ION FUNNEL DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Serial No. 62/010,036, filed June10, 2014, titled "RECTANGULAR ION FUNNEL," and to U.S. Application Serial No. 14/733,517, filed June 8, 2015, titled "ION FUNNEL DEVICE" hereby incorporated by reference in its entirety for all of their teachings.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] This invention was made with Government support under Contract DE-AC05-76RL01830 awarded by the U.S. Department of Energy and Grant R01-GM099549 awarded by the National Institutes of Health. The Government has certain rights in the invention.

TECHNICAL FIELD

[0003] This invention relates to ion funnels. More specifically, this invention relates to an ion funnel device wherein a first pair of electrodes and a second pair of electrodes are positioned in different directions.

BACKGROUND

[0004] The ion funnel has become a well-established interface for enabling the manipulation and focusing of ions between an ion source at the entrance of the ion funnel and an ion mobility or other ion manipulation device at the exit of the ion funnel. Current ion funnel interfaces, which have circular ring electrodes with a focusing lens at the exit, as

CLAIMS

We claim:

1. An ion funnel device comprising:
    a. a first pair of electrodes positioned in a first direction;
    b. a second pair of electrodes positioned in a second direction; and
    c. a RF voltage source and a DC voltage source, wherein a RF voltage with a superimposed DC voltage gradient is applied to the first pair of electrodes, and wherein a DC voltage gradient is applied to the second pair of electrodes and a RF voltage is not applied to the second pair of electrodes.
2. The ion funnel device of Claim 1 wherein each of the electrodes in the first direction has a RF phase that is shifted approximately 180 degrees from an adjacent first direction electrode.
3. The ion funnel device of Claim 1 wherein the first pair of electrodes are positioned in a y direction, and the second pair of electrodes are guard electrodes positioned in a x direction.
4. The ion funnel device of Claim 1 wherein an outlet of the ion funnel device is coupled to one of the following: an ion mobility device, a separate ion funnel device, and a mass spectrometer device.
5. The ion funnel device of Claim 1 wherein an inlet of the ion funnel device is coupled to a separate ion funnel device or an ion source.
6. The ion funnel device of Claim 1 wherein the RF frequency applied to the electrodes is in the range of 0.1 kHz to 50 MHz.
7. The ion funnel device of Claim 1 wherein the RF amplitude applied to the electrodes is in the range of 1V to 500 V.

8. The ion funnel device of Claim 1 wherein the distance between each pair of electrodes varies from the inlet of the ion funnel device to the outlet of the ion funnel device.
9. The ion funnel device of Claim 8 wherein the diameter at the outlet of the ion funnel device is smaller than the diameter at the inlet of the ion funnel device.
10. The ion funnel device of Claim 1 wherein the shape of the electrodes is at least one of the following: rectangular, circular, semicircular, and curved.
11. The ion funnel device of Claim 1 wherein ions moving through the device travel in a third direction, wherein the first direction, the second direction, and the third direction are different.
12. A method of making an ion funnel comprising:
    a. positioning a first pair of electrodes in a first direction;
    b. positioning a second pair of electrodes in a second direction;
    c. applying a RF voltage with a superimposed DC voltage gradient to the first pair of electrodes; and
    d. applying a DC voltage gradient to the second pair of electrodes without applying a RF voltage to the second pair of electrodes.
13. The method of Claim 12 wherein each of the electrodes in the first direction has a RF phase that is shifted approximately 180 degrees from an adjacent first direction electrode.
14. The method of Claim 12 wherein the first pair of electrodes are positioned in a y direction, and the second pair of electrodes are guard electrodes-positioned in a x direction.
15. The method of Claim 12 wherein an outlet of the ion funnel device is coupled to one of the following: an ion mobility device, a separate ion funnel device, and a mass spectrometer device.
16. The method of Claim 12 wherein an inlet of the ion funnel device is coupled to a separate ion funnel device or an ion source.

17. The method of Clam 12 further comprising providing a DC bias range from approximately -10 to approximately +10 V for an inlet of the device, and a DC bias range from approximately 1 to approximately 3 V for an outlet of the device.

18. The method of Claim 12 wherein the RF frequency applied to the electrodes is in the range of 0.1 kHz to 50 MHz.

19. The method of Claim 12 wherein the RF amplitude applied to the electrodes is in the range of 1V to 500 V.

20. The method of Claim 12 wherein the device is formed on a printed circuit board.

21. The method of Claim 12 wherein the distance between each pair of electrodes varies from the inlet of the ion funnel device to the outlet of the ion funnel device.

22. The method of Claim 21 wherein the diameter at the outlet of the ion funnel device is smaller than the diameter at the inlet of the ion funnel device.

23. The method of Claim 12 wherein the shape of the electrodes is at least one of the following: rectangular, circular, semicircular, and curved.

24. The method of Claim 12 wherein ions moving through the device travel in a third direction, wherein the first direction, the second direction, and the third direction are different.

25. An ion funnel device comprising:

    a. a first pair of electrodes positioned in a first direction;

    b. a second pair of electrodes positioned in a second direction; and

    c. a RF voltage source and a DC voltage source, wherein a RF voltage with a superimposed DC voltage gradient is applied to the first pair of electrodes, wherein only a DC voltage gradient is applied to the second pair of electrodes, and wherein ions moving through the device travel in a third direction.