Sputtering Machine Rebuild

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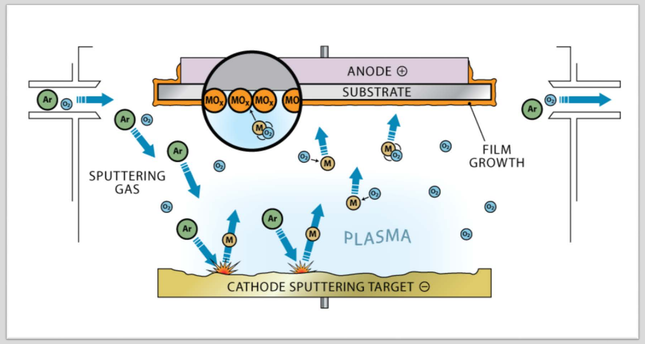
Introduction

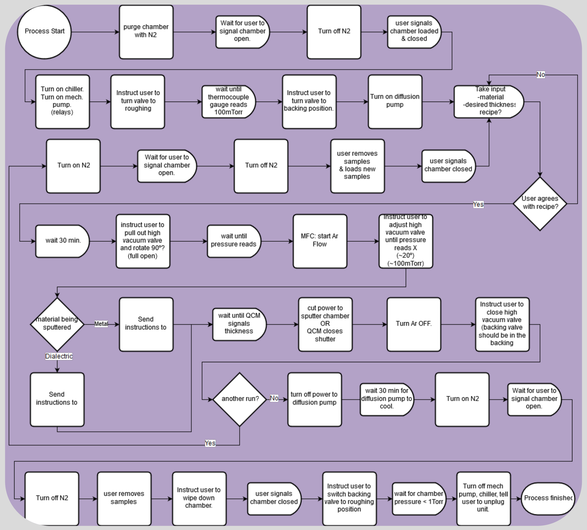
The purpose of this project is to redesign and build the thin film vapor deposition or sputtering machine in the EMDL. Sputtering is a method of depositing thin films of metal or dielectric materials onto substrate wafers. A plasma is generated inside a chamber at a high vacuum by holding a large voltage over argon gas. This ionizes the argon causing it to accelerate toward the source material etching away (sputtering) a few atoms. The now free electrons accelerate toward the substrate, where they land and adsorb to the surface. There are several applications of sputter deposition, including semiconductor fabrication, glass treatment, disk drive manufacturing and more. The previous sputtering machine was not fit for use due to worn down components and difficult controls. There were numerous settings to configure as well as buttons, knobs, and levers to fiddle with before any sputtering could be done. The aim of this project is to enhance the user experience by automating the process and allow a more unified control over the system as well as boost performance and increase reliability.



Source: http://lnf-wiki.eecs.umich.edu/wiki/Sputter_deposition

Process Model

Pictured below is the logic model that PLC follows when deciding the next step in the deposition process.

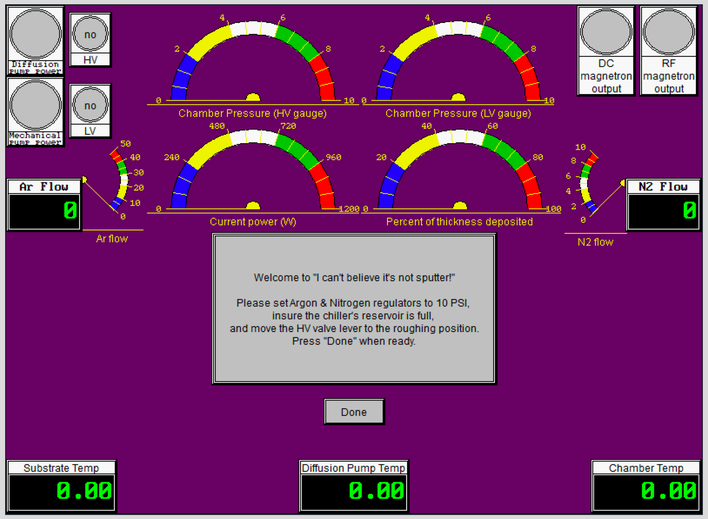


Engineering Requirements:

- System must be able to deposit 1nm to 5um of metal or dielectric within 20% tolerance.
- System must be able to pump down and maintain pressure of 10^-6 Torr in under 1 hour.
- System must be able to deposit films with sidewall thicknesses ranging from 0% to 100% of horizontal film thickness.
- System will have a single interface that is used to control all subsystems.
- System parameters such as pressure, electrical potential, temperature, and time must be capable of being set by the user, and their specific configuration should be able to be saved for future use.

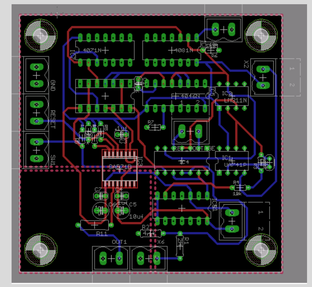
Automation and Controls

The picture below shows the main screen of the human machine interface (HMI) which guides the user through the sputtering process. The HMI is wired to the programmable logic controller (PLC) which actually controls the process. The interface displays the current process and relevant system parameters. The user can select from pre-made “recipes” or develop their own recipe to cater to their specific application. Recipes can be added over USB in a matter of minutes and can include sputtering power, argon flow rate, choice of DC or RF power, desired thickness and all other variables needed to ensure a successful deposition.



DC Power Control PCB Design

The following is a printed circuit board (PCB) that is designed to control the DC power supply during its operation. It functions in two modes: arc-detecting and pulsed DC. In arc-detecting mode it detects arcs in the chamber and reverses the voltage on the load to clear away any charge build-up. In pulsed DC mode it uses a PWM signal to continuously reverse the voltage on the load.



Results

The picture below shows the current construction of the machine. It combines most of the previous components of the old machine and adds several new components such as the PLC+HMI, thickness monitor, and close-loop cooling system. The new frame is more portable and organized to allow an easier experience. Although the individual components have been tested, the system as a whole has not been tested due to safety concerns regarding the 3-phase power required to operate the power supplies. Once the power can be safely connected, testing will begin. The PLC has been programmed with all the necessary instructions to operate the machine during the full system test.

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