Alkali Metal Photocathodes

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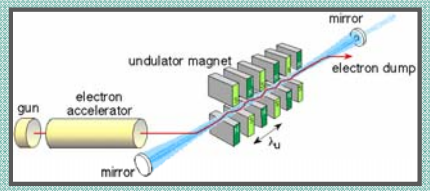
Motivation

To produce high powered electron beams for Free Electron Lasers through use of alkali metal photocathodes.

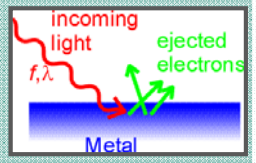
Introduction

•**Free Electron Lasers** (FELs) are high power lasers with optical beam quality, emit radiation with a wide range of wavelengths.



The FEL wiggler oscillates the beam through an alternating magnetic field.

•When photons strike a metal, electrons are emitted . If a photocathode is used, it would be the source for FELs to make an electron beam.



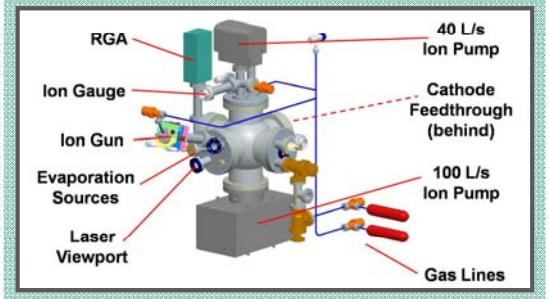
•An important feature of photocathodes is **Quantum Efficiency (QE)**, the ratio of emitted electrons per incident photons:

$$QE\ (\%) = \frac{i(A) * 124}{P(W) * \lambda(\mu m)}$$

•**Alkali metal** atoms ionize easily due to one valence electron. An alkali coating forms a dipole on a surface which lowers its **work function**, the amount of energy that is needed for an electron to escape and be emitted.

Experiment

•An **ultra high vacuum chamber** is used to keep the pressure at ~10^-9 Torr.



•**UV, Blue, Green, Red, and IR** diode lasers are mounted on a translating stage that is automated to cycle through each laser. Their photons will penetrate the cathode surface to excite the electrons.

375, 405, 532, 655, 808 nm

•**Tungsten metal** is the substrate for the cathode. The annular anode applies a voltage to collect the photoemitted electrons.

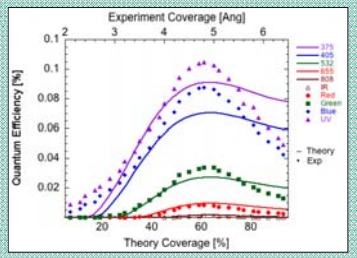
•The cathode is atomically cleaned between trials through argon ion bombardment using an ion gun.

Present Goal

Potassium, and **Sodium** alkali metals will be deposited onto the tungsten surface from external evaporation sources. The objective is to obtain **high quantum efficiency** from these alkali coatings and compare to successful Cesium on tungsten results.

Results and Conclusions

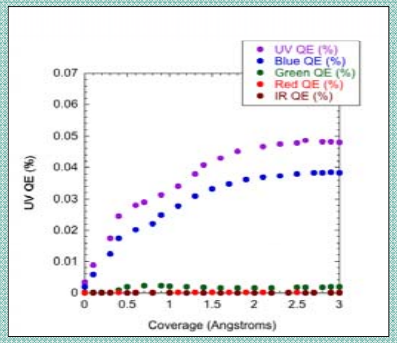
Cs - Theory and Experiment



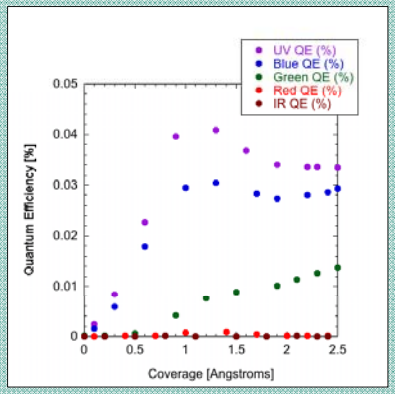
Cs on W

•Coverage is in terms of a percent of a monolayer, the diameter of a Cs atom (5.309 Å).
•Peak QE occurs when optimal coverage is reached, for Cs occurs about 63% of a monolayer.
•Cs on W yields an experimental peak at 0.11% QE for the UV laser.
•After optimal coverage, the turnover recedes to half the original peak value.

Alkali Metal Coatings



Na on W



K on W

•In magnitude, QE peaks for Na and K are lower than Cs on W, which is expected since K and Na are less electropositive elements and form a weaker dipole moment, so fewer electrons can escape.
•The turnover past the peak is less for Na and K than for Cs due to less interaction between the atoms.
•Na and K evaporate slower than Cs, for their vapor pressures are lower, so QE persists longer at monolayer coverage. The trade off: these alkalis give lower QE but create a more robust cathode.

Future Work

Studies of semiconductor coatings by designing multi alkali antimonide recipes of K-Na-Sb and of Cs-K-Na-Sb in order to further increase QE.