Multi-anode detector in mass spectrometer

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OVERVIEW

- New design of a 100-anode detector
- Three dimensional information about peptide ions by using this multi-anode detector

INTRODUCTION

One common way for acquiring signal in a TOF mass spectrometer is using a counting detection scheme (time-to-digital converter, TDC). A problem with this method is that the electronics cannot distinguish two or more particles arriving simultaneously at the detector. This prevents the detection of more than one particle for each mass in one cycle. Multi-anode detectors have been developed to solve this problem and increase the dynamic range of the detector. So far, 4-anode detectors have been investigated[1]. In addition, a multianode microchannel plate (MCP) based detector with completely independent anodes is a powerful tool to measure the spatial distribution of a large number of incident particles simultaneously hitting the detector[2]. In this work, a 100-anode detector was constructed. We successfully solved the problem of cross talk between the anodes and gained spatial information about ion packets.

METHODS

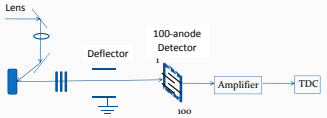
The multi-anode detector is mounted onto a MALDI TOF mass spectrometer. For the detector design, a circuit board with 100 anodes on 1mm center to center spacing was placed behind a pair of rectangular microchannel plates. Preamplifiers plug into the edge of the anode board and consist of a gain stage and a high speed comparator with adjustable threshold. Also, there is an auto-zero circuit that compensates for the offset of the amplifier and comparator. The differential output of the comparator is read out by a 128 channel multihit TDC (V1190A, CAEN Technologies, Inc.).

Peptide samples were prepared in 40pmol/μl, and 0.5μl of this solution was spotted on a MALDI plate. When the spots were dry, 0.5μl of matrix solution was applied on top.

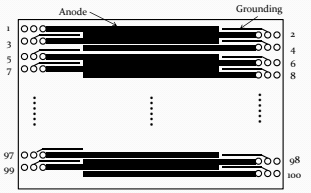
RESULTS

1. Instrument design

(A) The diagram of the MALDI-TOF apparatus

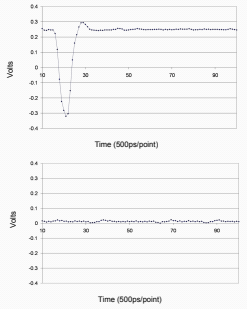


(B) The design of the printed circuit board (PCB)



2. Validation of the printed circuit board (PCB)

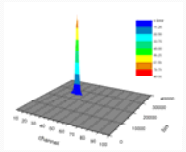
A 3 nanosecond, 100 mV pulse from a commercial pulse generator was applied to the center of anode 67. Amplified signals were recorded with a fast waveform digitizer for anode 67 (Top) and the adjacent anode, anode 68 (Bottom).



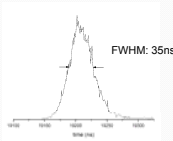
- The fast signal can be transferred without any distortion.
- The anodes are independent and cross talk is not observed.

3. Tests with peptide ions

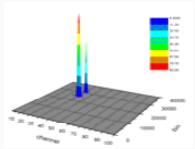
(A) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5)



(B) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5) from anode 31



(C) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5) and Fibrinopeptide A (ADSGEGDFLAEGGGVR, m/z=1536.5)



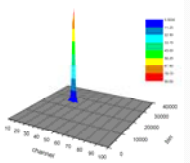
- Three dimensional information was obtained with peptide ions.
- All the anodes can be accessed by changing the voltage on the ion deflector .

REFERENCES

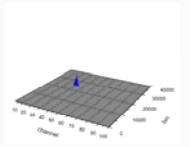
1. Barbacci, D. C.; Russell, D. H.; Schultz, J. A.; Holocek, S.; Ulrich, S.; Burton, W.; Van Stipdonk, M.. J Am Soc Mass Spectrom 1998, 9, 1328-1333.
2. Bouneau, S.; Cohen, P.; Della Negra, S.; Jacquet, D.; Le Beyec, Y.; Le Bris, Y.; Pautrat, M. Rev. Sci. Instrum. 2003, 74, 57-67.

4. Charging effect

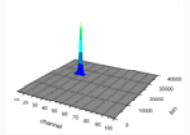
(A) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5) in normal conditions.



(B) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5) after the detector was charged up with matrix ions and peptide ions for 2 hrs



(C) MALDI-TOF spectrum of Angiotensin II (DRVYIHPF, m/z=1046.5) after deflecting matrix ions out of the detector for 6 hrs



- A temporary reduction in detection sensitivity was observed after continuous intense ion signals over a period of time
- Charging effect was minimized by deflecting matrix ions off the detector in which case the detector can maintain its sensitivity for 6 hrs

CONCLUSIONS

- A new 100-anode detector was constructed and successfully tested on a MALDI-TOF apparatus
- Fast signals can be transferred without any distortion and the cross talk between anodes was eliminated.
- Three dimensional information about ion packets was generated.
- The charging effect was considerably reduced by deflecting most of the matrix ions off the detector.