Photocathodes for High Repetition Rate Light Sources

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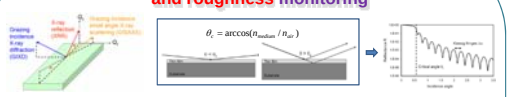
DIFFRACTION AND REFLECTOMETRY

Antimony Diffraction

Mo(2)

Preliminary diffraction data of antimony films, both sputtered and evaporated, has been obtained using beamline NSLS X21.

X-ray reflectometry (XRR) provides in-situ thickness and roughness monitoring



$$\theta_c = \arccos(n_{medium} / n_{air})$$

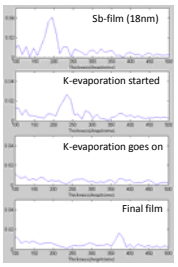
Sputtered Sb on Mo

Raw X-ray Image | FT giving film thickness

Evaporation

SEM EDX gave final thickness of 39 nm vs 37 nm from XRR

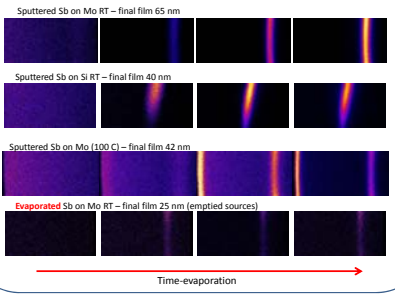
K evaporation onto Sb (130 C)



For an *in-situ* sputtered Sb film (18 nm) , fringes appear around 3 nm. The roughness increases as K-evaporation starts; the presence of a single peak shows that K instantaneously (1s) reacts and intermixes . As K-evaporation continues, the peak disappears, indicating significant roughness. For the final film (at 37 nm), the roughness decreases and the peak reappears. Crystalline phase transition?

X-ray diffraction (XRD) provides in-situ texture monitoring

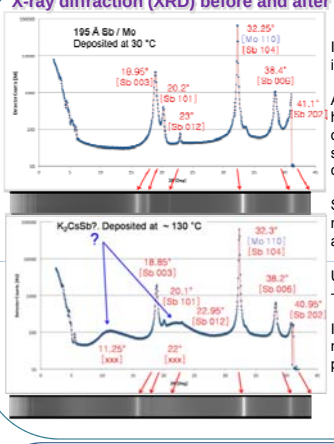
Real-time WAXS movie: Monitoring texture of Sb layer



In-situ growth :

- Broadened peaks become sharper and narrower as film gets thicker
- Phase transition from amorphous to crystalline structure around 8 nm
- Clear texture in RT films on both Si and Mo; texture less significant at 100C

X-ray diffraction (XRD) before and after cathode growth



Initial Sb film sputtered in-situ at room temp

After Cathode growth, high indexed Sb peaks disappear, indicating smaller or very strained crystallites

Some unreacted Sb remains – insufficient alkali?

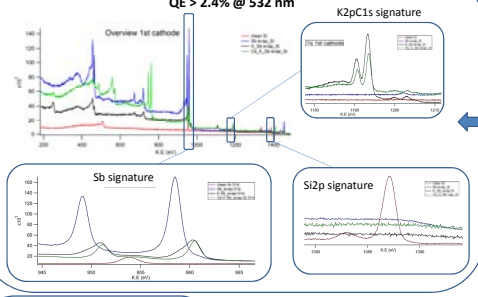
Unclear which Cs_xK_ySb -phases are produced

Is the active cathode material in amorphous phase?

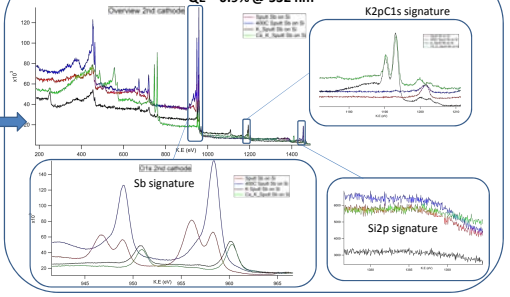
CATHODE GROWTH PROCESS

Two bi-alkali photocathodes have been grown and the chemistry of their subsequent layers have been analyzed by means of X-ray Photoelectron Spectroscopy (XPS). The goal is to understand the interdiffusion process which occurs during growth, and observe how this changes with recipe alteration. This will allow comparison of the final phase of the cathodes grown with different substrates or temperatures, and correlation of these differences with QE.

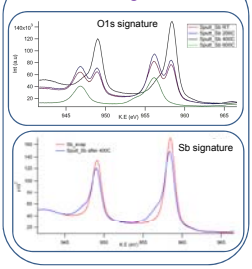
1st cathode: *In-situ* evaporated Sb
QE > 2.4% @ 532 nm



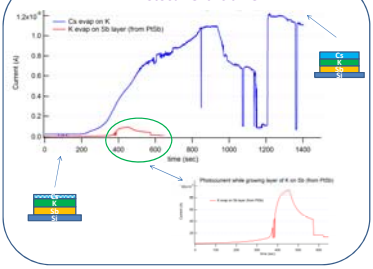
2nd cathode: *Ex-situ* sputtered Sb
QE ~ 0.9% @ 532 nm



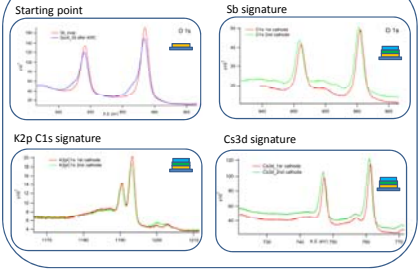
Thermal "cleaning" of substrate



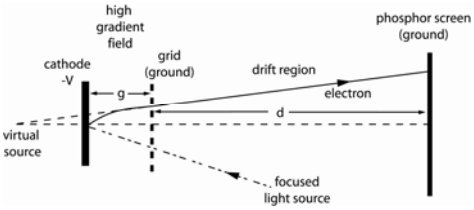
Photocurrent vs time

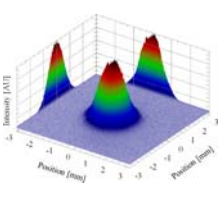


Comparing cathodes

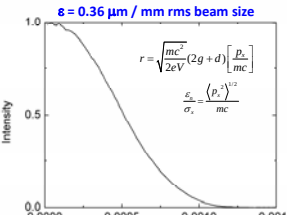


TRANSVERSE MOMENTUM





ε = 0.36 μm / mm rms beam size



$$r = \sqrt{\frac{mc^2}{2eV}(2g+d)}\left[\frac{p_x}{mc}\right]$$

$$\frac{\varepsilon_x}{\sigma_x} = \frac{\langle p_x^2 \rangle^{1/2}}{mc}$$

The transverse momentum (and therefore the intrinsic emittance) of a K_2CsSb cathode has been measured using 543 nm light. A bias of up to 20 kV can be applied to the grid, with a spacing (g) of 5 mm. A long drift (d=252 mm) is used to ensure the spot size on the phosphor is dominated by p_x and not the initial (0.1 mm) spot size. The system has been calibrated with metals (Mo & Sb) and has a resolution better than 25 meV.

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