Structures for Lossless Ion Manipulations Device as an Ion Mobility Filter

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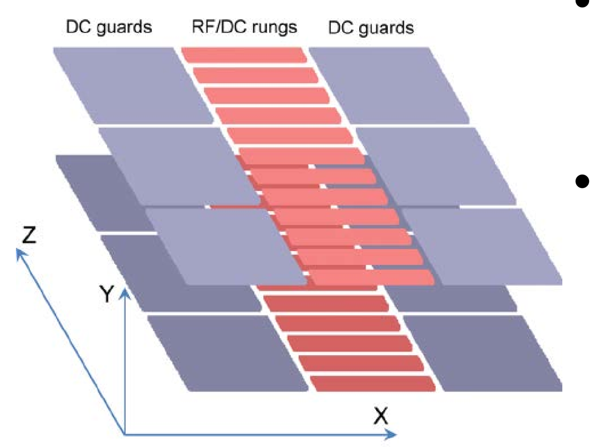
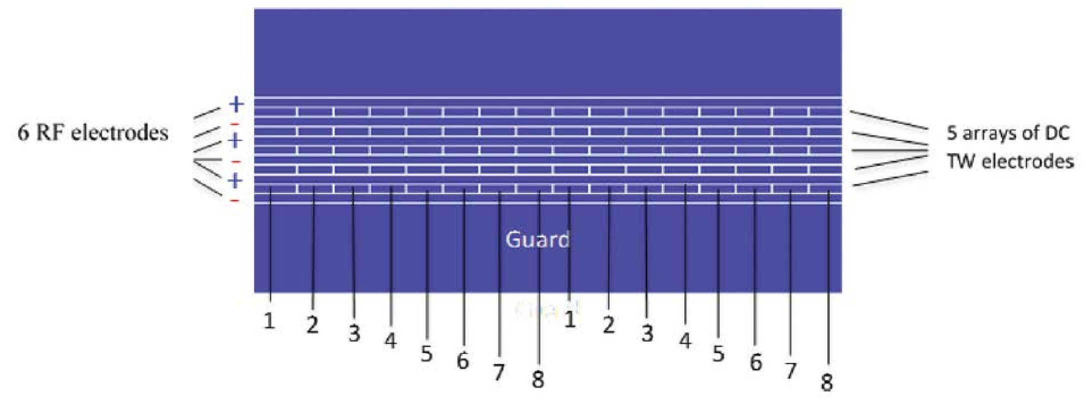
Overview

- Demonstration of a novel ion mobility Filtering capability (removing all other ions except the ions of interest based on their mobility) in a SLIM device.
- Functions utilizing the combined action of constant DC gradient and traveling waves to achieve ion mobility filtering.
- The SLIM Filter utilizes two sections, the first section filters (i.e., removes) low mobility ions while the second section filters high mobility ions.

Introduction



- Electrode arrangement of a constant DC field SLIM [1].
- RF voltages applied 180 degrees out of phase alternatively to the rung electrodes allow confinement along y axis
- A DC potential gradient superimposed on rung electrodes to enable directed ion motion along z axis.
- DC guard voltages allow confinement along x axis.

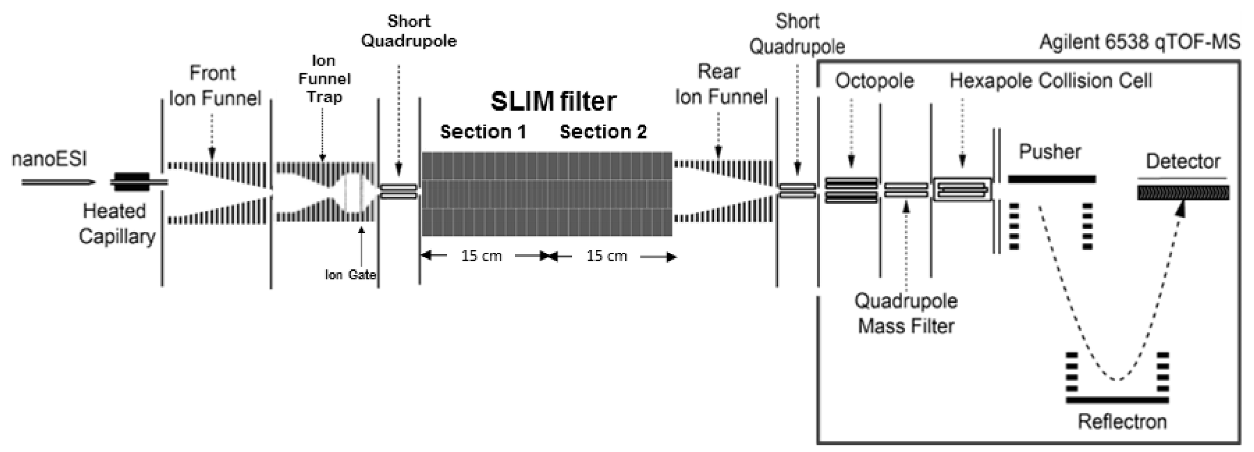


- In a Traveling wave SLIM, instead of a DC potential, a traveling wave defined by 8 electrodes enable ion motion along z axis.

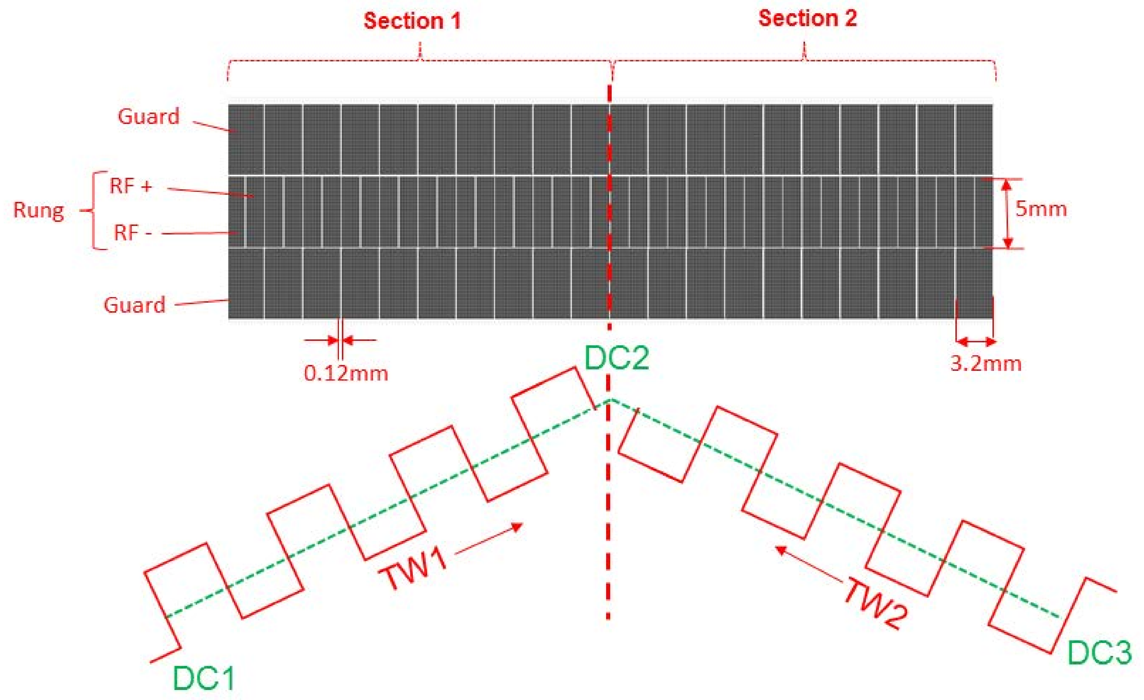
The SLIM filter combines constant DC filed and traveling wave SLIM.

Methods

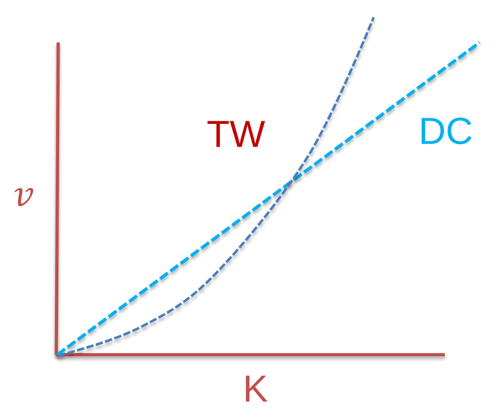
Experimental setup



Simulations



- Section 1 has a negative DC gradient and forward TW. Section 2 has a positive DC gradient and a reversed TW.

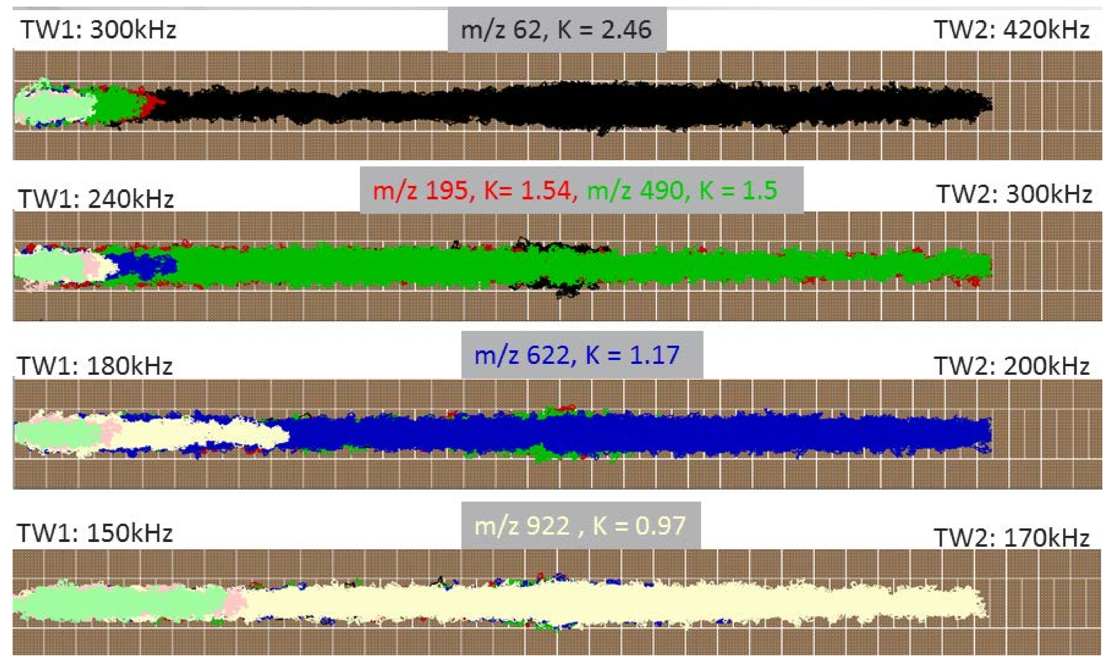


Plot illustrates ion velocity vs mobility [3]

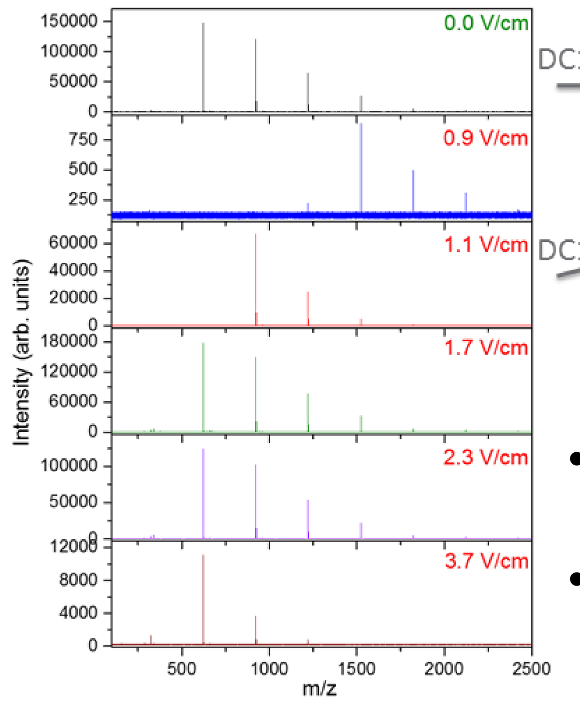
- Lower mobility species are filtered in the first section.
- Higher mobilities are filtered in the second section.
- A balance between the first and the second section accomplish the filter capability.

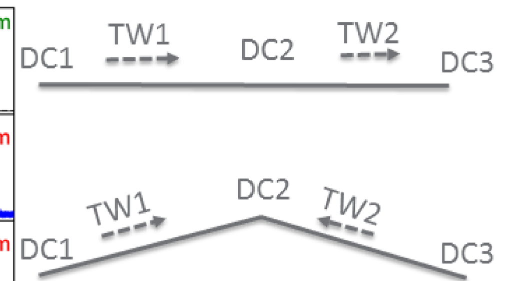
Results

Simulations



Effect of DC gradient on the Filter

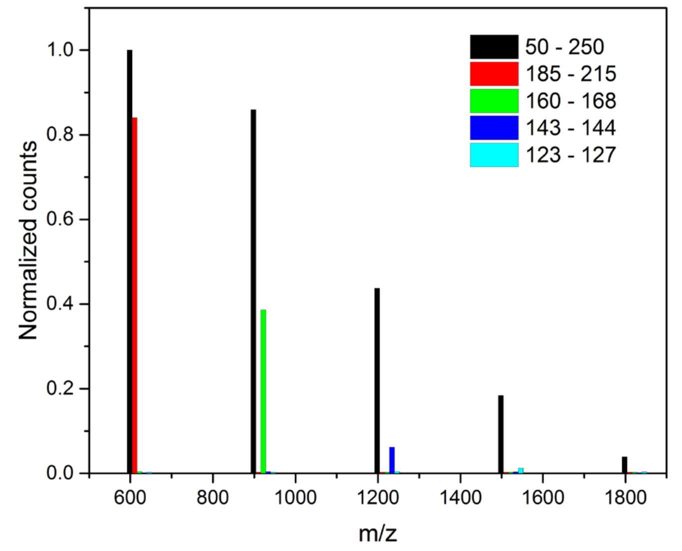




Panel 1 (top): Normal mode
Panel 2-6: Filter mode

- Agilent tune mix was used to characterize the filter.
- Got the full spectra with maximum intensity with 1.7 V/cm gradient.

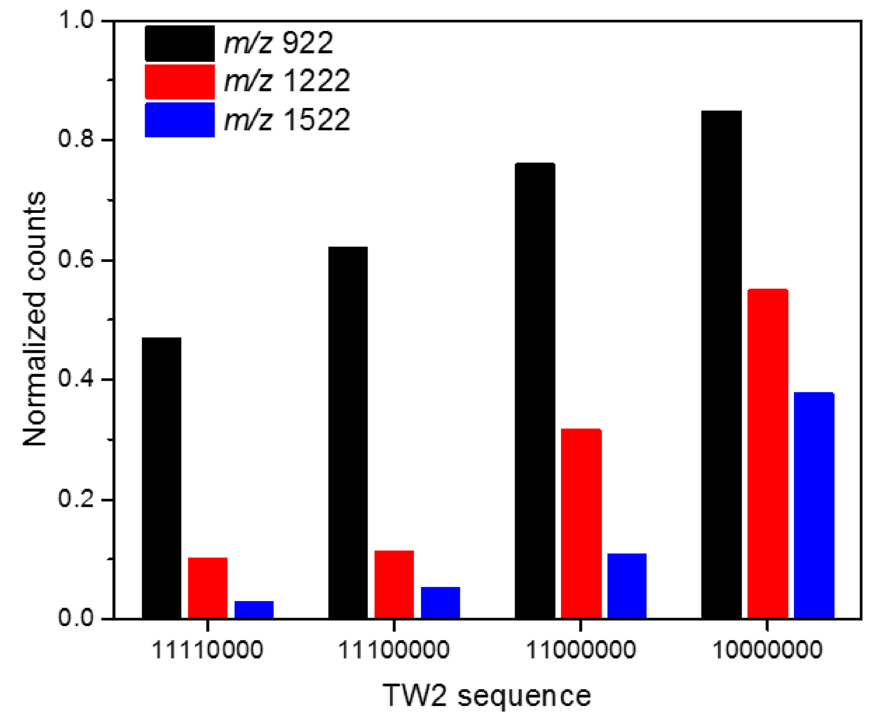
Effect of TW frequency



- Filtering can be achieved by keeping the TW amplitude and DC gradient on both sections same while adjusting the TW frequencies.

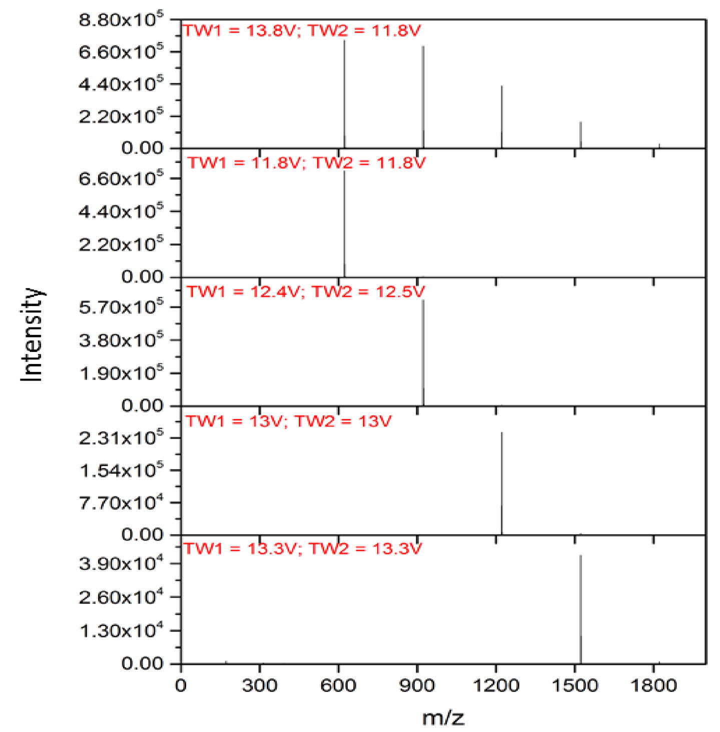
Effect of TW sequence

- 8 electrodes define a traveling wave sequence.
- 11110000 sequence found to be the best for TW1.



- 10000000 TW2 sequence found to be having best transmission.

Effect of TW amplitude



- The filter was achieved by keeping the TW1 frequency at 19kHz, TW2 frequency at 120kHz, TW1 sequence at 11110000 and TW2 sequence 10000000. The TW amplitude was suitable adjusted to choose the ion species of interest to pass through.

Conclusions

- Demonstrated the ion mobility filtering capability of SLIM device utilizing both simulations and experiments.
- Simulations show that filtering is achieved using a balance between velocity due to traveling wave and the opposing DC gradient in both sections.
- Experiments show that a 11110000 sequence for TW1, and a 10000000 sequence for TW2, and by adjusting TW amplitude on both sections, results in filtering with minimal losses.
- Further improvement of the SLIM filter is anticipated using multiple sections.

References

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2. AM Hamid, Ibrahim, Y.M., Garimella, S.V., Webb, I.K., Deng, L., Chen, T.-C., Anderson, G.A., Prost, S.A., Norheim, R.V., Tolmachev, A.V., Smith, R.D. Anal Chem., 2015, 87, 11301 .
3. Shvartsburg, A.A., Smith,R.D, Anal. Chem., 2008, 80 (24), 9689 - 9699

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