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Estimation of the ionic charge of non-metallic species into an electrical discharge through a web application

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Abstract. Estimate the ionic charge generated in electrical discharges will allow us to know more accurately the concentration of ions implanted on the surfaces of nonmetallic solids. For this reason, in this research a web application was developed to allow us to calculate the ionic charge generated in an electrical discharge from the experimental parameters established in an ion implantation process performed in the JUPITER (Joint Universal Plasma and Ion Technologies Experimental Reactor) reactor. The estimated value of the ionic charge will be determined from data acquired on an oscilloscope, during startup and shutdown of electrical discharge, which will then be analyzed and processed. The study will provide best developments with regard to the application of ion implantation in various industrial sectors.

1. Introduction

The three-Dimensional Ion Implantation technique (3DII) [1] performed in the JUPITER reactor [2] is a process of introducing dopant ions from nonmetallic species into metallic solid materials [3-6]. Therefore, change (no change in geometric dimensions) surface and sub-surface layers of solid substrates are subject of great interest in the energy sector, transport and manufacturing [7-10].

The 3DII generated from hybrid discharges of high voltage and electric arc at low pressures, is to make an impact with sufficient energy (between 5 and 60 kV) ions of non-metallic species on the surface of a solid substrate, which penetrate a few nanometric layers making change physical and chemical properties of the surface [11-12]. During travel of the ion into the material, a lot of interaction (collision) with the particles (atoms) composing the solid substrate are produced, which cause a series of collective processes which influence the final distribution of ions, such as the formation of defects, ions tunneling, cascade collisions, sputtering, etc. [13-17].

According to the above and considering that the final concentration of implanted ions is a very important feature of the surface modification by ion implantation [18-20], it is very important to characterize the estimation of the ionic charge in metallic and non-metallic species, moreover, there is a need to understand the complex phenomena that occur during the process. Therefore, the development of a web application with a computer simulation are both really important, especially because we can obtain information that today could not be obtained by other means. That is why it is necessary to develop computational tools that estimate more quickly, accurately and precisely the ionic charge generated in an electric discharge [21].



In this paper, we present EIGE - Estimation of the Ionic Charge Generated in an Electrical Discharge, a free web application that provides an user-friendly tool to estimate the ionic charge generated in an electric discharge. EIGE was developed in a joint effort between the Software Engineering Development Research Group (GIDIS) of the Universidad Francisco de Paula Santander and the Physics and Plasma Technology and Corrosion Research Group (FITEK) of the Universidad Industrial de Santander.

2. Experimental

In this article we use the methodological model proposed in [21] where the experimentation was divided in three phases. These phases allow us to retrieve the required data, processes it using an in-house web application and finally, display the results within the web application.

2.1. Data acquisition

The current pulses versus time during electric high voltage discharge at low pressures were obtained from the experimental parameters set in a process of nitrogen ion implantation into metallic solid substrates. The pulses recorded represent the total electronic charge transported.

2.2. Design and development of web application

A web application is a client-server application where the client runs in a web browser, like Chrome or Firefox. This is a web based application having two-tier architecture. Web application was developed using HTML, Google Charts, Java Server Pages and BootStrap. The latter help us to developing responsive web applications.

The design and development of this web application was made to quickly and accurately calculate the ionic charge generated in electrical discharges from the data acquired of a set of current pulses. Two data sets were required to be uploaded to the web app. Next, the obtained data was digitized and graphed in order to present it to the user. After that, the area under the curve was calculated in both cases, and then their difference was obtained.

2.3. Output data

The estimated data of the resulting area under curve (estimated total ionic charge) is reported through the web application.

3. Web application

A web application was implemented to quickly and accurately calculate the ionic charge from a pulse of electric current and the total electrical charge, both in function of the time. Figure 1 shows the use case diagram describing the available features for the user on the web application.

The web application allows the user to upload two images and two datasets in CVS format (see Figure 2). Each one of these datasets corresponds to the pulses of current that can be captured on an oscilloscope during turn on of the electric high voltage discharge (in this case we use the oscilloscope Tektronix TDS 2002 B).

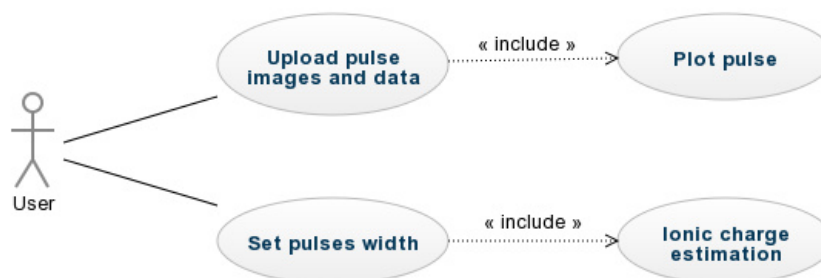


Figure 1. Use case diagram showing the functionality of the system.

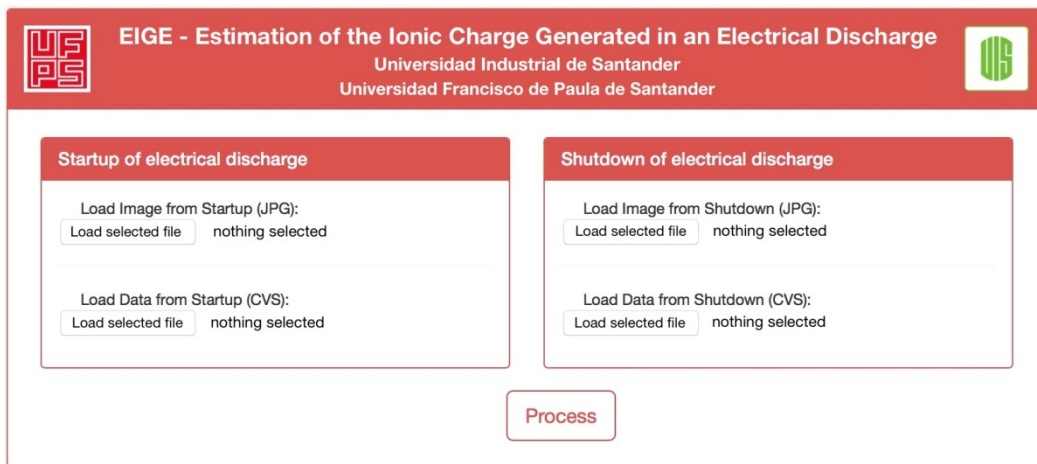


Figure 2. Screen to load the image and the pulse data.

After user loads the required data and clicked in Process button, the web app performs a process of digitization of datasets and graphics. The screen is splitted in two sides, each one presenting the graphic along with the image of the pulses. The web app allows the user to set the maximum and minimum values to determine the pulse width necessary to calculate the area under the curve and estimate the transported load for each pulse (see Figure 3).

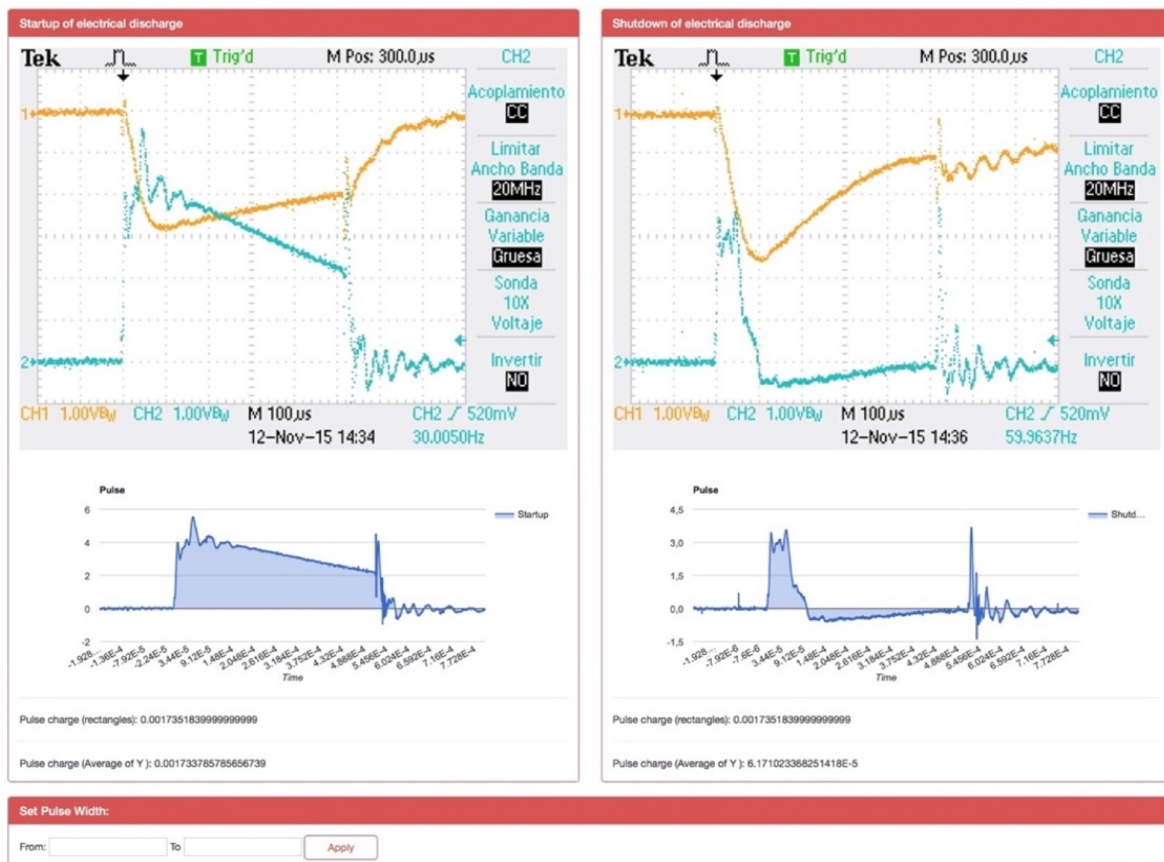


Figure 3. Images and graphics of pulses in the web application.

On top of Figure 3 is shown both pulses images obtained from Tektronix TDS 2002 B oscilloscope. Left one corresponds to the total charge transported during the electric high voltage discharge. Right one corresponds to the electric charge carried out. At the bottom of Figure 3 both pulses are graphed in different charts using our web application (the graph obtained is very similar compared to the graph acquired with the oscilloscope). User can filter the pulse width. In this case, user enter the required data corresponding to the X axis (Figure 4).



Figure 4. Pulse width adjusted by user.

Finally, user clicked the Next button to show both charts mixed in one chart, so the user can quickly identify the calculated area, corresponding to the ionic charge. Values entered in pulse width text box are kept in this chart. Finally, the estimated value of the ionic charge is presented (Figure 5).

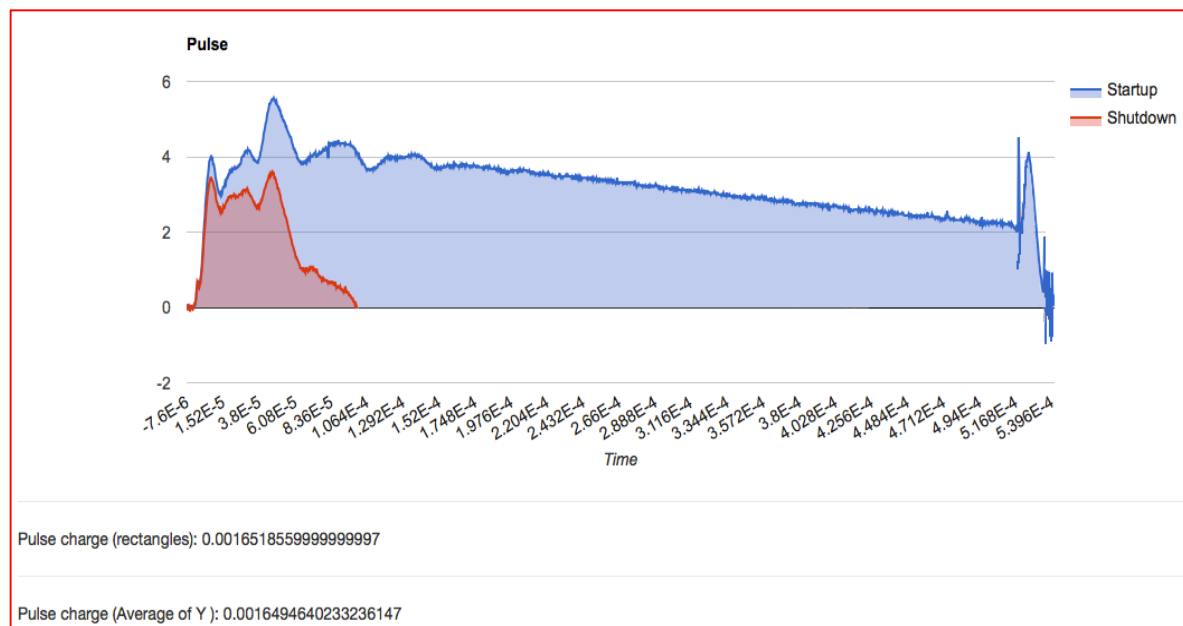


Figure 5. Results of the estimate ionic charge.

4. Conclusions

A computational web tool was built to streamline the estimation of the calculation of the ionic charge carried out in electrical discharges of high voltage at low pressures, bringing benefits to experimental researches in the UIS' plasma laboratory.

The web application developed can be used anywhere any time, only an Internet connection and the pulses data to be processed are required. The format of the data received by the system can be downloaded from the web application.

The processed data obtained from the web application are really similar to current pulses reported experimentally during the turn on of the electric discharge of high voltage, ensuring that the implemented web application works correctly to estimate the ionic charge.

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