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;

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

(c) a combination of RF and DC voltages applied to the arrays of electrodes to create confining and driving fields that move ions through the device;

in which the electrodes receiving the applied RF and DC voltages conform to the shape 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 applied to the external surfaces and/or electrodes 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 external surfaces and/or electrodes.

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

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

11. A device according to Claim 9 in which the DC voltages are applied to the first and second outer electrode arrays, and in which the RF voltages are applied to the inner array of electrodes.

12. A device according to Claim 11 in which the RF voltage on at least one inner electrode array is out of phase with its neighboring inner electrode.

13. A device according to Claim 12 in which the RF voltage applied to each inner electrode array is phase shifted with its neighboring inner electrode to form a pseudopotential.

14. A device according to Claim 13 in which the RF voltage applied to the inner electrode array is approximately 180 degrees out of phase with its neighboring inner electrode array to form the pseudopotential.

15. A device according to Claim 10 further comprising 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.

16. A device according to Claim 15 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.

17. A device according to Claim 16 in which a first DC voltage applied to the outer array of DC electrodes is the same, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC arrays.

18. A device according to Claim 16 in which a first DC voltage applied to the outer array of DC electrodes is different across the outer array or is a DC gradient, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC arrays.

19. A device according to Claim 18 in which the inner array of DC electrodes is misaligned or offset from the outer array of electrodes.

20. A device according to Claim 10 further comprising a superimposed DC field on the inner arrays of RF electrodes.

21. A device according to Claim 20 in which the RF voltage on at least one inner RF electrode array is out of phase with its neighboring inner RF electrode array.

22. A device according to Claim 1 in which the DC voltages are static DC voltages or time-dependent DC waveforms.

23. 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; and

(b) applying a combination of RF and DC voltages to the arrays of electrodes to create confining and driving fields that move ions through the single, non-planar surface;

in which the electrodes receiving the applied RF and DC voltages conform to the shape of the surface.

24. A method according to Claim 23 further comprising creating additional electric fields on the device via one or more surfaces and/or electrodes external to the device.

25. A method according to Claim 24 in which voltages applied to the external surfaces and/or electrodes are turned on or off.

26. A method according to Claim 23 in which the arrays of electrodes coupled to the surface extend above the surface and vary in the distance above the surface.

27. A method according to Claim 24 further comprising turning on or turning off at least one of the arrays of electrodes coupled to the surface by the external surfaces and/or electrodes.

28. A method according to Claim 23 in which the single, non-planar surface includes arrays of electrodes on each side of the single, non-planar surface.

29. A method according to Claim 23 further comprising disposing the device in a partially or completely transparent cover or enclosure.

30. A method according to Claim 23 in which the single, non-planar surface is one of the following shapes: cylindrical, a spiral, a funnel, hemispherical, or elliptical.

31. A method according to Claim 23 in which the arrays of electrodes comprises one or more arrays of inner RF electrodes and a plurality of arrays of outer electrodes, in which the inner array of RF electrodes and the outer array of DC electrodes extend substantially along the length of the surface.

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

33. A method according to Claim 31 in which the DC voltages are applied to the first and second outer electrode arrays, and in which the RF voltages are applied to the inner array of electrodes.

34. A method according to Claim 33 in which the RF voltage on at least one inner electrode array is out of phase with its neighboring inner electrode array.

35. A method according to Claim 34 in which the RF voltage applied to each inner electrode array is phase shifted with its neighboring inner electrode array to form a pseudopotential.

36. A method according to Claim 35 in which the RF voltage applied to the inner electrode array is approximately 180 degrees out of phase with its neighboring inner electrode array to form the pseudopotential.

37. A method according to Claim 32 further comprising providing 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.

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

39. A method according to Claim 38 in which a first DC voltage applied to the outer array of DC electrodes is the same, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC array.

40. A method according to Claim 38 in which a first DC voltage applied to the outer array of DC electrodes is different across the outer array or is a DC gradient, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC arrays.

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

42. A method according to Claim 32 further comprising superimposing a DC electric field on the inner arrays of RF electrodes.

43. A method according to Claim 23 in which the ions are introduced from the outside at an angle to the surface.

44. A method according to Claim 23 in which the DC voltages are static DC voltages or time-dependent DC waveforms.

45. 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 RF electrodes and a plurality of arrays of outer DC electrodes, coupled to the single surface, in which the inner array of RF electrodes and the outer array of DC electrodes extend substantially along the length of the single surface, in which a first and second outer array of DC electrodes is positioned on either side of the inner array of RF electrodes;

(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; and

(d) a combination of RF and DC voltages applied to the arrays of electrodes to create confining and 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.

46. A device according to Claim 45 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.

47. A device according to Claim 45 in which a first DC voltage applied to the outer array of DC electrodes is the same, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC array.

48. A device according to Claim 45 in which a first DC voltage applied to the outer array of DC electrodes is different across the outer array or is a DC gradient, and a second DC voltage applied to the inner array of DC electrodes is a DC gradient or different across the inner DC arrays.

49. A device according to Claim 46 in which the inner array of DC electrodes is misaligned or offset from the outer array of electrodes

50. 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 RF electrodes and a plurality of arrays of outer DC electrodes, coupled to the single surface, in which the inner array of RF electrodes and the outer array of DC electrodes extend substantially along the length of the single surface, in which a first and second outer array of DC electrodes is positioned on either side of the inner array of RF electrodes;

(c) a combination of RF and DC voltages applied to the arrays of electrodes to create confining and driving fields that move ions through the device; and

(d) a superimposed DC field on the inner arrays of RF electrodes to further confine and move the 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.

51. 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.

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

53. An apparatus according to Claim 51, in which the at least two surfaces are orthogonal to one another.