SBIR proposals

- Sb based photocathode with SVT
- Graded bandgap with SVT
- PPA proposal with St. Petersburg on flat conduction band SL structures

SBIR1

- TECHNICAL ABSTRACT
- GaAs based negative-electron-affinity (NEA) photocathodes produce polarized electrons are a vital component of linear electron accelerators, including the 2-mile linac at the Stanford Linear Accelerator Center (SLAC) and future linear colliders. With the successful completion of an SBIR to develop a highly-polarized GaAs/GaAsP strained-superlattice structure, we have achieved the peak polarization of (86±4)% with a record high 1% quantum efficiency. The newly developed structure has been successfully used at SLAC for a polarized Moller scattering experiment at 50 GeV and at other accelerator laboratories such as Jefferson Lab and MIT Bates Linear Accelerator Center.
- Despite these successes, the highest polarization (P) is limited to about 85%, while in principle, 100% polarization is obtainable. Also the robustness of these cathodes is severely compromised in the environment of an RF gun. In the SBIR the strain and superlattice structural parameters were widely varied to maximize the polarization. However, the maximum polarization appeared saturated, indicating a material specific spin-depolarization mechanism.
- To study the spin-depolarization mechanism, and increase the robustness of these cathodes for RF gunswe propose to develop strained-superlattice photocathodes based on GaAs and AlGaAsSb, partially replacing the As with Sb for 2 reasons:
- a. Sb has higher spin orbit coupling than As so we can study the effect of spin orbit coupling on depolarization
- b. Sb has 3 orders of magnitude lower diffusivity than Ga. Diffusivity is one of the main reasons of structural decomposition of cathodes especially during heat cleaning. We expect that the addition of Sb will provide more robust structures.
- In the proposed superlattice structures, alternating layers of GaAs and AlGaAsSb each with approximately ten monolayer thickness will be grown by the gas source molecular beam epitaxy (GSMBE) technique.
- The optimization will be performed by varying the structural design and the growth conditions in a matrix of experiments controlled by feedback from polarization measurements made at SLAC.

SBIR2

- TECHNICAL ABSTRACT
- The negative-electron-affinity (NEA) photocathodes which produce polarized electrons are a vital component of linear electron accelerators, including the 2-mile linac at the Stanford Linear Accelerator Center (SLAC) and future linear colliders. With the successful completion of an SBIR to develop a highly-polarized GaAs/GaAsP strained-superlattice structure, we have achieved the peak polarization of (86±4)% with a record high 1% quantum efficiency. The newly developed structure has been successfully used at SLAC for a polarized Moller scattering experiment at 50 GeV and at other accelerator laboratories such as Jefferson Lab and MIT Bates Linear Accelerator Center.
- Despite these successes, the highest polarization (P) is limited to about 85%, while in principle, 100% polarization is obtainable. In the SBIR the strain and superlattice structural parameters were widely varied to maximize the polarization. However, the maximum polarization appeared saturated, indicating a material specific spin-depolarization mechanism. In a more recent SBIR with Saxet Interface we have demonstrated that the transport mechanism of the electrons in the active region plays a significant role in both the QE and the polarization of electrons and can produce short electron bunches.
- Here we propose a graded bandgap active region which provides an internal accelerating field for the photogenerated electrons. That way no additional modifications are required at the cathode region of the gun to accommodate any bias electrodes. Another advantage is that wide bandgap materials or structures can be used which provide robustness, an important cathode requirement for RF guns. The bandgap variation must be less than the heavy hole light hole splitting in these structures in order to maintain polarization selectivity during photogeneration of the electrons.
- To study the graded bandgap structures we propose to begin with AlGaAs/GaAs superlattice structures with the Al concentration varying in each barrier to provide the grading of the bandgap. Two important features of this structure are the following:
- 1. The bandgap change happens exclusively in the conduction band so maximum accelerating field can be achieved for the electrons for any bandgap variation.
- 2. The same strain can be maintained through out the structure.
- In this structure, alternating layers of GaAs and AlGaAs each with approximately ten monolayer thickness will be grown by the gas source molecular beam epitaxy (GSMBE) technique.
- The optimization will be performed by varying the structural design and the growth conditions in a matrix of experiments controlled by feedback from polarization measurements made at SLAC. Once the effect of the electric field on the polarization is established we will test more complicated structures with varying strain as well as bandgap.