Optimization Of A Mass Spectrometry Process

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Abstract. In this paper we present and discuss a system developed in order to optimize the mass spectrometry process of an ion implanter. The system uses a PC to control and display the mass spectrum. The operator interacts with the I/O board, that interfaces with the computer and the ion implanter by a LabVIEW code. Experimental results are shown and the capabilities of the system are discussed.

Keywords: Ion Implanter, LabVIEW, Mass Spectrum
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INTRODUCTION

Ion implantation is a materials engineering process by which ions can be introduced into any material, thereby changing their properties. One of the most relevant advantages of ion implantation is the selectivity of the implanted chemical species and in most of the cases isotope selection is easily achievable. In this sense mass spectrometry is fundamental to guarantee beam purity avoiding the contamination of the implanted samples [1-4]. The ion implanter installed at Instituto Tecnológico e Nuclear (ITN) is dedicated to materials research which makes isotope selection an important requirement. The system previously installed allowed printing the mass spectrum in a plotter, after deflecting the ion beam through a magnetic field controlled manually through the current source.

In this work we describe a new system developed to control the mass spectrometry through a PC application. The mass spectrum is given through the PC allowing an instantaneous analysis and correction of the experimental parameters in order to maintain the beam purity.

SYSTEM DESCRIPTION

The high current ion implanter installed at ITN, Sacavém, Portugal, represented in Figure 1, is the model 1090 of Danfysik [5-6]. The operating flexibility of the ion source (gas and sputter version), makes possible the production of ion beams from nearly all elements of the periodic table [7]. However, for safety reasons, radioactive or very hazardous elements are not handled.

The maximum ion beam acceleration voltage is 210 kV (160 kV post-acceleration plus 50 kV extraction). The acceleration tube is specially developed to minimize space charge effects and hence avoid expansion of the beam in an uncontrolled manner. Furthermore, by blocking back streaming electrons it minimizes X-ray emission from the acceleration section. With an electromagnetic two-dimensional beam scanning system the ion beams may be scanned for homogenous exposure over large areas. The maximum beam scanning area depends on the mass-energy product.

The global record of all the extracted ion species from the source (i.e. a mass spectrum) requires two signals, one proportional to the analyzing magnet magnetic field (x-axes) and another proportional to the beam current intensity (y-axes). The first signal is taken from a voltage proportional to the analyzing magnet current, available from the magnet power supply. The use of this signal comprises two difficulties: (i) the magnet current has hysteresis, thus it is advisable to continuously scan the current during a mass spectrum; (ii) the analyzing magnet is located on the post-acceleration potential. Therefore, an optic-

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fiber based circuit was developed to send the magnet current signal to the ground potential.

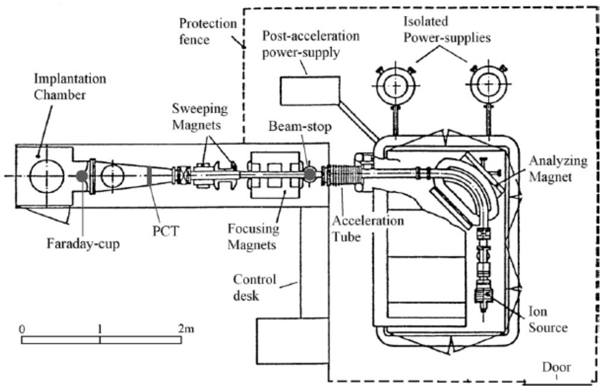

FIGURE 1. Layout of the high-current ion implanter installed at the Nuclear and Technological Institute, Sacavém, Portugal.

To carry out this control system a personal computer was equipped with multifunction input/output board from National Instruments, model USB-6251. Those boards have both analog inputs and outputs. The program that was chosen for this work was National Instruments LabVIEW, a graphical programming language specially created for instrumentation and measurement [8].

In FIGURE 2 we show the display of the application created. It has buttons to control the ion implanter and indicators (numerical and graphical). The application developed allows the control of the ion implanter through a PC and the exportation of the data obtained with the mass spectrometry.

As already mentioned, the mass spectrometry is essential step of ion implantation in order to make a precise selection of the implanted isotope. With this system, the mass spectrometry PC application displays the mass spectrum and offers the possibility to analyze online the results. The developed system still requires that the operator calculates the values for calibration. For this purpose, the user needs the values of two different elements. Usually the value obtained for Hydrogen (lowest calibration peak) is used, because it is the first deflected element by the analyzing magnet, together with the signal from the gas used in the ion source, usually Argon (highest calibration peak) which is the most intense ion current in the beam. The developed application allows for the user to save two files related to the obtained mass spectrometry: (1) a text format file with all the x-y data acquired by the DAQ; (2) a bmp format file with the mass spectrometry obtained. The txt file is extremely important because it provides the correct values to be used in the calibration calculation. The bmp file gives the user the possibility to study the mass spectrum and use it without printing, allowing a careful analysis with the help of a simple design program.

It is essential to mention that the files saved by the program will permit that the user gets a more accurate calibration reducing errors, and also reducing the time needed for this procedure.

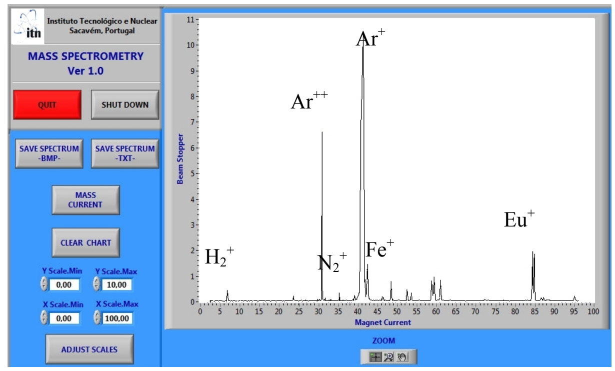

FIGURE 2. User interface of the control and monitoring application.

CONCLUSIONS

In this paper we presented the control system developed to improve the mass spectrometry of the ion implanter used by ITN for scientific research. The system used a personal computer, one multifunction input/output board, some custom made electronic interface modules and a LabVIEW application.

One of the goals was to acquire the signals of the ion implanter and give the information to the user through a PC. Currently, the user is able to: (i) observe the mass spectrometry through the PC; (ii) acquire x-y values with more accuracy; (iii) calculate the calibration more efficiently and quickly; (iv) print the mass spectrometry when desired, as it is saved automatically by the system.

The next step of this work is the full automation of the mass spectrometry. For that the system must be able to be self-calibrating. Another goal to achieve is the automatic identification of the elements in the mass spectrometry so any user can be able to know which element is present in the ion beam.

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