule, ion-ion or ion-surface reactions and ion trapping.

19. A device according to Claim 1, in which the first DC voltage is a static voltage field or a dynamic voltage field.

20. A device according to Claim 19, in which the static voltage is a DC gradient and the dynamic voltage is a traveling wave.

21. A device according to Claim 1, in which one or more electrodes of the array of inner electrodes, the first outer array of electrodes, and the second outer array of electrodes has 0.5 to 10 mm relief from a surface of the pair of parallel surfaces.

22. A device according to Claim 21, in which the one or more electrodes of the array of inner electrodes, the first outer array of electrodes, and the second outer array of electrodes has sufficient relief from the surface so that degradation of device performance due to charging of the surfaces between electrodes is prevented.

23. A device according to Claim 1, in which the substantially parallel surfaces are planar.

24. A device according to Claim 1, in which the substantially parallel surfaces are non-planar.

25. A method of manipulating ions comprising:

injecting ions within a space defined between a pair of substantially parallel surfaces that extend along a longitudinal axis, in which each of the parallel surfaces includes:

an array of inner electrodes contained within each parallel surface, and arranged substantially along the longitudinal axis, in which at least two electrodes of the inner array of electrodes are positioned adjacent to one another along the longitudinal axis

a first and second array of outer electrodes each positioned on either side of the array of inner electrodes, contained within each parallel surface, and arranged substantially along the longitudinal axis;

applying a radiofrequency (RF) voltage and a first direct current (DC) voltage to the array of inner electrodes in order to generate a pseudopotential and a first DC potential, respectively;

applying a second DC voltage to each of the first and the second outer array of electrodes to generate a second DC potential;

in which the pseudopotential and the second DC potential are configured to manipulate movement of ions between the parallel surfaces, and the first DC potential is configured to drive ions along the longitudinal axis.

26. A method according to Claim 25, further comprising transferring the ions through an aperture in at least one surface of the pair of parallel surfaces, in which the ions travel to another pair of parallel surfaces.

27. A method according to Claim 25, further comprising configuring the pair of parallel surfaces with patterns of electrodes to form at least one of the following:

a substantially T-shaped electrode configuration, in which ions are switched at a junction of the T-shaped electrode configuration;

a substantially Y-shaped electrode configuration, in which ions are switched at a junction of the Y-shaped electrode configuration;

a substantially X-shaped or cross-shaped electrode configuration, in which ions are switched at a junction of one or more sides of the X-shaped or cross-shaped electrode configuration; and

a substantially multidirectional shape, such as an asterisk (*)-shaped electrode configuration, with multiple junction points, allowing ions to be switched at a junction to one or more sides of the electrode configurations.

28. A method according to Claim 25, in which the RF field applied to the array of inner electrodes is between 0.1 kHz and 50 MHz and pressure is between 10^{-3} torr and atmospheric pressure.

29. A method according to Claim 25, in which one or more electrodes of the array of inner electrodes, the first outer array of electrodes, and the second outer array of electrodes are perpendicular to at least one of the surfaces.

30. A method according to Claim 25, in which the second DC potential applied to the inner and outer electrodes are static, a time-varying DC offset, or a combination of static and time varying DC.

31. A method according to Claim 25, in which the time-varying DC potential allows the ions to move in a circular-shaped path or a rectangular-shaped path, through which the ions make more than one transit.

32. A method according to Claim 25, in which positive and negative charged ions are induced to fragment or allowed to undergo ion-ion reactions while moving in specific regions.

33. A method according to Claim 25, further comprising forming ions without use of an external ion source.

34. A method according to Claim 25, further comprising a second pair of surfaces and one or more apertures configured to allow transfer of ions from between the pair of parallel surfaces to between the second pair of parallel surfaces.

35. A method according to Claim 34, in which transfer of ions from between the pair of parallel surfaces to between the second pair of parallel surfaces is guided by two or more adjacent transfer electrodes configured to receive at least one of DC and RF potentials of alternating polarity on adjacent transfer electrodes.