Topic 1
Energetic Particle Damage Mitigation for High Polarization Photocathodes in RF Guns
---

A fundamental issue with high field electron guns is the generation of stray electrons and ions which can damage the photoemitter. Both the photogenerated electron bunch and (unintended) field emitted electrons can directly impact the photocathode, desorb molecules from the gun structure and act as ionization agents for background-gas atoms. The preponderance of ion generation in long pulse or DC guns is from the photogenerated electrons. In RF guns the fluence at the cathode depends on several factors including the gun RF frequency, the time structure of the exciting light pulse, the available particle species and the geometry of the gun cell.

A successful strategy for the design and operation of a polarized gun so as to maximize the lifetime of the photocathode requires the species and energy spectrum of the incoming particle flux at the cathode to be identified and the associated specific damage to be quantified. A large body of experimental data on cathode damage does not yet exist, however, particularly with respect to the lower and intermediate energies, and especially ~~on~~ with respect to the sensitivity of the activation layer. Saxet Surface Science, in collaboration with SLAC, will first model the system for determination of species, energy and flux and then experimentally measure the interaction effects for those energies and species where existing data is nonexistent. The algorithms and methodology employed in modeling a specific structure will be regularized so that application to similar gun systems will be straightforward.

The results of a successful project can be used to improve the operational lifetime of any polarized electron cathode regardless of gun structure and may prove to be crucial especially for the operation of polarized RF guns.

SLAC effort in Phase I estimated to be ~0.2 FTE (0.1 FTE Bob Kirby [SMS], 0.1 FTE Feng Zhou [ILC]).

Topic 2

Activation Layer Stabilization of High Polarization Photocathodes in Sub-Optimal Environments

---

Negative electron affinity photocathodes used as sources of spin-polarized electrons are currently restricted to operation in the very best ultra-high vacuum environments. This is especially true when it is required that the electron source exhibit stable operation over periods greater than several hours. The primary factor contributing to the need to limit many vacuum vessel gas species is the relatively high chemical reactivity of the activated surface with many background vacuum gasses.

Modest efforts to work around this problem have included encapsulating the photocathode and overcoating with a somewhat less reactive species, e.g., antimony. Saxet Surface Science, in collaboration with SLAC, will test and compare the effects on electron yield and spin-polarization of potential stabilization methods including the use of: 1) small covalent-radii alkali post-activation treatment; 2) intermediate alkali-antimonide layer; 3) oxidizer anti-flip pinning; and 4) photoelectron transparent overlayers.

The most promising treatments will be further checked for effects on charge output.

A successful project will result in a significantly longer lifetime for polarized photocathodes in any gun system and may prove to be crucial for successful operation of polarized RF guns. In addition, it will make polarized electron sources for commercial applications much more feasible.

SLAC effort in Phase I estimated to be ~0.1 FTE (Katerina Ioakeimidi [ILC]).

Topic 3

Optically Oriented Electrons via Field Emitting GaAs Nanowires as an RF Gun High Polarization Photocathode

---

Negative electron affinity photocathodes used as sources of spin-polarized electrons are currently restricted to operation in the best of vacuum environments. The chemicals used to activate the surface to a state of negative electron affinity also may contribute to RF breakdown during operation, primarily by migration of alkali metals onto the gun cell walls. One potential solution to eliminate alkali poisoning is through the use of an alkali-free field emitter as the source of spin-polarized electrons. The emission process first consists of optical orientation and excitation to the conduction band of valence band electrons in the usual fashion. Rather than lowering the surface barrier by chemical adsorbates, the emission probability can be greatly enhanced by the application of high fields, i.e., through field emission. Recently, it has been shown that an etched, isolated GaAs tip will emit spin-polarized photoelectrons under these conditions. Saxet Surface Science will first develop a surface composed of GaAs nanowires. Then in collaboration with SLAC, Saxet will test the photoemission yield and spin-polarization of photoemitted electrons. This new material has the advantage of being readily grown with high tip densities and work to date shows a tunneling current turn-on field consistent with RF- and pulsed-gun field maxima. It is also expected to exhibit much of the robustness of the carbon nanotube, which is a similar material.

A successful project will result in a radically new type of polarized photocathode that will completely bypass high-voltage problems associated with traditional surface activation materials.

SLAC effort in Phase I estimated to be ~0.1 FTE (Katerina Ioakeimidi [ILC]).