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The computer controlling of the time delay of the extraction of ions from the ion source of the TOF mass spectrometer

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Abstract

Computer control of time delay of the extraction of ions from the ion source of the TOF mass spectrometer is presented. Owing to the computer, the user has the full control of power parameters and ion current delay, which is about microseconds.

1. Introduction

The idea of the TOF MS (Time of Flight Mass Spectrometer) is given in Fig. 1 [1-3]. The ion system consists of the sample holder, two pairs of deflecting electrodes, the reflectron and the detector. The focused, pulsed beam of the nitrogen laser (LN300C Laser Photonics, λ = 337nm, the width of a pulse Δt = 5 ns, the maximal power - 50 kW) is used to light a sample placed on the sample holder [4].

The generated ions are accelerated in the electric field between the sample holder and the grounded flat electrode. The accelerated ions move between the deflecting electrodes for correction of their trajectory. After that, they go through the field free region and the reflectron to the detector. The signal from the detector is directed to the oscilloscope, which is triggered by the laser signal.

The ions separation proceeds with regard to their velocity. Ions with the greater mass (m) to charge (z) ratio achieve lower velocities and their time of flight from the ion source to the detector is adequately longer. Thus the ion packet created in the ion source as a mixture of different ions is separated into series of packets dependening on the mass to charge ratio.

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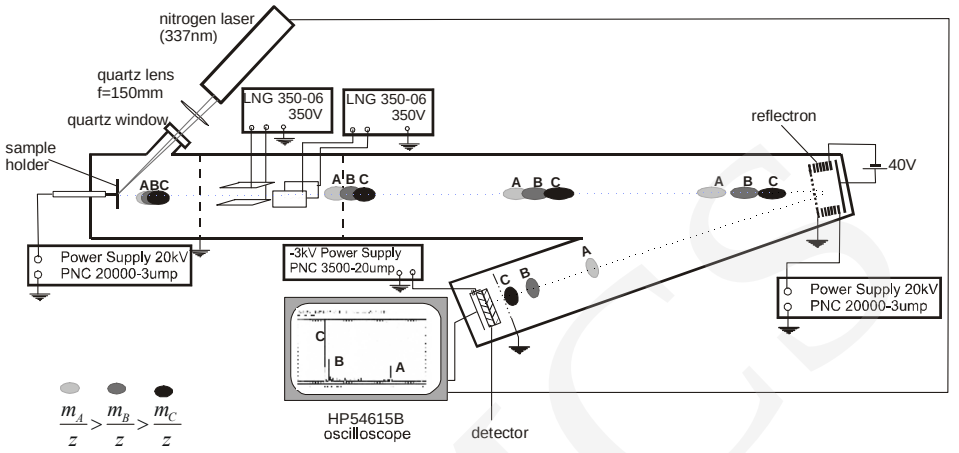

Fig. 1. The TOF MS scheme and the idea of ions formation and separation

2. The computer controlling of the time delay of ions extraction

In the measurement process the electric field between the sample holder and the grounded flat electrode is usually set before the sample is lighted by the laser beam. The generated ions during the laser desorption ($\Delta t = 5$ ns) are immediately accelerated and fly to the detector. Thus they are created in a very short time and an abundance of ions produced by ion/molecule reactions in the ion source is adequately low. To increase this abundance the time delay between the laser shot and turning on the acceleration voltage should be applied.

To achieve the time delay in the order of microseconds the computer program controlling the TOF MS working under the Windows 98 was used [1-2]. This operating system offers some tools to measure the time. The most common is *TTimer* [5]. Theoretically, it allows to time with 1 ms accuracy while using the Delphi software. Practically, the operating system Windows 9x generates *TTimer* every 55 ms (for comparison the Windows NT/2000/XP generates it every 10 ms). Moreover, *TTimer* has the lowest priority, which means that it depends on the system load to a great extent and has a very low resolution. Another function of the operating system Windows 9x, which allows to count milliseconds, is *GetTickCount* [5]. To count shorter times than milliseconds other functions are needed. These functions are:

- *QuertyPerformanceFrequency*
- *QueryPerformanceCounter* [5].

The *QueryPerformanceFrequency* and *QueryPerformanceCounter* functions retrieve the frequency and the current value of the high-resolution performance counter, respectively. Using these functions with a computer (Pentium III 700MHz CPU) it is possible to count times with 10^{-5} s resolution.

To obtain times lower than 10^{-5} s the assembler language must be used. To get the high time resolution and accurated measurements all interrupts under the operating system should be turned off. Then, it is certain that the computer cannot start other processes while measuring the time. Such a start of any process would cause the failure of the time measurement. To do this, the assembler functions as *cli* (disabling interrupts) and *sti* (enabling interrupt) must be used. Using assembler language it is possible to obtain times in the order of 5.6×10^{-7} s.

The next time delay is the time of the voltage increasing in the power supply to set the electric field in the ion source. To increase the voltage from 0 V to 15kV the time of about 1 μs is needed (Fig. 2). As measurements have shown the meaningful ion current appears when the accelerating voltage value is about 4 kV – Fig. 3 [6].

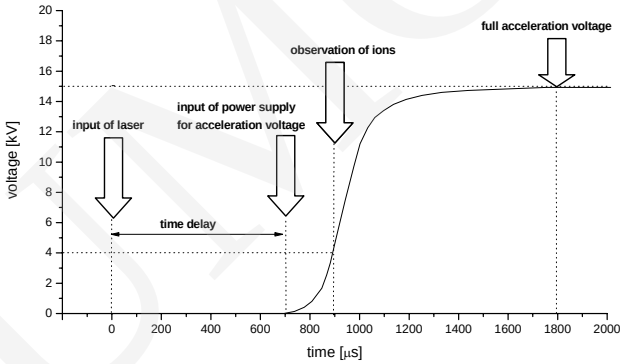

Fig. 2. The increase of acceleration voltage as a function of the time

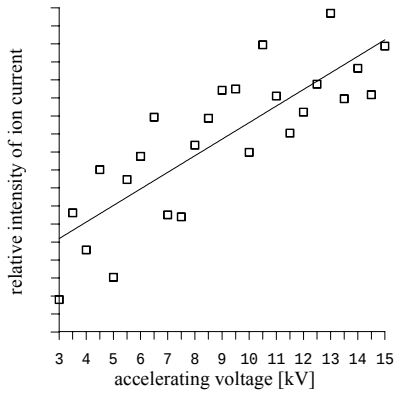

Fig. 3. Relative intensities of the ion current as a function of the accelerating voltage

To achieve the accelerating voltage of 4 kV the time in range of 200 μs is needed. This time must be taken into account during work with the mass spectrometer.

3. Results

2,5-dihydroxybenzoic acid was used to study the influence of the time delay between the laser shot and turning on the accelerating voltage on the intensity of the ion current. The intensity of the ion current was measured for different time delays. The results of these measurements are shown in the mass spectra in Fig. 4. Each spectrum is an average of measurements obtained for successive 16 laser shots. In these mass spectra there are seen many ion peaks from the 0-25 μs time of flight range. The effect of the time delay between the laser shot and turning on the accelerating voltage is observed for all ions. Especially it is evident for the ions whose time of flight from the ion source to the detector is 24 μs (m/z = 308). These ions are generated as a result of ion/molecule reactions.

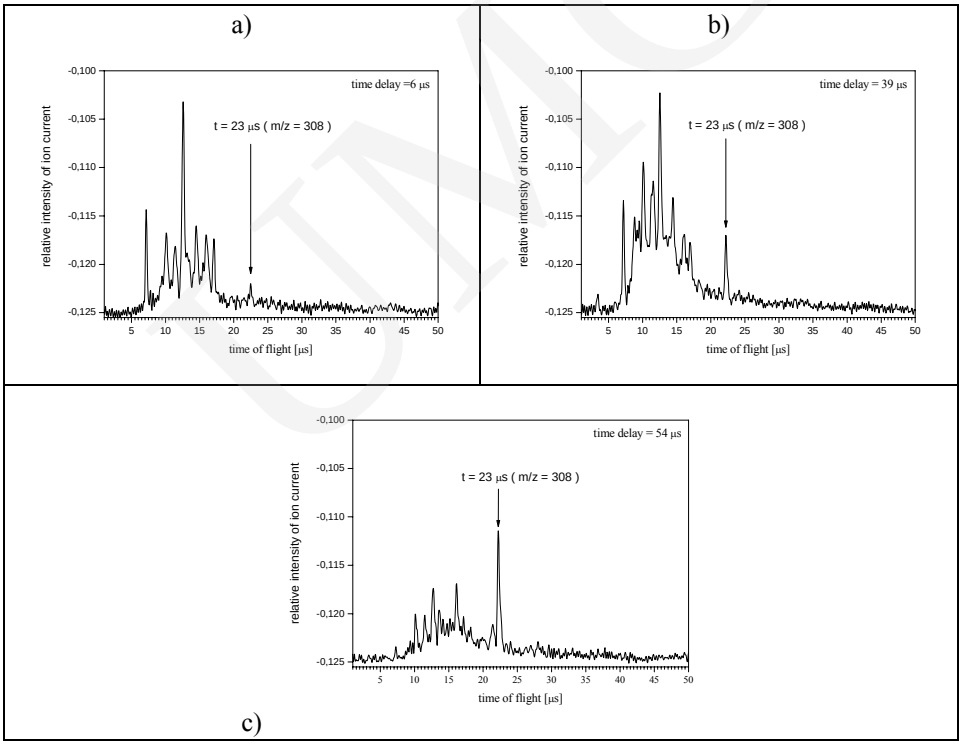

Fig. 4. Relative intensity of the ion current of 2,5-dihydroxybenzoic acid. The time delay between the laser shot and turning on the accelerating voltage: a) 6 μs, b) 39 μs, c) 54 μs

From the physical point of view the longer time delay allows to observe ions that are not seen in the case of lack of the time delay (Fig. 4). It means that the time delay of extraction of ions from the ion source gives the opportunity of studies of ions which do not appear without this time.

4. Conclusions

Owing to the use of the computer program operating the TOF MS it is possible to create the time delay between one laser shot and the accelerating voltage. It increases opportunities of the mass spectrometer. The time resolution achieved allows to use time delays in the range of microseconds.

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