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DISCLAIMER

THE CATHODE PREPARATION CHAMBER FOR THE DC HIGH CURRENT HIGH POLARIZATION GUN*

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Abstract

A compact cathode preparation chamber for the high current high polarization gun for the proposed eRHIC project has been designed and assembled at Brookhaven National Laboratory. This preparation chamber will be used to activate GaAs photocathodes to be used in the Gatling gun. The chamber is capable of achieving XHV on a consistent basis. Bulk GaAs samples were activated in this chamber with standard QE for the respective wavelength. In this paper, we discuss the design of this vacuum system, the heat cleaning and the activation procedure for the GaAs sample which will eventually be followed for the Gatling gun.

INTRODUCTION

The High Current High Polarization Electron Gun is one of the most important research projects for the proposed eRHIC project [**?**]. The average current is required to be 50 mA and the polarization requirement is more than 80%.For weekly exchange of cathodes, given that two guns are used, one cathode has to provide 50 mA of average current for 85 hours, which yields to 15300 C of charge. The maximum reported charge extracted is 1000 C, which is a order of magnitude lower than the requirement [**?**]. To solve this problem, 50 mA of current can be distributed over 20 photocathodes such that each cathode has to provide 2.5 mA of current for 85 hours, yielding 765 C of charge. This solution of combining 20 bunches to one common beam axis solves the problem of charge limitation without sacrificing the high average current requirement. The high polarization can be obtained using Superlattice GaAs which is able to provide polarization greater than 80% in a consistent basis [**?**]. For the R&D and "proof of principle" experiment, bulk GaAs will be used.

DESIGN OF THE CATHODE PREPARATION CHAMBER

The cathode preparation chamber is a compact design including 3 crosses, two of them are 6-way crosses and the other one is a standard 4 way cross. These three crosses are stacked on top of each other with the 4-way cross at the bottom. The cathode holder is moved up and down using a magnetic manipulator. One NEG pump and one turbo pump is attached to the bottom 4-way cross. The middle cross contains the tungsten filament, another NEG pump, one Ion pump and a view port. The top-most cross includes the Cs source, a pick up anode, a variable leak valve for Oxygen, an Extractor gauge to measure low pressure and a window through which laser shine the sample. A cross sectional view of the assembly is shown in Fig. 1 and the front view of the actual system is shown in Fig. 2. The vacuum and heat cleaning components are described in detail in the following sections.

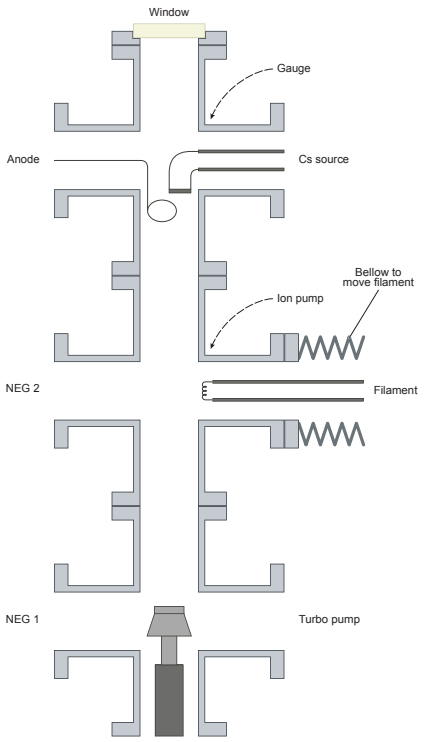

Figure 1: Cross sectional view of the cathode preparation chamber.

VACUUM COMPONENTS AND BAKE OUT PROCEDURE

The bake out procedure is extensive since activating GaAs requires XHV i.e low 10^{-11} Torr scale vacuum. The chamber at 200°C for approximately a week. Heater tapes are used to wrap the chamber and K-type thermocouples are used in 8 different locations of the chamber to make

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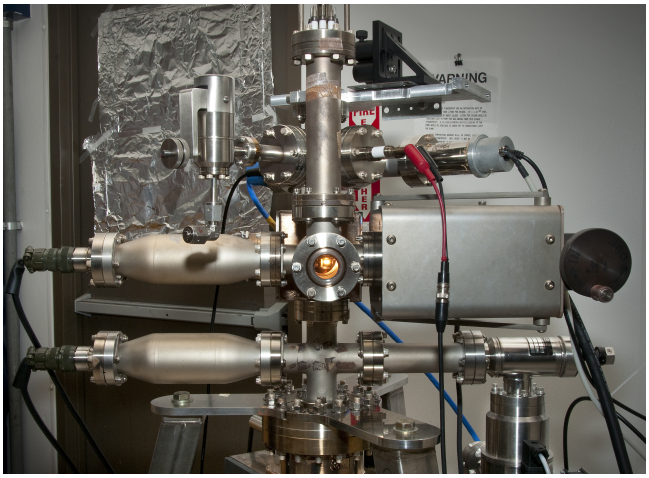

Figure 2: Front view of the cathode preparation chamber.

Table 1: Vacuum Pumps used in the prep. chamber

Pump	Pumping speed	location in the chamber
Ion pump	50 l/s	Middle cross
NEG 1	80 l/s	Bottom cross
NEG 2	80 l/s	Middle cross

sure that the temperature is uniform over the entire chamber.Different pumps that are installed in this system is described in Table 1.The NEG pumps are Capacitorr D400 units from SAES getters and the Ion pump is a standard Gamma Vacuum one.

Temperature data is saved to a computer using an Omega USB data acquisition module. The temperature of the chamber is increased gradually from room temperature to 200°C in 50°C increments over the course of two days.

One AxTRAN ISX2 gauge, a hot cathode extractor type gauge, is used to monitor pressure data. The NEG pumps are activated twice during the bakeout cycle, once the temperature of the system is 100°C and then right before the cooling of the system begins. Every other component of the system is also degassed during the heating cycle when the system is at 200°C including the filament, the Cs source, the cathode holder and the gauge.

A typical Pressure Vs Time graph is show in Fig. 3. While cooling down, the system is also brought down gradually from 200°C to 80°C to room temperature. While the system is at 80°C, the RGA is degassed.

HEAT CLEANING AND ACTIVATION

Before GaAs is activated, the surface of the sample needs to be cleaned either by conventional heat cleaning or atomic Hydrogen cleaning. We use a commercially available Tungsten filament from a 250W light bulb to heat up the sample by radiation to a desired temperature.

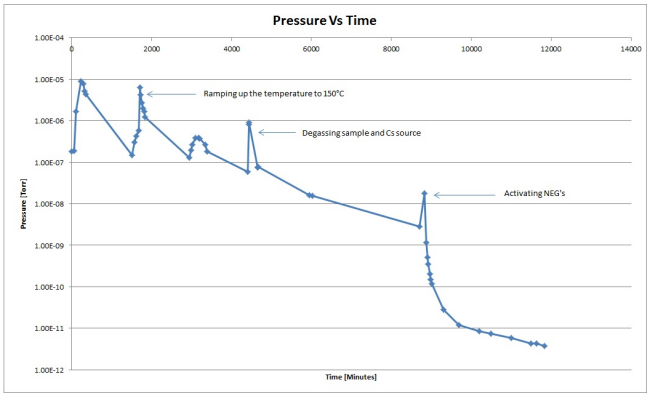

Figure 3: Pressure of the chamber during a bake-out procedure.

The heat cleaning setup is shown in Fig. 4. The filament is inserted into the chamber using a feedthrough which is connected to a bellow that is compressible and the position of the filament can be adjusted.

It should be noted that the vertical position of the cathode

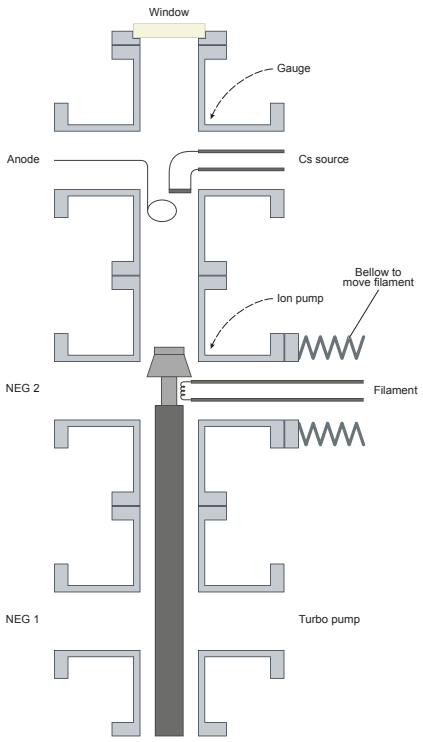

Figure 4: Schematic diagram of the heat cleaning procedure.

and the position of the filament has to be exact in order to have the right temperature on the surface of the sample. Meticulous calibration tests were performed to measure the surface temperature of the GaAs as a function of the driving current through the filament with a fixed

vertical height and fixed filament position. For our heat cleaning procedure, we use the calibration curve to obtain a temperature of 580°C on the surface of the GaAs.

After the heat cleaning is done for 45 minutes, it takes approximately 2 hours for the sample to come back down to room temperature (also obtained from the calibration experiment). For activation, we use a standard evaporation Cs source from SAES getters. The laser is a 650 nm diode CW laser. A sample activation curve is shown in Fig. 5.

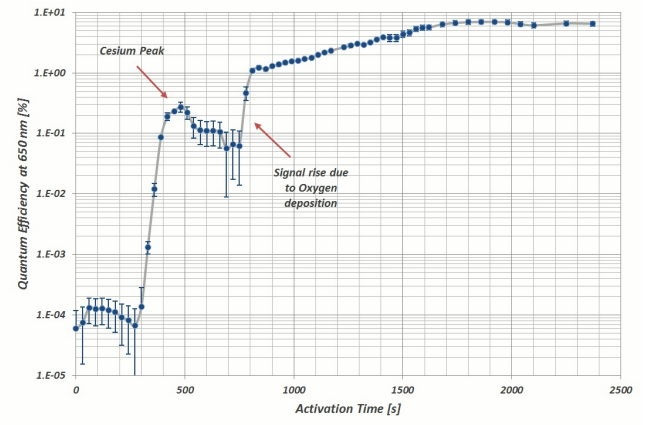

Figure 5: Typical activation curve.

Typically the first real signal is measured after 350 seconds and the Cs peak is seen after 500 seconds. This activation process is a co-deposition process where the Cs and Oxygen are applied to the surface simultaneously after the signal has reached the Cs peak. Multiple activations were performed using this technique and the QE ranges between 6% to 8% for 650 nm light.

CONCLUSION AND FUTURE PLAN

A compact prototype preparation chamber to activate GaAs photocathodes is assembled and tested. The chamber has shown to be XHV achievable and bulk GaAs samples were activated in the chamber with standard QE for 650 nm light. This chamber is scheduled to be installed on the storage chamber and a two cathode test is scheuled to be performed early next year. Eventually, this chamber prototype will be used to activate Superlattice GaAs photocathodes for the full operation of the High Current High Polarization Gun.

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