Estimate of the concentration of implanted ions in solid substrates using a web application

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Estimate of the concentration of implanted ions in solid substrates using a web application

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Abstract. The three-dimensional ionic implantation technique (3DII) is used to modify the surface of solid metal by electric discharges pulsed of high voltage at low pressures. Knowing the density of ions implanted in the surface of a functional element, in a faster and estimated way, will help to optimize the surface treatment technique. Therefore, a web application was developed which from experimental parameters established in a process 3DII estimates the concentration of ions implanted in solid metal substrates. The results obtained in this research work demonstrate the feasibility of the computational web tool to perfect the experiments of surface modification by ion implantation.

1. Introduction

The modification superficial consists in alter the composition and structure of materials either by creating a coating (with typical thicknesses of a few microns) or by introducing new elements into the surface (dopant ions) in nanometric depths [1].

The three-dimensional ion implantation (3DII) [2] is a superficial modification process generated by high voltage discharges at low pressures, which turns on in the left branch of the Paschen curve, and it is used as an alternative to improve physical and chemical properties of materials [3-6]. The pioneers in the study of this type of discharge were Klarfeld and Pokrovskaya-Soboleva [7] and McClure [8]. The reactor JUPITER (Join Universal of Plasma and Ion Technologies Experimental Reactor) [9] is the only equipment built based on this technology that allow the implantation of ions in solid substrates of metallic and non-metallic species. The parameters that characterize the implementation are: the ion's type, the ion's energy and the implanted dose [1, 2, 10-12].

The calculation of superficial density of ions implanted in some material depends mainly of time of treatment, density of ionic current, repetition frequency and pulse duration, the secondary emission ion-electron coefficient of material and the area of the cathode. This paper presents a computational tool, which allows us estimate the value for implanted dose on the surface of solid substrates after a process of surface modification by ion 3DII. These calculations are faster and correct that traditional form. The web application is the result of a technological applied research, which can be used at any time, from anywhere, in different electronic devices (computers, tablets, mobile phones, etc.).

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2. Methodology

The estimation of superficial implanted dose of a material using the web application is carried out according to the scheme presented in Figure 1.

In first place the experimental data are acquired from the JUPITER reactor, this data correspond to the data and image of the voltage and current pulses of electrical discharge used in the ion implantation process. These data and image are introduced into the web application for subsequent scanning and digitalization; after the graphics are displayed, next the user proceeds to set the pulse width depending on the region of interest, then the total electrical charge is estimated using the method proposed in [12]. Finally, the superficial implanted dose of solid substrates is estimated.

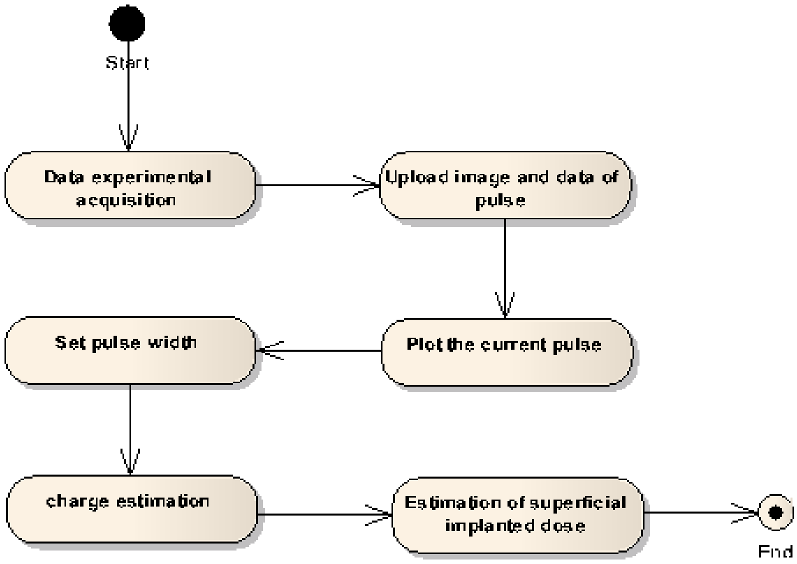

Figure 1. Methodology of estimation superficial implanted dose.

3. Results - web application

The algorithm for the estimation of surface ion implantation was developed in JAVA, the web application was implemented in Java Server Pages (JSP) using Google Chart to plot and digitize the pulse of the implementation process.

The process begins with the acquisition of data and image pulse, after the user upload the information into the web app, he has the possibility of set the pulse width and provide the input data (experimental parameters of the ion implantation process) which are: frequency (f) of the discharge pulse (Hz), total time (t) of the discharge (s), total area (A) exposed (cm^2), number of ion of the charge (Ze) and the secondary emission coefficient (γ). The web application calculates the total pulse charge (Q) [4] and the dose approximate of ions implanted superficially using the Equations (1)-(6).

$$n = f * t \tag{1}$$

$$Q_T = Q * n \tag{2}$$

$$Q_T = Q_i + Q_e \tag{3}$$

$$Q_e = \gamma * Q_i \tag{4}$$

$$Q_i = \frac{Q_T}{\gamma+1} \tag{5}$$

$$D = \frac{Q_i}{A*Ze} \tag{6}$$

Where, n: pulses number. Q_T: total charge transported, Q_i: ionic charge, Q_e: electronic charge.

Next in Figures 2-5 are presented in detail how the calculation of the ions implanted superficially through the web application is performed. Figure 2 shows how to load the image and data pulse will be digitized.

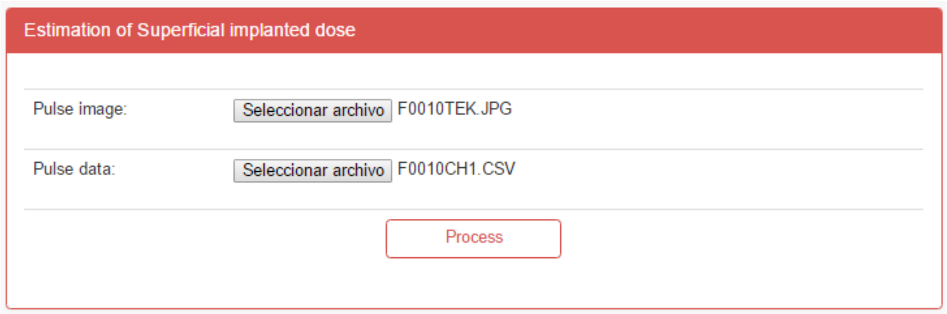

Figure 2. Upload pulse data and image.

In Figure 3, the pulse's image obtained from the reactor JUPITER is presented, the web application shows the graphic of the digitized pulse. The user proceeds to define the pulse width and establish the experimental parameters required in the surface modification process (see Figure 4).

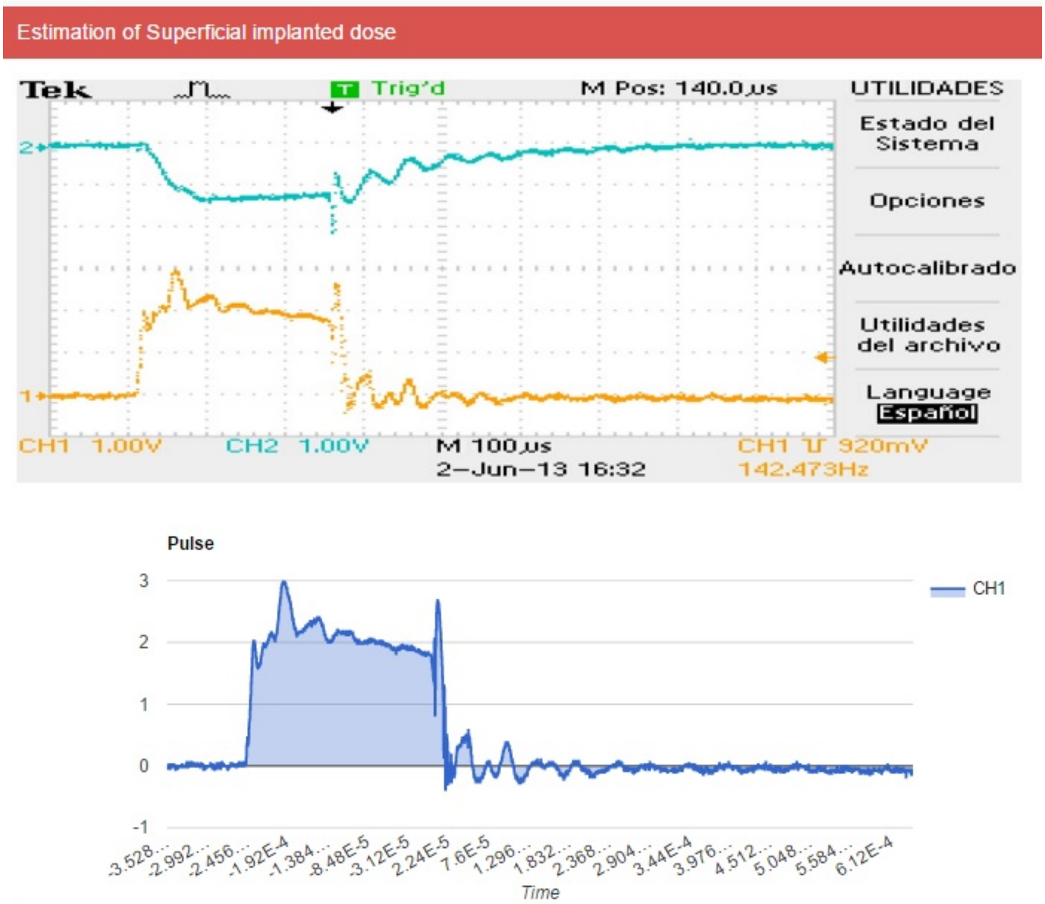

Figure 3. Current pulse plot.

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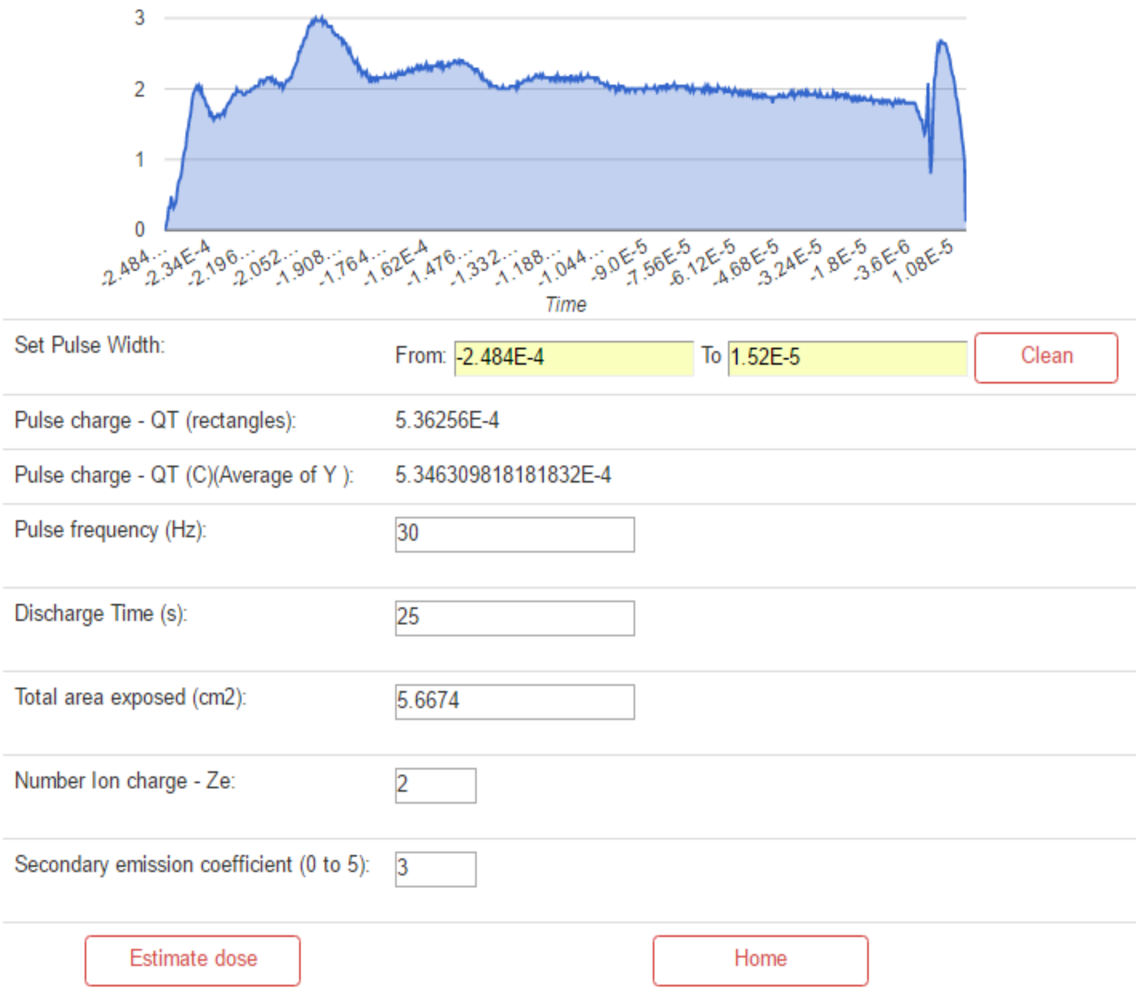

Figure 4. Experimental parameters of the ion implantation process.

Finally, the web application proceeds to estimate the superficial implanted dose according to Equations (1) to (6) and whose value is reported in Figure 5.

Figure 5. Estimation of superficial implanted dose.

4. Conclusions

This paper presents a web application that provides a friendly and easy-to-use tool to estimate the dose of ion concentration implanted in solids. These calculations are faster and more precise than traditional methods.

The construction of computational tools to speed up and improve the calculation of this type of process brings benefits to the Plasma Laboratory. Researchers can focus on other tasks and not spend time making complex calculations which can lead them to inaccurate and faulty implementations.

The calculations for the estimation of the surface dose of ions obtained from the web application are very similar to the theoretical calculations, ensuring that the implemented web application works correctly.

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