(particle) beam. Circular ion beams are often much thicker, especially at higher flux because of Coulomb repulsion, whereas a belt-shaped beam of much lower ion density can remain thin for a long time as explained above. In another embodiment, a laser beam crosses a coplanar belt-shaped ion beam produced by a wedge funnel or a train of laterally elongated cuboid packets generated by a wedge IFT. This configuration would benefit various spectroscopies using laser or synchrotron beams (including optical, IR, PES, photodissociation, and X-ray imaging techniques). Some IMS/MS instruments feature a PES or other spectroscopic capability in the MS stage for more specific characterization of IMS-separated ions, and ion funnels known in the art have been employed at both IMS termini n these systems and are crucial for their practicality from the sensitivity viewpoint, Wedge ion funnels and IFTs can be used in these platforms to focus spherical ion packets separated by DTIMS into elongated cuboid packets for improved spectroscopic and MS analyses or to perform the whole IMS/spectroscopy/MS sequence on (chopped) belt-shaped ion beams.

Like existing ion funnels, wedge funnels of the invention may receive ions from various sources. For example, FIG. **9***a* shows a wedge funnel **100** receiving ions from a single ESI emitter **36**. FIG. **9***b* shows a wedge funnel **100** interfaced with an ESI multi-emitter array **38**, in particular a linear or rectangular one that matches the shape of the opening **12** of funnel **100**. With emitters in those arrays commonly spaced apart by ~0.5-1 Mm, the exemplary single funnel with 5 mm span allows ~5-10 emitters per row. Rectangular 2-D arrays can allow more emitters, e.g., ~20-80 with 4-8 rows covering the 5×4 mm opening of the exemplary funnel above. Funnel arrays with larger openings allow larger emitter arrays comprising a greater number of emitters.

FIG. **9***c* shows a wedge funnel **100** of the invention following a planar FAIMS unit **40**. As seen here, the funnel **100** may be especially useful to collect ions exiting planar or transverse-cylindrical FAIMS filters that inherently output rectangular beams. In this configuration, the exemplary funnel **100** has a linear span of 15 mm that exceeds the maximum lateral expansion of ion beams over reasonable timescales in existing FAIMS devices, while its 1.2 mm width approximately matches the thickness of those beams emerging from the typical 2 mm gap of these devices.

FIG. **10** shows a system **700** comprising a wedge ion funnel **100**, which enables complete "cradle-to-grave" in-plane ion analysis, according to an embodiment of the invention. In the figure, an ESI multi-emitter array **38** delivers ions to the (first) funnel **100**. The rectangular ion beam **14** exiting the rectangular slit **12** is delivered to a DTIMS analyzer **30** described above. Cuboid ion packets are then delivered through another (second) wedge funnel **100** into a ToFMS **15** for ion detection and analysis. System **700** is exemplary of similar systems including, but not limited to, e.g., ESI/IMS/ToF, ESI/FAIMS/ToF, or ESI/FAIMS/IMS/ToF, where wedge funnels can provide in-plane beam processing over the entire analysis path, including a spectroscopy step in the ToF stage if desired. The utility of wedge funnels for producing ion beams of rectangular cross section that are thin to minimize the coordinate spread in one direction and wide to maximize the overlap with light or particle beams in the perpendicular direction, can make those funnels attractive even at lower gas pressures, where known conical funnels focus ions effectively. Wedge funnels operating at lower pressure can have macroscopic gap widths, differing from present circular funnels only in the (elongated rectangular) aperture shape, However, the wedge funnels with microscopic gaps can have proportionally narrower exit slits, providing much tighter beam focusing without causing unacceptable ion trapping. Realization that (i) conventional (drift tube or traveling-wave) MS, FANS, ToF MS, other MS analyzers, laser or synchrotron spectrometry systems, and various combinations thereof may benefit from the use of belt-shaped beams and that (ii) wedge ion funnels can effectively deliver such beams is a third key facet of the present invention.

While a number of embodiments of the present invention have been shown and described, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from the invention in its broader aspects. The appended claims are therefore intended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A device for spatial confinement, guidance, or focusing of ions in gases, comprising:

a plurality of electrode elements having microscopic gaps therebetween that produce a Dehmelt pseudopotential due to an oscillatory electric field created by an alternating voltage applied to said elements, wherein field intensity required for effective confinement or focusing under the operational gas pressure is precluded by electrical breakdown through the gas in macroscopic gaps but permitted in microscopic gaps having a higher breakdown threshold.

2. The device of claim **1**, wherein said gas pressure is the ambient atmospheric pressure; or a pressure ranging from 50 Torr to about 1 atm; or a pressure ranging from about 1 atm to 5 atm.

3. The device of claim **1**, wherein said microscopic gaps range in width from 10 μm to 200 μm; or from 20 μm to 100 μm.

4. The device of claim **1**, wherein said electrode elements have microscopic thicknesses that range from 10 μm to 200 μm; or that range from 20 μm to 100 μm.

5. The device of claim **4**, wherein the electrode elements have microscopic thicknesses that range from ⅓ times to 3 times the width of gaps between the electrode elements; or the thicknesses are equal to the width of the gaps between the electrode elements.

6. The device of claim **1**, wherein the frequency of said oscillatory field ranges from 10 MHz to 150 MHz; or from 25 MHz to 60 MHz.

7. The device of claim **1**, wherein the electrode elements are plates having internal apertures of any geometry arranged in a stack that conveys ions through said apertures sequentially across the stack while repelling ions inside from the aperture circumference by the Dehmelt pseudoforce.

8. The device of claim **7**, wherein neighboring plates carry opposite phases of an alternating voltage.

9. The device of claim **8**, wherein ions are propelled along the stack by a time-independent longitudinal electric field derived from a ladder of fixed voltages applied to said plates in superposition with the alternating voltage.

10. The device of claim **7**, wherein ions are propelled along the stack by a gas flow resulting from vacuum suction into a following instrument stage maintained at a lower gas pressure selected from: a mass spectrometer, an ion mobility spectrometer, a photoelectron spectrometer, a photodissociation spectrometer, and combinations thereof.

11. The device of claim **7**, wherein said apertures have essentially the same geometry and cross-sectional area, defining an ion-guiding tunnel.

12. The device of claim **7**, wherein said apertures have homologous shapes and cross-sectional areas that decrease along the stack, defining a funnel that focuses ion beams