Multi-Alkali and GaAs cathodes

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GaAs: Unpol.
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Multi-Alkali Photocathode

- Technology already exists
- Based on Boeing results
- Tailored to our requirements
  - High average (>50 mA) and high peak current (>100 A)
  - Large area (up to 7 mm diameter)
  - SRF injector
  - Long Life time
  - High QE
  - High reliability
K$_2$CsSb Cathode

Following work done by others: Photomultiplier development, Spicer, Dowell etc

32 mA at 25% duty factor

D. Dowell et al. NIM A 356 (1995) 167

RCA Photomultiplier Handbook

T. Rao, FLS 2010, SLAC March 2010
Photocathode Deposition System V1

10^{11} Torr in all chambers
All sources in prep.
Chamber Cooling, high current capability in test chamber
Measurement capability in both chambers

Focused on
Large Area
Recipe development
Life time measurements
High current tests
Temperature Dependence
Established the recipe

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Å Sb</td>
<td>150 °C</td>
</tr>
<tr>
<td>200 Å K</td>
<td>140 °C</td>
</tr>
<tr>
<td>Cs to optimize QE</td>
<td>135 °C</td>
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</tbody>
</table>

Determination of wavelength: 366 nm

Large area uniformity

Long Life time

Cross contamination

Long deposition time

T. Rao, FLS 2010, SLAC March 2010
Photocathode Deposition System V2

T. Rao, FLS 2010, SLAC March 2010
Comparison of Substrate Material

SS better than Cu, Mo under investigation

Reproducibility

10-20% QE, reproducible

Unpolished copper (a)
Polished copper (b)
Stainless Steel (c)
Stainless Steel, 1 week after deposition (d)
High current (47.7mW, 0.526mA)
Cathode 4
Cathode 3 (120 C substrate temp)
Cathode 2
Cathode 2 High current (0.526 mA, 47.7 mW)
Cathode 4 High current (0.126 mA, 5.9 mW)
Temperature Dependence

No degradation at cryogenic temperature
Linearity and Space Charge

ERL Current density is 1.3 mA/mm²

80 µm FWHM spot on cathode

Optical Power @ 532 nm (mW)
2010

Photocurrent (µA)

1 kV bias
3 kV bias

2.2 mA/mm²
QE Decay
80 µm FWHM spot on cathode, 0.7 mW laser power, base pressure $10^{-10}$ Torr

Decay due to ion bombardment
Comparison between three step model theory and experiment

Max QE measured @ 350 nm ~ 16%

 QE

 Photon Energy (eV)

data - cathode 4
5 nm el-ph mfp
Photocathode Deposition System & transport Cart V3

Depo. Chamber tested to 3x10^{-10} Torr, awaits HT bake. Transport cart being assembled

T. Rao, FLS 2010, SLAC March 2010
GaAs Photocathode

Testing in SRF gun: GaAs and Cs in SRF environment
  SRF gun modification
  Cryostat
  GaAs Plug design and fabrication
  Laser system
  Phase lock system
  Diagnostics
Polarized electron source for Electron-Ion Collider
0.6 cell BNL SRF PG
GaAs in the plug: Recessed Insertion

T. Rao, FLS 2010, SLAC March 2010
Cathode Preparation Chamber

Jlab recipe followed, Max QE at present 5.6%, still being improved
Vacuum level: low $10^{-11}$ Torr
TSP was acceptable
Sample heating: Direct Stalk heater, Stalk heater of Cu enclosure $\rightarrow$ Mostly radiant heating of sample
Saes Getter Cs source (Alvatec source was problematic)
NEA surface: Oxygen exposure, Yo Yo process

QE of 5.6 %
Life time in prep. Chamber 24 hrs., commensurate with monolayer formation time
Life time in transport section very poor
   Improved pumping system
   Improved baking
Status

- Cryostat in place
- Top flange being assembled
- SRF gun tested with Nb plug
- GaAs insertion technique designed and tested
- GaAs:Cs cathode ready 5.6% QE at 532 nm
- Laser available-Transport being designed
- RF available
- Synchronization/Phase lock system being designed and built
- Safety certification in process
  - Shielded enclosure
  - RF interlock
  - Laser interlock