PROCEEDINGS OF SCIENCE

Conference Summary EWPAA 2024

Kurt Aulenbacher[a,*]

[a] *Institut für Kernphysik, Johannes Gutenberg-Universität Mainz*
J.J. Becherweg 45, Mainz, Germany

E-mail: aulenbac@uni-mainz.de

This paper summarizes spin-polarization relevant results from the European Workshop on Photocathodes for Accelerator Applications (EWPAA)

20th International Workshop on Polarized Source, Targets, and Polarimetry (PSTP2024)
22-27 September 2024
Jefferson Lab, Newport News, VA

---

[*] Speaker

1. Introduction

The fourth European Workshop on Photocathodes for Accelerator Applications (EWPAA) took place at Helmholtz-Zentrum Dresden-Rossendorf (HZDR) [1]. The workshop had a three day program (September, 17-19, 2024) with about 30 oral contributions and a poster session. Most of the talks were dealing with the generation of high brightness bunches for unpolarized beams. It is remarkable that methods which were initially used for the production opto-electronic devices (and, linked to it, spin-polarized photocathodes) are now also more and more used for the optimization of the "unpolarized" materials such as cesium-telluride or alkali-antimonides. Epitaxial growth and surface analysis techniques like RHEED become more and more prominent, see, for instance, [2]. Several talks discussed materials and methods which are also relevant for the spin-polarized case, for instance the extension of MTE-measurements to three dimensions, as discussed in [3].

Four talks and two posters were directly related to spin-polarization. I report the main aspects in the following section.

2. GaAs-surface activation studies

M. Herbert [4] reported on activities at TU-Darmstadt/Germany where an apparatus "Photo-Catch" is dedicated to activation studies. So far, mainly GaAs cathodes have been activated. An automated procedure for the Alkali and Oxygen deposition has been developed, including a piezo valve for oxygen dosing. The automatic procedure provides similar outcome if compared to manual operation.

An addition of Lithium has resulted in considerably increased lifetime parameters, see figure 1. Vacuum lifetime increased in the best case by a factor 19 and the charge lifetime by a similar factor up to 1 Coulomb. Future activities will be related to the production of a beam in the multi-keV range.

At JGU-Mainz, long term observations of the polarization drift where performed by M. Trieb. These results are also presented in more detail at this conference [5].

3. Superlattices and SPV-effect

Apart from ongoing research programs, new facilities using polarized electron beams are coming up, for instance EIC at Brookhaven National Laboratory and - on a much smaller scale- MESA at JGU Mainz. All projects will profit from further developments in photocathode quality. Probably triggered by the upcoming demand, research activities in the US, but also in China and Germany, seem to intensify again.

A variety of results was presented by O. Raman [6] which are directed towards the application at the EIC. The EIC polarized electron storage-ring will need highly charged polarized bunches (7 nC in 1.6 ns) which requires a gun voltage of 300 kV. Though the average current is not very high (56 nA) surface photovoltage (SPV) becomes a relevant topic. During experiments at SLAC, SPV was observed [7] to limit the extractable charge in a short bunch since the rapid accumulation of charge at the cathode surface leads to a dynamic change of the electron affinity. The resulting trend towards positive affinity reduces the quantum efficiency after a very short time and therefore

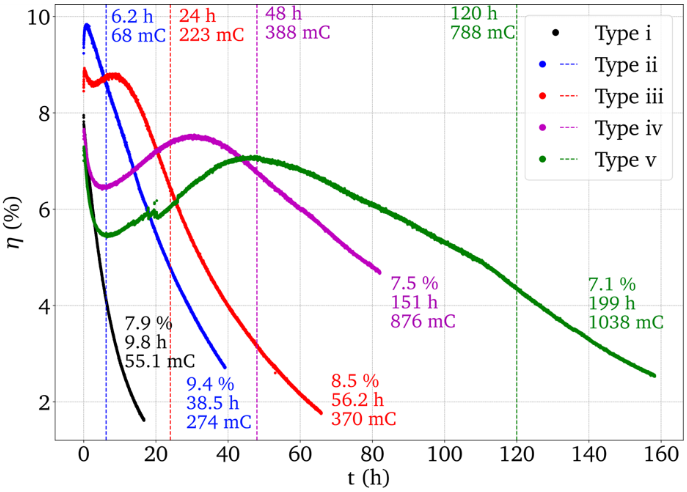

Figure 1: Quantum efficiency evolution after several activations. In some cases like the scheme 2b the Cs:O co-deposition was supported by adding Lithium during short intervals. Those activations have considerably higher chage lifetime. Taken from [4].

limits the extractable charge or, equivalently, the (peak-) current density. Even in long pulse or CW-operation SPV leads to a reduction of QE with increasing laser intensity. The photocathodes used where GaAs/GaAsP superlattices with enhanced absorption caused by a DBR mirror build into the cathode structure. This mirror was formed by another superlattice from GaAlAs/GaAs.

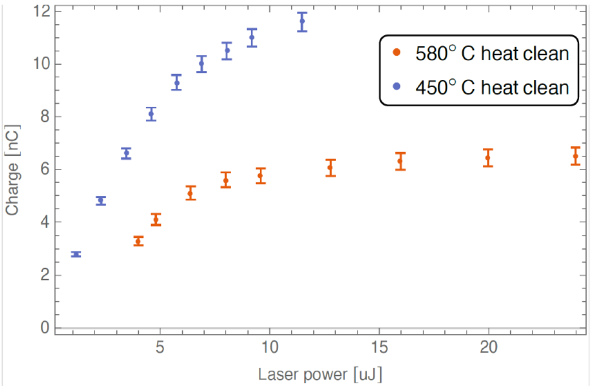

Figure 2: Extracted charge vs. laser energy obtained at the BNL-source. Taken from [6].

Experiments at BNL have shown that the occurrence of SPV depends on several parameters. Preparing the cathode at lower temperatures - 450 degree Celsius instead 580 - increased the charge limit (fig. 2). The highest bunch charge achieved so far is 11.6 nC with a peak current density of 14.5 A/cm^2. In this experiments the source was operated reliably with 300 kV using an inverted insulator geometry.

4. Polarized positrons in Europe

There is considerable interest in polarized positrons in Europe for applied research. Polarized positrons are presently produced from β^+-emitters or nuclear reactors, but creating them from bremsstrahlung from polarized electrons may become a very promising option. This principle was demonstrated a few years ago [9, 10]. The conversion efficiency is small if a small phase space volume of the positron beam is aimed at. For instance at MAMI in Mainz, a 855 MeV beam in the 100 nano-ampere range is used. To keep the angular divergence after the target small, the thickness of the Tungsten target is only $10\mu m$. An unpolarized 600 MeV beam is then generated with a conversion efficiency about $17e^+/nA$ with 0.1% energy width. The normalized transverse emittance was estimated to be $\approx 20\mu m$.

Fortunately, the applied physics experiments only require polarized positron currents of the order of 100 kHz, (ten's of femto-amperes) which can be generated from about 10 micro-amperes of polarized electron beam at energies in the 30 MeV range, for instance at the ELBE accelerator in HZDR. Whereas the average current and the power handling on the target seem feasible for these experiments, another challenge arises from the desired time structure of the polarized positron beam. These demands are similar to the ones mentioned for EIC above, i.e. increased demands for the quantum efficiency and surface charge limit. The Mainz group has started activities with German research organizations in order to define the growth conditions for such optimized cathodes which could be used for experiments at MESA as well as a driver for a polarized positron source.

5. New Polarimeter Approach

Future electron beam polarimetry for the P2-experiment at the MESA accelerator in Mainz will meet unprecedented demands as, for instance, the proposed parity-violating scattering asymmetry measurement of the 12C-nucleus requires a polarization accuracy in the vicinity of 0.1% [11]. This is challenging even for the most advanced schemes proposed so far [12]. As a new approach, we investigate a Møller-scattering polarimeter which uses colliding bunches. We aim for operation at a subharmonic of MESA's 1300 MHz RF frequency which will increase the bunch charge in order to maximize luminosity while obeying the limitation of P2 towards average beam current. Such a device is suitable for online operation, which is a considerable advantage compared to conventional Mott or Møller polarimeters. The basic scheme (Fig.3) recirculates longitudinally polarized electron bunches in a 180-degree arc. If the length of the recirculation back to the interaction point (IP) is chosen as an integer multiple of the inter-bunch separation, bunches will collide at an interaction point (IP). A spin rotator in the recirculating arc switches the spin direction at the IP periodically. During bunch collisions, Møller scattering occurs with short electron bunches optimized for luminosity. All electron bunches have the same polarization of typical $P_e = 85$ %. The experimental asymmetry A_{exp} is measured by switching the bunches from parallel to anti-parallel direction. The beam polarization is then extracted from the measured asymmetry via $A_{exp} = P_e^2 A_{zz}$, with A_{zz} being the analyzing power that is known with very high precision. Taking into account cross sections and luminosity constraints, we find that the experiment should be integrated at the energy of the source in a range of 0.1-0.3 MeV. This arrangement can be operated online. While preliminary rate estimations indicate signal rates which can become reasonable when

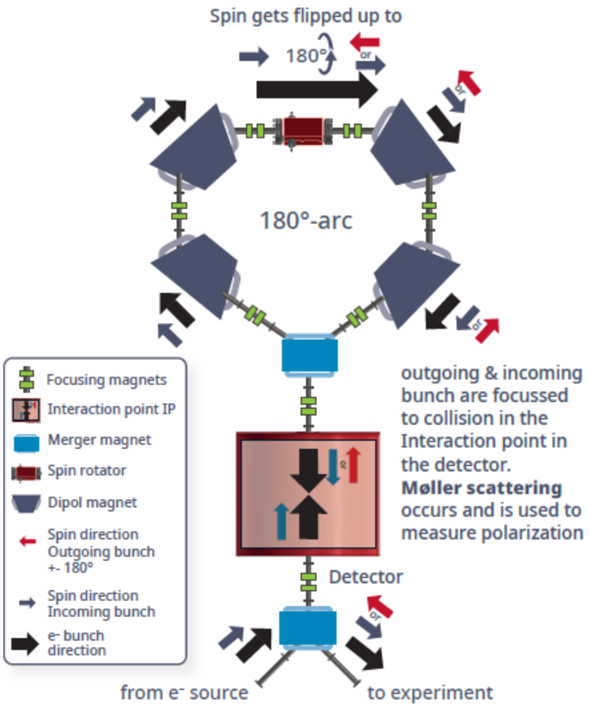

Figure 3: Sketch of the proposed colliding beam Møller polarimeter.

the source is operated with bunch charges of about 10 pC at the typical average current needed for P2, background conditions and luminosity fluctuations could limit performance since they have to be controlled at the 10^{-4} level under the operation of flipping the spin direction. Such studies can be done by modifying an existing source and beamline, for the time being independent from MESA.

References

[1] EWPAA - full list of talks at: https://events.hifis.net/e/ewpaa2024

[2] J.Maxson, Promoting Epitaxy in Alkali Antimonides, talk at EWPAA 24, https://events.hifis.net/e/ewpaa2024

[3] L. Jones, An Overview of MTE Measurement Techniques and Photocathode R& D at Daresbury Laboratory, talk at EWPAA 24, https://events.hifis.net/e/ewpaa2024.

[4] M. Herbert, Activation studies for GaAs photocathodes at Photo-CATCH, talk at EWPAA 24, https://events.hifis.net/e/ewpaa2024

[5] J. Trieb, Precision Measurements of Asymmetry and Quantum Efficiency in Photocathodes for Polarised Electron Beam Experiments, this conference.

[6] O. Raman, DBR photocathodes for EIC polarized electron source, talk at EWPAA 24, https://events.hifis.net/e/ewpaa2024

[7] G. Mulhollan, et al., Physics Letters A 282 (2001) 309–318

[8] E. Wang et. al. High-intensity polarized electron gun featuring distributed Bragg reflector GaAs photocathode. Applied Physics Letters, 124(25).

[9] G. Alexander et al., Phys. Rev. Lett., 100, 210801 (2008). doi:10.1103/PhysRevLett.100.210801

[10] D. Abbott et al. Phys. Rev. Lett., vol. 116, p. 214 801, 21 (2016) DOI: 10.1103/PhysRevLett.116.214801

[11] D. Becker et al., Eur. Phys. J. A 54, DOI 10.1140/epja/i2018–12611–6 (2018).

[12] K. Aulenbacher, E. Chudakov, D. Gaskell(*), J. Grames and K. Paschke, International Journal of Modern Physics E 27,7, p. 1830004 (2018).