fields that move ions through the device 500. Lateral confinement is achievable by the curved nature of the surface and application of electric fields to the outer electrodes 510. The inner RF and DC electrode arrays 520, 525, and 530 confine and drive ions through the device. The ions can be driven either through a static DC field or a time-dependent DC waveform or field.

[0076] Figure 6 is a plot of ion counts over arrival time using the embodiment of Figure 1, showing the mobility separation of two ions with different mass-to-charge ratios – m/z 622 and m/z 922.

[0077] Figure 7A is a three-dimensional schematic diagram of the device of Figure 1, with ions moving through the device at a distance from the surface, in accordance with one embodiment of the present invention.

[0078] Figure 7B is a plot showing ion confinement within the device of Figure 7A at the high portion of a time-dependent electric field, a dynamic electric field.

[0079] Figure 7C is a plot showing ion confinement within the device of Figure 7A at the low portion of a time-dependent electric field, a dynamic electric field.

[0080] Figure 8 is a plot of ion counts over arrival time of two ions with different mass-to-charge ratios (m/z 622 and m/z 922) using two different configurations - the embodiment of Figure 4 or a single board ion mobility separation device and a prior dual board ion mobility separation device. The prior dual boards are straight or planar, while the single board configuration is curved. The length of each device is approximately 76 mm.

[0081] Figures 9A and 9B show a cross section and three-dimensional schematic diagram, respectively, of the ion mobility device 200 of Figure 2, with ions 950 moving through the device at a distance from the surface, with a DC traveling wave field applied to the outside electrodes and opposing phases of RF applied to the inner electrodes, in accordance with one embodiment of the present invention.

CLAIMS

1. An ion mobility separation or manipulation device comprising:

(a) a single, non-planar surface that is curved to form an ion separation channel; and

(b) arrays of electrodes coupled to the surface, in which the arrays of electrodes include inner arrays of RF electrodes, and one or more inner arrays of DC electrodes;

in which the inner arrays of RF electrodes is configured to receive RF voltage to create confining fields and the one or more inner arrays of DC electrodes is configured to receive DC voltages to create driving fields that move ions through the device,

in which the array of electrodes receiving the RF and DC voltages conform to the shape of the surface and extend substantially along the length of the surface.

2. A device according to Claim 1 further comprising one or more surfaces and/or electrodes external to the device to create additional electric fields on the device.

3. A device according to Claim 2 in which voltages received by the one or more surfaces and/or electrodes external to the device are turned on or turned off.

4. A device according to Claim 1 in which the arrays of electrodes coupled to the surface extend above the surface and vary in the distance above the surface.

5. A device according to Claim 2 in which one or more of the arrays of electrodes coupled to the surface are turned on or turned off by the surfaces and/or electrodes external to the device.

6. A device according to Claim 1 in which the single, non-planar surface includes arrays of electrodes on each side of the single, non-planar surface.

7. A device according to Claim 1 in which the single, non-planar surface is located in a partially or completely transparent cover or enclosure.

8. A device according to Claim 1 in which the single, non-planar surface is one of the following shapes: cylindrical, a spiral, a funnel, hemispherical, or elliptical.

9. A device according to Claim 1 in which the arrays of electrodes comprise a plurality of outer arrays of DC electrodes comprising a first outer array of DC electrodes and a second

outer array of DC electrodes, in which the inner array of RF electrodes and the plurality of outer arrays of DC electrodes extend substantially along the length of the surface.

10. A device according to Claim 9 in which the first outer array of DC electrodes is positioned on one side of the inner arrays of RF electrodes, and the second outer array of DC electrodes is positioned on the other side of the inner arrays of RF electrodes.

11. A device according to Claim 1 in which the RF voltage received by at least one inner array of RF electrodes is out of phase with its neighboring inner array of RF electrodes.

12. A device according to Claim 11 in which the RF voltage received by each inner array of RF electrodes is phase shifted with respect to its neighboring inner array of RF electrodes to create the confining fields comprising a pseudopotential.

13. A device according to Claim 12 in which the RF voltage received by each inner array of RF electrodes is approximately 180 degrees out of phase with respect to its neighboring inner array of RF electrodes to form the pseudopotential.

14. A device according to Claim 10 in which the one or more inner arrays of DC electrodes extending substantially along the length of the single, non-planar surface, in which each inner array of DC electrodes is positioned between an adjacent pair of the inner array of RF electrodes of the inner arrays of RF electrodes.

15. A device according to Claim 14 in which a RF voltage received by at least one inner array of RF electrodes of the inner arrays of RF electrodes is out of phase with a neighboring or adjacent inner array of RF electrodes of the inner arrays of RF electrodes.

16. A device according to Claim 15 in which a first DC voltage received by the first outer array of DC electrodes and the second outer array of DC electrodes, and a second DC voltage received by the one or more inner arrays of DC electrodes is a DC gradient across the inner arrays of DC electrodes.

17. A device according to Claim 15 in which a first DC voltage received across the first outer array of DC electrodes and the second outer array of DC electrodes is a DC gradient, and a second DC voltage received by the one or more inner arrays of DC electrodes is a DC gradient across the one or more inner arrays of DC electrodes.

18. A device according to Claim 17 in which the one or more inner arrays of DC electrodes is misaligned or offset from the first outer array of DC electrodes.

19. A device according to Claim 10 further comprising a superimposed DC field received by the inner arrays of RF electrodes.

20. A device according to Claim 19 in which the RF voltage received by at least one inner array of RF electrodes of the inner arrays of RF electrodes is out of phase with its neighboring inner array of RF electrodes of the inner arrays of RF electrodes.

21. A device according to Claim 1 in which the DC voltages received by the plurality of outer arrays of DC voltages are static DC voltages or time-dependent DC waveforms.

22. A method of separating or manipulating ions in gas phase comprising:

(a) coupling arrays of electrodes to a single, non-planar surface that is curved to form an ion separation channel, in which the arrays of electrodes include inner arrays of RF electrodes and one or more inner arrays of DC,

in which the inner arrays of RF electrodes is configured to receive RF voltage to create confining fields and the one or more inner arrays of DC electrodes are configured to receive DC voltages to create confining and driving fields that move ions along the single, non-planar surface,

in which the electrodes receiving the RF and DC voltages conform to the shape of the surface and extend substantially along the length of the surface.

23. A method according to Claim 22 further comprising creating additional electric fields via one or more surfaces and/or electrodes external to the single, non-planar surface and the arrays of electrodes.

24. A method according to Claim 23 in which voltages received by the surfaces and/or electrodes external to the single, non-planar surface and the arrays of electrodes are turned on or off.

25. A method according to Claim 22 in which the arrays of electrodes coupled to the surface extend above the surface and vary in the distance above the surface.

26. A method according to Claim 23 further comprising turning on or turning off at least one of the arrays of electrodes coupled to the surface by the surfaces and/or electrodes external to the single, non-planar surface and/or electrodes external to the single, non-planar surface and the arrays of electrodes.

27. A method according to Claim 22 in which the single, non-planar surface includes arrays of electrodes on each side of the single, non-planar surface.

28. A method according to Claim 22 further comprising disposing the arrays of electrodes coupled to the single, non-planar surface in a partially or completely transparent cover or enclosure.

29. A method according to Claim 22 in which the single, non-planar surface is one of the following shapes: cylindrical, a spiral, a funnel, hemispherical, or elliptical.

30. A method according to Claim 22 in which the arrays of electrodes comprise a plurality of outer arrays of DC electrodes comprising a first outer array of DC electrodes and a second outer array of DC electrodes, in which the inner array of RF electrodes and the plurality of outer arrays of DC electrodes extend substantially along the length of the surface.

31. A method according to Claim 30 in which the first outer array of DC electrodes is positioned on one side of the inner arrays of RF electrodes, and the second outer array of electrodes is positioned on the other side of the inner arrays of electrodes.

32. A method according to Claim 30 in which the DC voltages received by the first outer array of DC electrodes and second outer array of DC electrodes, and in which the RF voltages are received by the inner arrays of RF electrodes.

33. A method according to Claim 22 in which the RF voltage received by at least one inner array of RF electrodes is out of phase with its neighboring inner array of RF electrodes.

34. A method according to Claim 33 in which the RF voltage received by each inner array of RF electrodes is phase shifted with respect to its neighboring inner array of RF electrodes to create the confining fields comprising a pseudopotential.

35. A method according to Claim 34 in which the RF voltage received by each inner array of RF electrodes is approximately 180 degrees out of phase with respect to its neighboring inner array of RF electrodes to form the pseudopotential.

36. A method according to Claim 31, in which each inner array of DC electrodes is positioned between an adjacent pair of the inner array of RF electrodes of the inner arrays of RF electrodes.

37. A method according to Claim 36 in which a RF voltage received by at least one inner array of RF electrodes of the inner arrays of RF electrodes is out of phase with a neighboring or adjacent inner array of RF electrodes of the inner arrays of RF electrodes.

38. A method according to Claim 37 in which a first DC voltage received by the first outer array of DC electrodes and the second outer array of DC electrodes, and a second DC voltage received by the one or more inner arrays of DC electrodes is a DC gradient across the inner arrays of DC electrodes.

39. A method according to Claim 37 in which a first DC voltage received across the first outer array of DC electrodes and the second outer array of DC electrodes is a DC gradient, and a second DC voltage received by the inner arrays of DC electrodes is a DC gradient across the inner arrays of DC electrodes.

40. A method according to Claim 39 in which the one or more inner array of DC electrodes is misaligned or offset from the first outer array of DC electrodes.

41. A method according to Claim 31 further comprising superimposing a DC electric field on the inner arrays of RF electrodes.

42. A method according to Claim 22 in which the ions are introduced from the outside at an angle to the surface.

43. A method according to Claim 22 in which the DC voltages are static DC voltages or time-dependent DC waveforms.

44. An ion mobility separation or manipulation device comprising:

(a) a single non-planar surface that is curved to form an ion separation channel;

(b) arrays of electrodes including one or more arrays of inner arrays of RF electrodes and a plurality of outer arrays of DC electrodes, coupled to the single surface, in which the inner arrays of RF electrodes and the outer arrays of DC electrodes extend substantially along a length of the single surface, in which a first outer array of DC

electrodes and a second outer array of DC electrodes are positioned on either side of the inner arrays of RF electrodes; and

(c) one or more arrays of inner DC electrodes extending substantially along the length of the surface, in which each inner array of DC electrodes is positioned between an adjacent pair of the inner array of RF electrodes,

(d) in which the inner arrays of RF electrodes is configured to receive RF voltage to create confining fields and the one or more arrays of inner DC electrodes are configured to receive DC voltages to create driving fields that move ions through the device;

in which the one or more arrays of inner RF electrodes, the plurality of arrays of outer DC electrodes, and one or more arrays of inner DC electrodes conform to the shape of the surface and extend substantially along the length of the surface.

45. A device according to Claim 44 in which a RF voltage on at least one inner array of RF electrodes is out of phase with a neighboring or adjacent inner array of RF electrodes.

46. A device according to Claim 44 in which the first outer array of DC electrodes is configured to receive a first DC voltage, and the one or more inner arrays of DC electrodes is configured to receive a second DC voltage to create a DC gradient across the inner arrays of DC electrodes.

47. A device according to Claim 44 in which a first DC voltage received across the first outer array of DC electrodes and the second outer array of DC electrodes is a DC gradient, and a second DC voltage received by the inner arrays of DC electrodes is a DC gradient across the inner arrays of DC electrodes.

48. A device according to Claim 45 in which the inner arrays of DC electrodes are misaligned or offset from the first outer array of DC electrodes.

49. An ion mobility separation or manipulation device comprising:

(a) a single non-planar surface that is curved to form an ion separation channel;

(b) arrays of electrodes including one or more arrays of inner arrays of RF electrodes, one or more arrays of inner DC electrodes and a plurality of outer arrays of DC electrodes comprising a first outer array of DC electrodes and a second outer array of DC electrodes, coupled to the single surface, in which the inner arrays of RF electrodes

and the outer arrays of DC electrodes extend substantially along a length of the single non-planar surface, in which the first outer array of DC electrodes and the second outer array of DC electrodes are positioned on either side of the inner arrays of RF electrodes,

(c) in which the inner arrays of RF electrodes are configured to receive RF voltage to create confining fields and the one or more arrays of inner DC electrodes are configured to receive DC voltages to create driving fields that move ions through the device; and

(d) in which the inner arrays of RF electrodes is configured to receive a superimposed DC field to further confine and move the ions through the device;

in which the one or more arrays of inner RF electrodes, the plurality of outer arrays of DC electrodes, and the one or more arrays of inner DC electrodes conform to the shape of the surface and extend substantially along the length of the surface.

50. An ion mobility separation or manipulation apparatus comprising:

(a) at least two non-planar surfaces that are curved to form an ion separation channel extending therebetween;

(b) arrays of electrodes coupled to the at least two surface; and

(c) a combination of RF and DC voltages applied to the arrays of each surface to create confining and driving fields that move ions from one surface to another, thus providing a “waterfall” effect of the ions moving through each surface;

in which the electrodes receiving the applied RF and DC voltages conform to the shape of the surfaces to which they are coupled.

51. An apparatus according to Claim 50, in which one of the surfaces is positioned above and offset from the other at an angle.

52. An apparatus according to Claim 50, in which the at least two surfaces are orthogonal to one another.