FIGS. **6a** to **6d**. Advantageously, the selectively transmitted ions are at least partially separated in space along the wavefront in dependence upon their low field mobility properties.

The segmented FAIMS with stationary or moving longitudinal fields considerably simplifies the ion transmission pathway relative to tandem-in-space hybrids in which the ions separated by FAIMS are coupled into the inlet of a conventional drift tube ion mobility spectrometer. The coupling of two systems together to get a separation based on FAIMS as well as a tandem in space separation based on low-field mobility suffers from ion losses in the transfer between systems. Although the mechanical assembly and the electronic control of a segmented FAIMS is complex, the ion pathway is very simple, and results in high ion transmission efficiency. The ions are separated both on FAIMS and low-field mobility properties within a single device. An embodiment of the invention is shown to combine the measurements relating to the FAIMS separation and the conventional drift tube ion mobility spectrometer into one instrument.

Generally, for a particular type of ion the high-field ion mobility properties used by FAIMS may not be related in a simple manner to the low-field ion mobility properties, therefore the separation of ions based on both ionic properties has superior specificity to either taken alone. Separations based on the present invention are faster than condensed phase separations such as liquid chromatography or electrophoresis, and the additional specificity of combined FAIMS and low-field mobility reduces the number of types of separations that require the slower condensed phase methods.

Use of cylindrical FAIMS electrodes provides high ion transmission efficiency. Conventional drift ion mobility spectrometers for low-field ion mobility measurements are generally characterized by an ion cloud that disperses in space, and this cloud of ions is difficult to transfer efficiently into a mass spectrometer. Similarly, those FAIMS systems based on flat parallel plates lack focusing and the ions are continuously lost to the electrodes, requiring fast ion transit times to minimize ion loss. If ion separation requires time, this additional required time is associated with further ion loss through diffusion and ion-ion mutual repulsion. It is an advantage of FAIMS that the ions can be confined in space in both 2-dimensions and 3-dimensions to avoid collisions with the electrode surfaces. Although a separation may require time, the ion loss is minimized.

The ions are often provided to FAIMS in a continuous stream from an ionization source. If FAIMS is designed to accept the ions continuously, this beneficially eliminates the need for ion gating to provide pulses of ions at specific windows of time, as is required in conventional drift tube ion mobility spectrometers. Acceptance of a continuous stream of ions minimizes ion loss. Conventional drift tube ion mobility spectrometry typically employs ion gates to introduce ions into a tube through which the ions drift. Arrival times at the end of the drift reflect the drift velocity, hence the low-field ion mobility of the various types of ions. This time-of-flight system is limited because the ions are only introduced to the flight tube intermittently, with concomitant reduction of duty cycle. One embodiment of the invention described here permits continuous acceptance of a flowing stream of ions, and selecting a subset of the stream of ions based both on high-field mobility and the low-field mobility properties of the ions. The ions may be transmitted out of FAIMS in a time-dependent fashion related to their low-field mobility, or a selected ion may be transmitted after removal of ions with other than the selected low field mobility.

This invention describes a means for gating a continuous stream of ions using segmented FAIMS. All ions are pre-separated by FAIMS. A time-limited portion of ions can be gated using segmented FAIMS, by controlling a stopping voltage within certain parts of the segmented FAIMS. In this way, the present invention illustrates that a packet of ions can be isolated and trapped prior to release for separation using a time-of-flight system based on a transport by sinusoidal waves traveling along the length of a segmented FAIMS. Separation using this mechanism in a cylindrical geometry FAIMS is highly efficient because of the focusing mechanism that helps minimize the collisions of the ions with the electrode walls.

Numerous other embodiments may be envisaged without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of separating ions, comprising:

providing a segmented analyzer region having an average ion flow path;

during a period of time, providing within the analyzer region an electrical field component that is directed along a direction normal to the average ion flow path, for selectively transmitting within the analyzer region ions having predetermined high field mobility properties; and,

during the period of time, providing within the segmented analyzer region an electrical field component that is directed approximately along the average ion flow path, for at least partially separating the selectively transmitted ions in space along the average ion flow path in dependence upon the low field mobility properties of the selectively transmitted ions.

2. A method of separating ions according to claim **1**, wherein the strength of the electrical field component that is directed approximately along the average ion flow path one of increases and decreases along the average ion flow path.

3. A method of separating ions according to claim **1**, wherein the strength of the electrical field component that is directed approximately along the average ion flow path is approximately constant along the average ion flow path.

4. A method of separating ions according to claim **1**, wherein the electrical field component that is directed approximately along the average ion flow path comprises a train of repeating voltage waveforms, the electrical field strength one of increasing and decreasing smoothly along each one of the train of repeating voltage waveforms.

5. A method of separating ions according to claim **4**, comprising translating the train of repeating voltage waveforms along a direction of the average ion flow path during the period of time.

6. A method of separating ions according to claim **1**, wherein the electrical field component that is directed approximately along the average ion flow path comprises a train of sinusoidally varying repeating voltage waveforms.

7. A method of separating ions according to claim **6**, comprising prior to the period of time, gating ions having the predetermined high field mobility properties into the segmented analyzer region.

8. A method of separating ions according to claim **1**, comprising subsequent to the period of time, changing the electrical field component that is directed approximately along the average ion flow path for supporting extraction of the at least partially separated selectively transmitted ions in an order relating to the low field mobility properties of the ions.