

A NEW LOAD LOCK SYSTEM FOR THE SOURCE OF POLARIZED ELECTRONS AT ELSA*

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Abstract

Since 2000, an inverted source of polarized electrons at the electron stretcher accelerator ELSA routinely provides a pulsed beam with a current of 100 mA and a polarization degree of about 80%. One micro-second long pulses with 100 nC charge are produced by irradiating a GaAs strained-layer superlattice photocathode (8 mm in diameter) with laser light.

Future accelerator operation requires a significantly higher beam intensity, which can be achieved by using photocathodes with sufficiently high quantum efficiency. Therefore, and in order to enhance the reliability and up-time of the source, a new extreme high-vacuum (XHV) load lock system was installed and commissioned at the beginning of this year. It consists of three chambers: The activation chamber for heat cleaning of the photocathodes and activation with cesium and oxygen. The storage chamber in which up to five different types of photocathodes with various diameters of the emitting surface can be stored under XHV conditions. The loading chamber in which an atomic hydrogen source is used to remove any remaining surface oxidation. Additionally, tests of the photocathodes' properties can be performed during operation.

INTRODUCTION

Since 2006, experiments on baryon spectroscopy are performed at the University of Bonn, requiring circularly polarized photons which are generated by bremsstrahlung of longitudinally polarized electrons [1]. The polarized electrons cannot be produced via self-polarization according to the Sokolov-Ternov mechanism [2] due to a considerably long polarization time. Thus, in Bonn, polarized electrons are generated in a dedicated source [3] (see figure 1) and are transported to the experiment while aiming at the highest possible conservation of polarization.

Polarized electrons are generated by irradiating a GaAs strained-layer superlattice photocathode with circularly polarized laser light from a flash lamp pumped pulsed Titanium Sapphire laser [4]. The emitted current (by default 100 mA) is controlled by space charge limitation. In order to vary the beam intensity, the perveance¹ can be adjusted

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¹The perveance is the constant of proportionality between the emitted current and the applied voltage and is only dependent on the geometry.

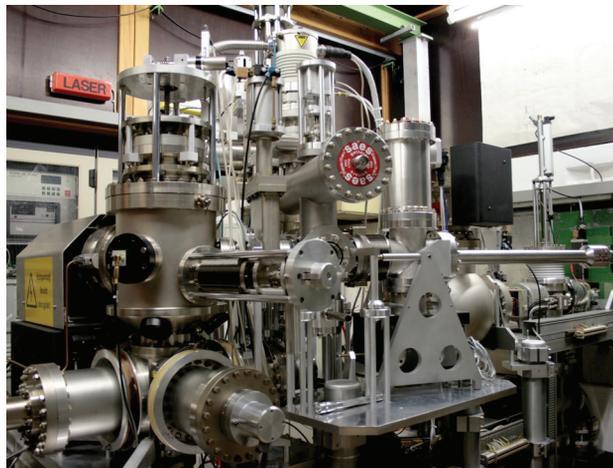


Figure 1: The source of polarized electrons and the new load lock system.

by changing the distance between the anode and the cathode.

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THE NEW LOAD LOCK SYSTEM

Overview

Figure 2 shows a schematic drawing of the new load lock system. It consists of three chambers: A new photocathode is brought into the loading chamber and is cleaned with atomic hydrogen while heating the photocathode to moderate temperatures ($< 400^\circ\text{C}$) for a better removal of surface oxidations. Afterwards, it is transported to the storage chamber via an elevator. In the storage chamber, up to five photocathodes can be stored in extreme high vacuum (total pressure $P < 1 \times 10^{-12}$ mbar). The activation is done

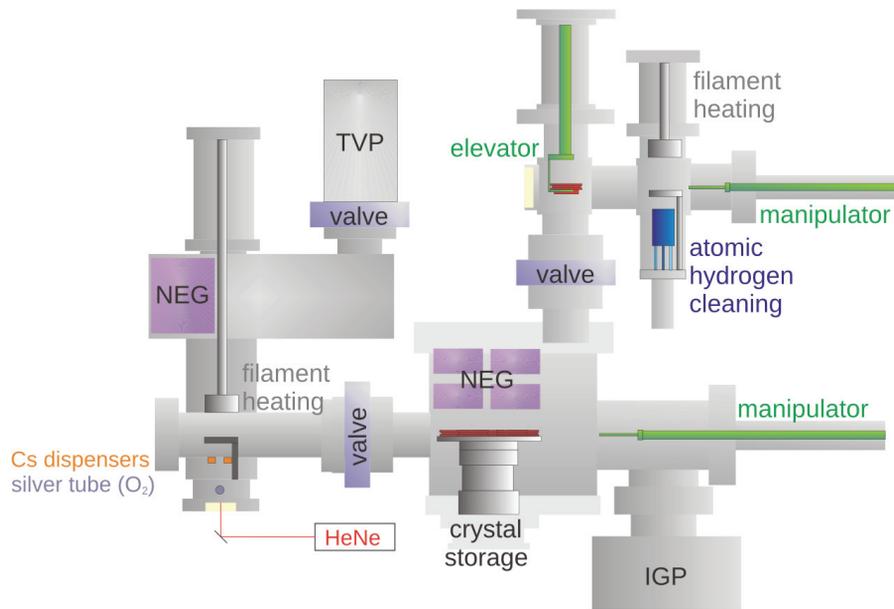


Figure 2: Overview of the new load lock system with its three XHV chambers.

with cesium and oxygen in the activation chamber, before the photocathode is transported into the gun for operation.

The Activation Chamber

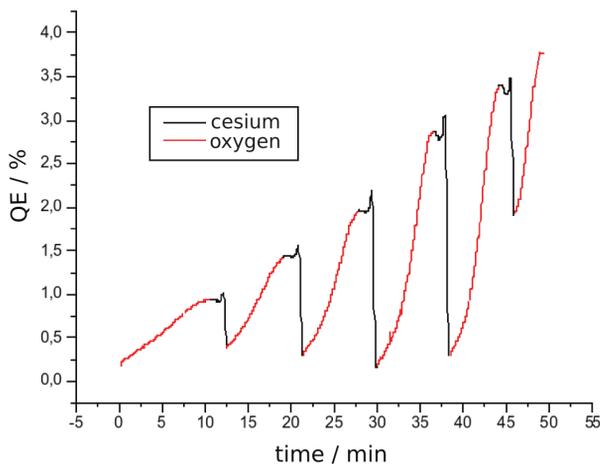


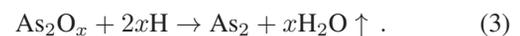
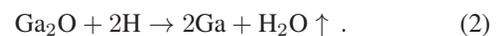
Figure 3: A typical activation procedure with cesium (black) and oxygen (red).

In the activation chamber, which is connected to the operation chamber by a vacuum valve, the photocathode can be heat cleaned and activated. In order to provide an ultra high vacuum during the activation process, two NEG-pumps (2000 l/s each), an ion getter pump (75 l/s) and a turbo molecular pump (300 l/s) are installed. The activation is done with cesium and oxygen. A sub-mono atomic layer of Cs,O-dipoles is evaporated on the photocathode's surface by alternately heating cesium dispensers and a sil-

ver tube². Figure 3 shows a typical activation procedure. To measure the emitted current and the quantum efficiency (QE) during the activation process, the photocathode is irradiated with laser light from a helium-neon laser and an accelerating voltage is applied between the photocathode and the ground potential. To avoid backstreaming ions evaporated from the cesium dispensers a countervoltage within the distance of acceleration is applied.

The Loading Chamber

Besides bringing in new photocathodes into the load lock system, atomic hydrogen cleaning can be applied to the photocathode in the loading chamber. Molecular hydrogen is purified by passing through a heated palladium tube³ and is collected in a reservoir (100 mbar, 0.02 l). After piped through a calibrated leak valve, a well-defined particle flux in the range of 10^{14} hydrogen molecules per second is injected into a 2000 K hot capillary. The molecular hydrogen is cracked into atomic hydrogen when passing the hot capillary surface [6] and is lead to the photocathode. Strong ligated molecules on the photocathode's surface like Ga_2O_3 , Ga_2O and As_2O_x are converted by atomic hydrogen into volatile ones:



²Heated silver is permeable for oxygen only.

³Heated palladium is permeable for hydrogen only [5].

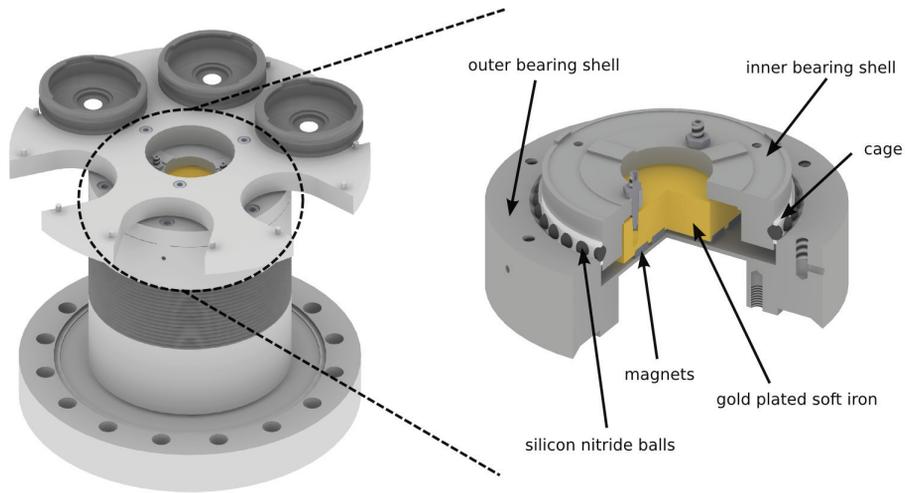


Figure 4: The rotary plate in the storage chamber and a cut through the ball bearing.

The gallium and arsenic reaction products remain on the surface, the oxidations (ligated as H_2O) are removed by additionally heating the photocathode to moderate temperatures ($< 400^\circ C$). Because of the cracking procedure, the atomic hydrogen beam does not contain any hydrogen ions, resulting in an atomically clean and flat surface with only a few defects near to the surface. Atomic hydrogen cleaning will be used for new photocathodes without any protective cap or for multiply activated photocathodes whose quantum efficiency fails to regain its initial value because of remaining surface oxidations after only applying heat cleaning.

The Storage

In the storage chamber, up to five photocathodes can be stored on a rotary plate (see figure 4) under XHV-conditions [total pressure $P < 1 \times 10^{-12}$ mbar achieved by four NEG modules (330 l/s each) and an ion getter pump (75 l/s)]. The rotary plate is adjustable in height via a bellow. Because the rotary plate and its ball bearing are positioned in vacuum, magnets are used for a contactless force transmission between the vacuum and non-vacuum side. The ball bearing, consisting of an inner bearing shell and an upper as well as a lower outer bearing shell filled with silicon nitride balls, was developed in-house. In the first design, the bearing was completely filled with balls to achieve a maximum load capacity. After baking out the chamber, no movement of the rotary plate was possible due to the high friction of the purified surfaces. An evaporation of the surfaces with tungsten disulfide would reduce the friction by a factor of 100, but was discarded because it is not suitable for XHV. Under the assumption that the moving of the balls against each other⁴ is the main reason for friction, a cage was designed and attached to the bearing.

⁴In a completely filled ball bearing, the balls move in one direction, but the areas of contact move against each other.

This in-house developed cage prevents the friction between the balls but also reduces the amount of attachable balls. The lower load capacity is compensated for by using half the amount of magnets. After baking out this newly designed setup, the rotary plate moves almost free of friction, which verifies the hypothesis that the increased friction is attributable to the high friction between the bearing balls.

The storage of up to five photocathodes will increase the reliability and uptime of the source, because the replacement of the photocathode in the operation chamber will take only a few hours. In comparison, the formerly used procedure required a downtime of two weeks. Furthermore, the storing of different types of photocathodes with various diameters of the emitting surface will allow a quick change of the operation parameters like the emitted current and polarization degree. Additionally, tests of the quantum efficiency, polarization degree and the success of atomic hydrogen cleaning of different types of photocathodes can be performed during regular operation.

CONCLUSION

Since 2000, the source of polarized electrons reliably provides a beam of 100 mA and a polarization degree of 80%. With the installation and commissioning of the new load lock system with a storage for up to five photocathodes and atomic hydrogen cleaning, an enhancement of the source performance is achieved.

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