UHV PHOTOCATHODE PLUG TRANSFER CHAIN FOR THE bERLinPro SRF-PHOTOINJECTOR*

J. Kühn†, J. Borninkhof, M. Bürger, André Frahm, A. Jankowiak, T. Kamps, M. A. H. Schmeißer, M. Schuster, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB), Germany
P. Murcek, J. Teichert, R. Xiang
Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany

Abstract

A dedicated particle free UHV photocathode plug transfer chain from the preparation system to the SRF-Photoinjector was set up and commissioned at HZB for the bERLinPro project. The plug handling system was designed in collaboration with the ELBE team at HZDR, where the same transfer chain is in commissioning phase. In the future the exchange of photocathodes between the laboratories offers the possibility to test different types of photocathodes in different SRF-photoinjectors.

INTRODUCTION

The development of high brightness photoelectron injectors requires photocathodes with exceptional performance, which is considered for bERLinPro, the ERL project at HZB [1]. The SRF-photoinjector for bERLinPro is currently under commissioning [2]. A photocathode and drive laser combination must be employed where the quantum efficiency is high (QE > 1%) and the drive laser emits close to the photoemission threshold in order to achieve both high average current and low intrinsic emittance. All available candidates, and especially CsK_2Sb, require ultra-high vacuum environments to preserve the QE. The photocathode transfer systems therefore serve three main purposes: (1) connecting the cathode growth chamber and the SRF-photoinjector through a transportable vacuum suitcase while ensuring that the photocathode sample is handled in an ultra high vacuum environment of 10^{-10} mbar. (2) Avoid any contamination of the cathode from foreign particles which might reduce the performance of the SRF-photoinjector. (3) Finally, the cathode must be installed in the photoinjector cavity without contact to the superconducting cavity. Here we present the full photocathode infrastructure, that has been set up at HZB for bERLinPro and was designed in collaboration with the HZDR [3].

PARTICLE FREE CONDITIONS

The UHV-systems were all set up under particle free conditions in a clean room (ISO 5) or a clean room cell, respectively. All UHV parts were cleaned carefully by e.g. dry ice cleaning, blowing with ionized nitrogen, wiping with isopropyl alcohol or acetone. Standard UHV parts, screws, washers, nuts and bolts were washed in separate ultrasonic baths with and without Tickopur detergent solution in ultra pure and particle filtered water. To avoid galling of stainless steal screws and nuts, titanium (grade 5) was chosen as nut and stud material, which during mounting shows less generation of visible particles than CuNiSi.

Particle Free Pumping

Figure 1 shows the fully automated pumping station, which was developed and commissioned by the HZB's vacuum group for bERLinPro in order to evacuate or vent the particle free assembled UHV-systems and superconducting Nb-cavities, because their performance is very sensitive to any particle contamination. Mass flow controllers are used for venting with dry nitrogen at a controlled rate that avoids stimulation of particle movement. A slow evacuation process is also realized using a mass flow controller bypassing the turbo pump. With this pumping setup a final pressure of about $1{\times}10^{-6}$ mbar can be reached. A programmable logic controller runs the two modes of venting and pumping, without any further user interaction.

Figure 1: Automatic particle free pumping station.

PHOTOCATHODE PLUGS

The design of the photocathode plug has been optimized in terms of avoiding field emission in strong acceleration fields in the SRF environment [4]. Figure 2 (a) shows the

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† Julius.Kuehn@helmholtz-berlin.de

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ultra-smooth polished Cu plug sitting on an adapted flag-style sample holder. The bulk Cu plug itself will be used as a photocathode (after particle free preparation and removing the oxide layer) in combination with an UV-laser, for the commissioning of the SRF-photoinjector. Figure 2 (b) shows the Mo plug, which is used as substrate for Cs-K-Sb photocathodes, and Fig. 2(c) shows an empty sample holder with the CuBe-spring holding the plugs.

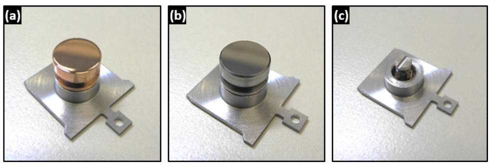

Figure 2: The flag style sample holder system with: (a) polycrystalline Cu plug for initial commissioning of the SRF-Photoinjector. (b) a polycrystalline Mo plug used as substrate for Cs-K-Sb photocathodes. (c) an empty sample holder to show the CuBe spring holding the plug.

PREPARATION AND ANALYSIS SYSTEM

The growth and characterization of Cs-K-Sb photocathodes is carried out in the Preparation and Analysis System (PAS) shown in Fig. 3 (a) [5]. The base pressure of the preparation chamber is in the low 10^{-10} mbar range. The preparation system was recently upgraded with a spectral response setup for measuring the QE in the visible wavelength range and to monitor the photocurrent at 515 nm during the growth process [6]. A Cs-K-Sb photocathode with an QE of about 10% was produced by co-depositing Cs and K on the Sb layer. The analysis section of the PAS has a base pressure of $1{\times}10^{-10}$ mbar and is equipped with an X-ray photoelectron spectroscopy setup for chemical analysis and a momentatron for intrinsic emittance measurements [7].

TRANSFER SYSTEM #1

Transfer system #1, as shown in Figure 3 (b), is attached to the Cs-K-Sb preparation and analysis system and is located under an ISO 5 clean room cell. It consists of a transfer chamber with a cart for 4 flag-style (Omicron) sample holders (see Fig. 2) and connects the preparation chamber with the UHV load lock and with the vacuum suitcase. Particle free plugs are introduced into UHV environment and then transferred in to the preparation chamber for further processing. After preparation, the photocathode can be transferred into the vacuum suitcase, which can be disconnected and moved to transfer system #2.

VACUUM SUITCASE #1

The vacuum suitcase (VS) has a compact design and has also been assembled under particle free conditions. It can be attached to transfer system #1 in Fig. 3 (b) and to transfer system #2 in Fig. 3 (c). In the future the VS can be attached to the transfer system at HZDR ELBE for the exchange of photocathodes. The VS is equipped with a pick-up anode and a viewport to measure the QE of a photocathode if located there. The volume and internal surface of the VS chamber is small resulting in a good base pressure by pumping with a NEG and IGP combination pump (NEXTorr). The NEG-pump of the vacuum suitcase is ensuring stable UHV conditions in the low 10^{-10} mbar regime, while the VS is disconnected from the grid and moved to the second transfer system at the SRF-photoinjector module.

TRANSFER SYSTEM #2

Transfer System #2 is shown in Fig. 3 (c) attached to the first bERLinPro SRF-photoinjector. The system has been commissioned in the clean room and is now under UHV at the photoinjector module. The final pressure of Transfer System #2 is expected reach the low 10^{-10} mbar regime as well

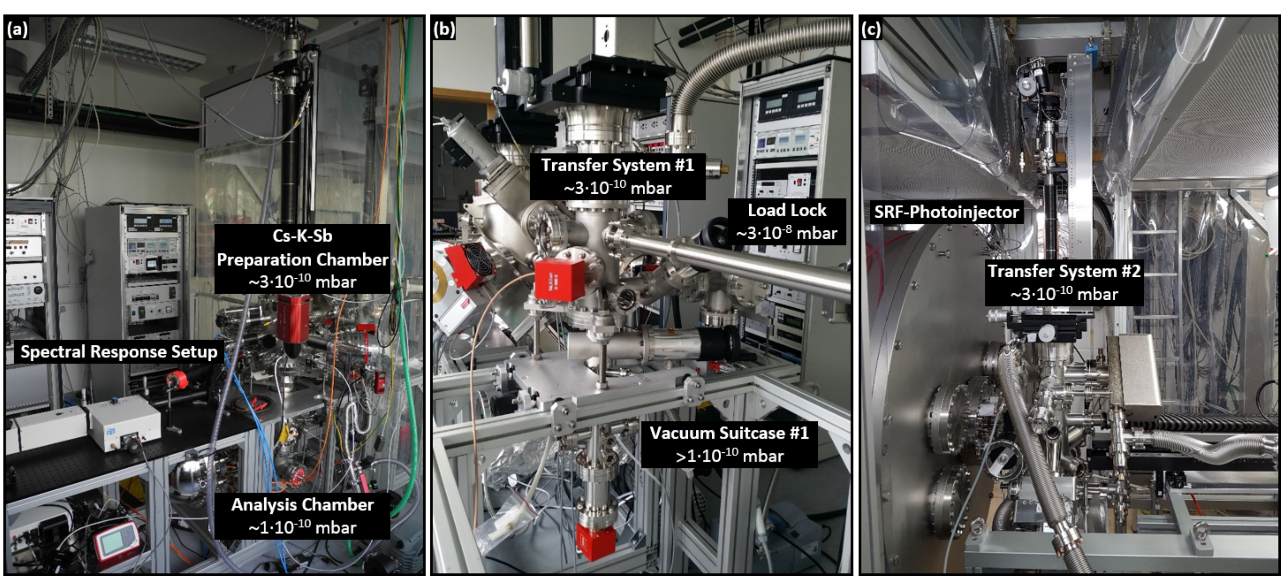

Figure 3: The bERLinPro photocathode infrastructure: (a) Preparation and Analysis System with spectral response setup. (b) Transfer system #1 with load lock and Vacuum Suitcase #1. (c) Transfer system #2 at the SRF-photoinjector.

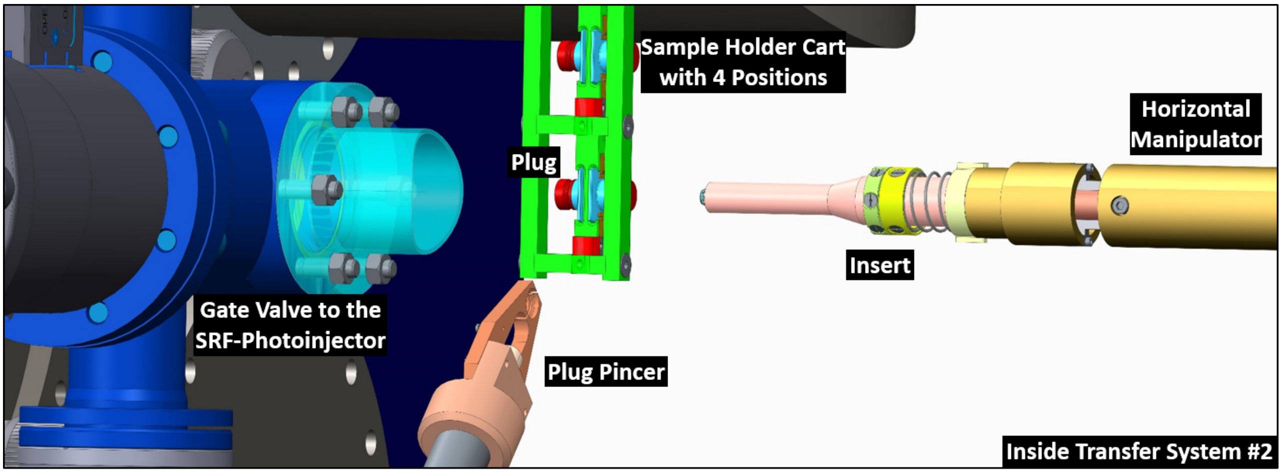

Figure 4: A reduced 3D model of the inside view of transfer system #2 attached to the SRF-photoinjector module.

and can be monitored by a mass spectrometer, especially for avoiding the contamination of the Cs-K-Sb photocathodes with any residual gas components, e.g. water. The transfer mechanism to unload the VS (if attached) is the same as in transfer system #1 and is done by the vertical manipulator. Photocathodes are moved upwards into the transfer chamber, where the QE can be measured and a high resolution camera image can be taken for inspection purposes. In the position in front of the horizontal manipulator the photocathode plug can be taken from the sample holder with a plug pincer, which is illustrated in Fig. 4. After that, the horizontal manipulator carrying the cathode insert receives the plug from the cathode pincer. The insert has a special mechanism inside to open and close a spring to fix and release the photocathode plug on the insert, controlled by a linear feed through at the end of the horizontal manipulator. The insert with the photocathode is then moved very slowly from the transfer system (at room temperature) into the cryogenic environment (80 K gaseous He cooling system) to its final position in the back wall of the superconducting Nb-cavity of the SRF-photoinjector. There, the complete insert can be released by an additional rotary feed through at the end of the horizontal manipulator, which is then moved back into the transfer chamber. During the movement of the insert into the back wall of the cavity, it can be observed with a camera imaging system. For commissioning purposes of the SRF-photoinjector the transfer of the plug will be tested with a Cu photocathode, before using Cs-K-Sb photocathodes on a Mo plug.

CONCLUSION

For bERLinPro a complete photocathode infrastructure has been set up including the preparation and analysis system for Cu and Cs-K-Sb photocathodes, transfer systems to load and unload the vacuum suitcase and to insert the photocathode into the back wall of a superconducting Nb-cavity. For commissioning purposes of the SRF-photoinjector the complete plug transfer chain will be tested with a Cu plug which serves at the same time as the first photocathode. Due to the fact, that the SRF cavities are sensitive to any particle contamination, all UHV parts of the transfer systems and the vacuum suitcase have been carefully cleaned and assembled under clean room conditions. With this infrastructure and our plug handling experience we are ready to provide a Cu photocathode for the first beam of the SRF-photoinjector in the near future and to deliver Cs-K-Sb photocathodes for bERLinPro, subsequently.

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REFERENCES

[1] M. Abo-Bakr *et al.*, "Status of the Berlin Energy Recovery Linac Project bERLinPro," IPAC'17, Copenhagen, May 2017, paper MOPVA010, this conference.

[2] T. Kamps *et al.*, "Setup and Status of an SRF Photoinjector for Energy-Recovery Linac Applications," IPAC'17, Copenhagen, Denmark, May 2017, paper MOPVA005, this conference.

[3] P. Murcek *et al.*, "Plug Transfer System for GaAs Photocathodes," SRF'15, Whistler, BC, Canada, September 2015, TUPB010, p. 553.

[4] A. Neumann *et al.*, "First Commissioning of an SRF Photo-Injector Module for bERLinPro," IPAC'17, Copenhagen, Denmark, May 2017, paper MOPVA049, this conference.

[5] M. Schmeisser *et al.*, "CsK_2Sb Photocathode Development for BERLinPro," ERL'15, Stony Brook, NY, USA, June 2015, THPTHL072, p. 97.

[6] H. Kirschner *et al.*, "Measuring the Spectral Response of Cs-K-Sb Photocathodes for bERLinPro," IPAC'17, Copenhagen, Denmark, May 2017, paper TUPAB028, this conference.

[7] M. Schmeisser *et al.*, "In-situ characterization of K_2CsSb photocathodes," IPAC'14, Dresden, Germany,June 2014, MOPRI019, p. 627.

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