Probing Anomalously High Quantum Efficiency of Self-Healing Gold Photocathodes

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Introduction
• Designed and built new UHV test stand allowing physical vapor deposition of gold and cesium as well as measurements of quantum efficiency
• Gold deposited on cathodes using molybdenum boat evaporator
• Cesium deposited on a gold-coated cathode in new test chamber
• Quantum efficiency of CsAu cathode tested during cesium deposition

Experimental Setup

Cesium Auride
• CsAu of interest because it displays high QE compared to other materials compatible with self-healing design
• To form CsAu:
  • Gold evaporated onto sintered tungsten photocathode
  • Cesium deposited onto thin layer of gold, forming CsAu alloy

Motivation
• Understanding of inconsistent measurements of CsAu QE
• Formation of high QE, long lifetime photocathodes for use in Free Electron Lasers
• Applications to naval defense systems
• High QE, self-healing cathodes useful for photoinjector tune-up

Self-Healing Photocathodes
• Dispenser cathodes equipped with cesium reservoir for in-situ recesiation
• Recesiation can replenish QE of cathode, thus increasing lifetime
• CsAu may be compatible with self-healing cathode design

Results
• Profilometer scans showed gold thickness of ~12 Å
• When viewed under microscope, gold layer appears uneven
• Possible spitting of gold observed in some evaporations

Conclusions/ Future Work
• New evaporation chamber fully assembled and ready for future tests
• Test effects of atmospheric contamination between gold evaporation and cesium deposition
• Installation of self-healing cathodes with built-in heaters
• CsAu QE measured lower than previous measurements at UMD
• Demonstrated consecutive vapor depositions without breaking vacuum
• New tests stand enables further examination of CsAu photocathodes to determine reason for QE differences

 QE = \frac{\text{electrons emitted}}{\text{photons incident}}

Troubleshooting
• Dependence of current on pressure observed in some tests, may have masked changes in photocurrent
  • Ion pump and gauge had line of sight to cathode and anode feedthroughs


QE vs Cesium Applied

Previous Gold Evaporation Chamber

New Test Chamber

New Chamber Features:
• S43.5 nm HeNe drive laser
• Fully automated in LabVIEW
• Equipped for both gold and cesium physical vapor deposition
• Cathode mount compatible with current and future cathode designs
• Equipped with quartz crystal deposition monitor
• Flexible design ensures compatibility with future equipment

Gold coating on Silicon chip

QE observed lower than expected, peaks at .0056% and .0071%
• Unique ability of CsAu for repeat tests without surface cleaning

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Cathode, anode, quartz crystal mounted inside chamber