**Demonstrating improved lifetime in superlattice photocathodes with robust activating coatings for high current, highly spin-polarized beam production**

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GaAs-based photocathodes are the state-of-the-art electron source for the production of highly spin polarized electron beams used in large scale accelerators for high energy (e.g. ILC) and nuclear physics experiments (CEBAF, Electron-Ion-Collider, LHeC), as well as in small scale accelerators like spin-polarized electron microscopy to investigate magnetic properties of condensed matter.

GaAs-based photocathodes can produce spin polarized electron beams only if the work-function is lowered with an activating dipole layer at the vacuum interface strong enough to generate Negative Electron Affinity (NEA), so that photoemission is enabled at photon energies near the bandgap. NEA is typically achieved by depositing just under a monolayer of Cs-O or Cs-NF3 on the photocathode surface. However, these activation layers are extremely sensitive to poor vacuum conditions and require extreme vacuum (in the range of $10^{-11}$ Torr or below). Even at such low pressures, their operation at moderate to high average beam currents (from few microamperes to few milliamperes) often results in a rapid quantum efficiency degradation over time (1/e decay measured from days to hours, respectively).

Recently, the Cornell University photocathode development group has been investigating alternative methods to produce NEA activation on bulk GaAs and on superlattice structures based on GaAs/GaAsP. We have demonstrated that activating layers based on Cs-O-Sb and on Cs-Te can provide one order of magnitude longer lifetimes with respect to the standard Cs-O activation layer without any spin depolarization and with minimal losses in the quantum efficiency. However, these demonstrations were only performed with low beam energies, and at low currents and small extraction fields.

If the lifetime improvements at low electric field, low energy and low charge translate to realistic gun conditions (high current, high energy), this technology can pave the way to the realization of future facilities based on high average current Energy Recovery Linacs to deliver highly intensity spin polarized beams. Furthermore, this could broaden the application of spin polarized cathodes beyond conventional high voltage DC guns, to less forgiving but potentially higher brightness guns like high field SRF guns.

We propose a dedicated set of experiments, using both surface science analysis at Cornell University, and a state-of-the-art photoinjector at a test beamline at Thomas Jefferson National Accelerator Facility to further study such methods and perform lifetime measurements and polarimetry at in an electron gun with beam energy up to 200 kV and with high currents in mA range. We expect to train a graduate student in the growth and characterization of these new activating layer and in the operation and characterization of photocathodes in a state-of-the-art photoinjector facility.