Photoelectrochemical H_2 Production

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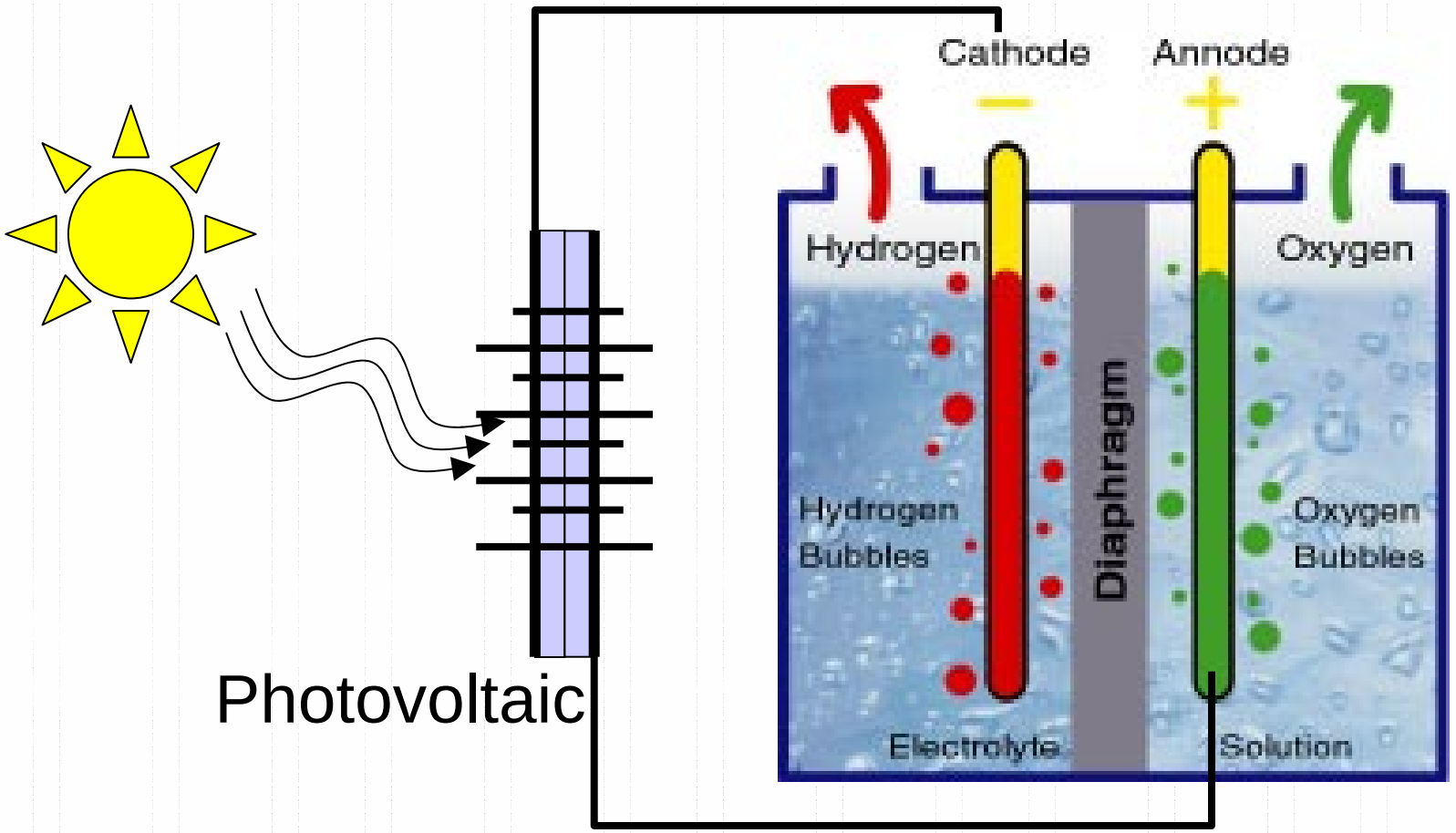
H_2 Production

- Clean renewable fuel source
- High fuel value of 142 kJ/g
- Reduces the use of fossil fuels
- Combustion produces H_2O

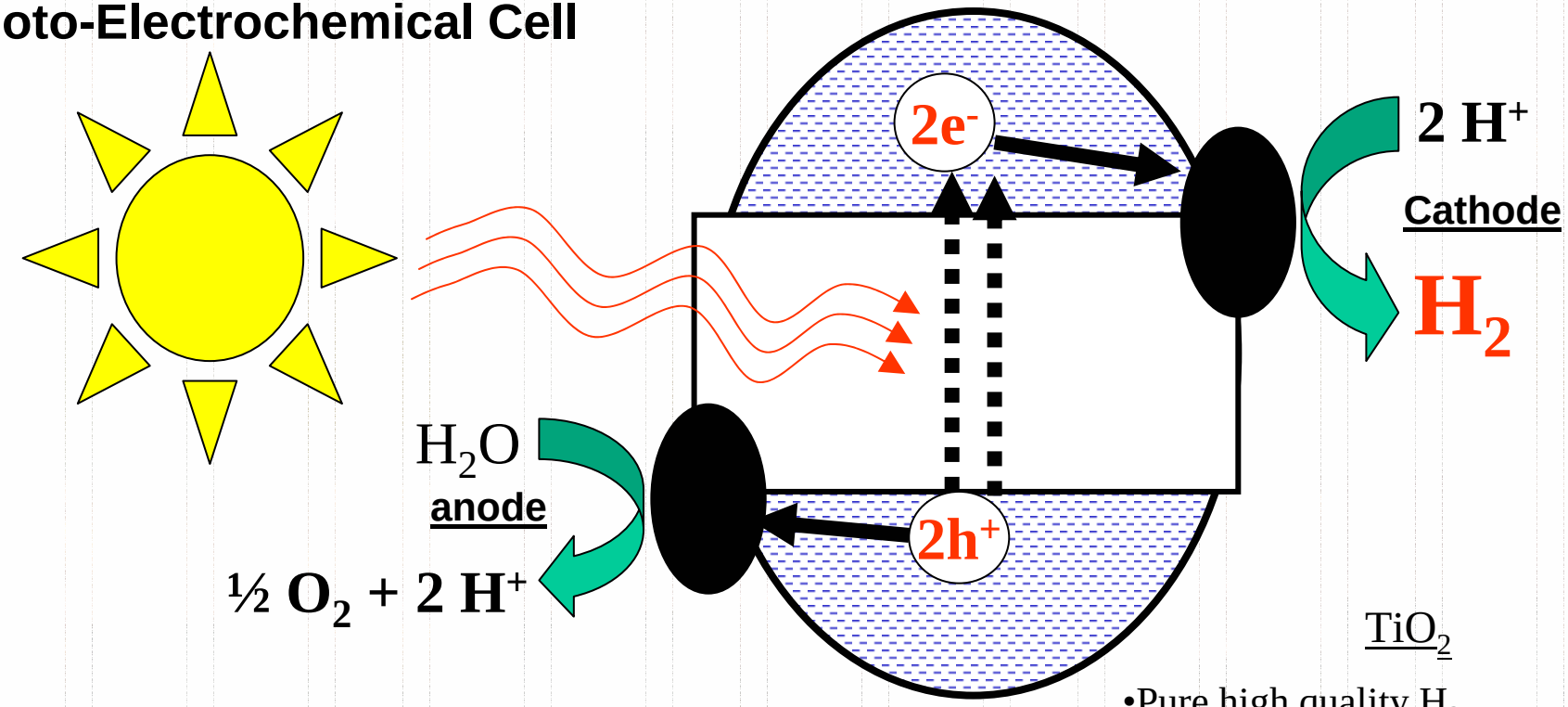
- Little H_2 in nature
- decomposed H_2O or hydrocarbons, fossil fuels
- cost more energy to make
- expensive materials for solar energy
- Gas-storage

Photovoltaic + Electrochemistry



Solar Energy → Chemical Energy

1972 Fujishima and Honda
Photo-Electrochemical Cell



TiO$_2$

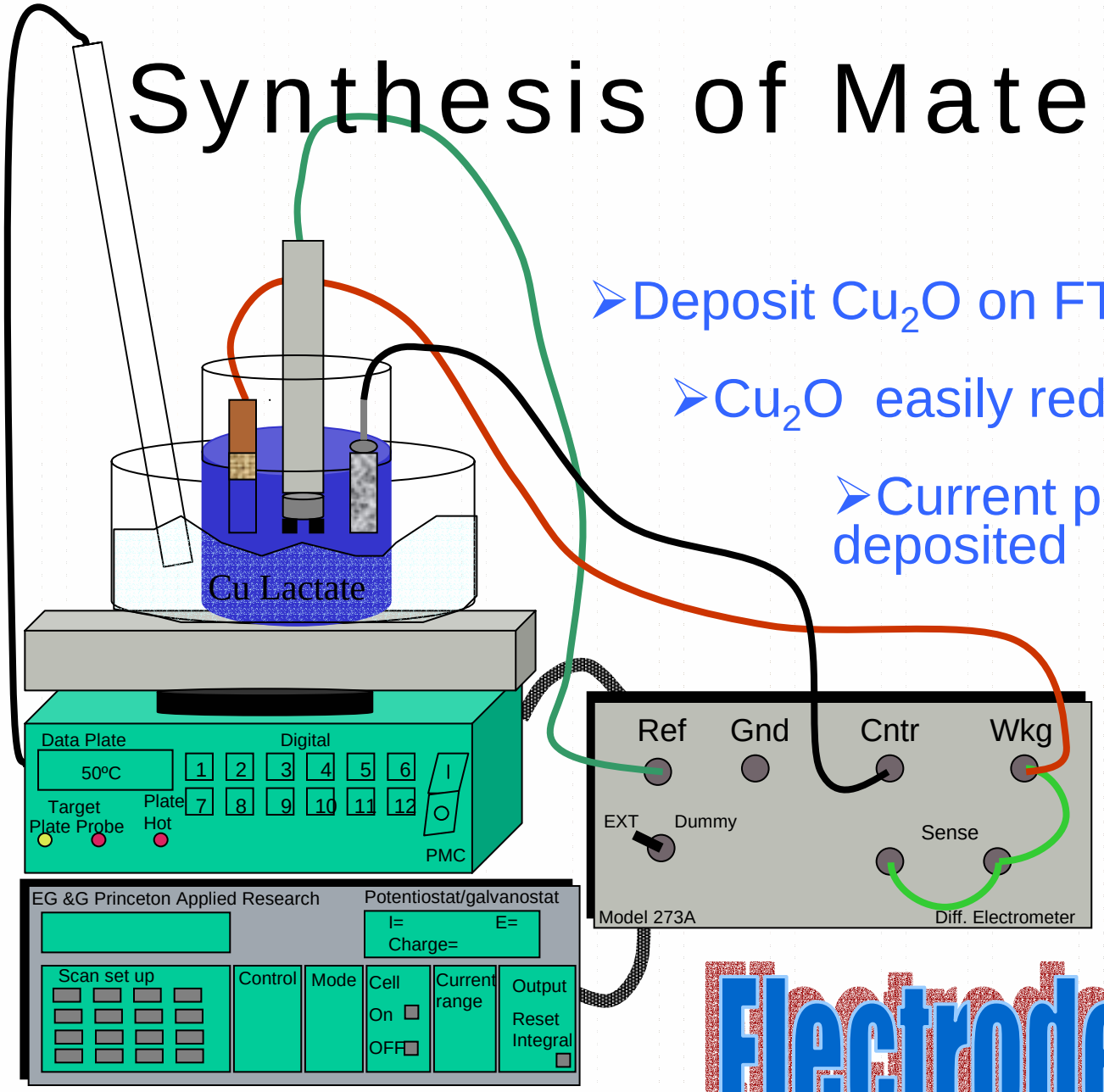
- Pure high quality H_2
- Required expensive Pt catalyst
- Band gap too large for efficiency
- Poor solar absorption (UV only)

Practical H_2 from Photoelectrodes

- ✓must be inexpensive and stable
- ✓semiconductors with bandgaps in the energy range of visible light
- ✓potential cathode materials is Cu_2O
- ✓Cu_2O is prone to “photocorrosion”

Cu_2O-based heterojunction photocathode

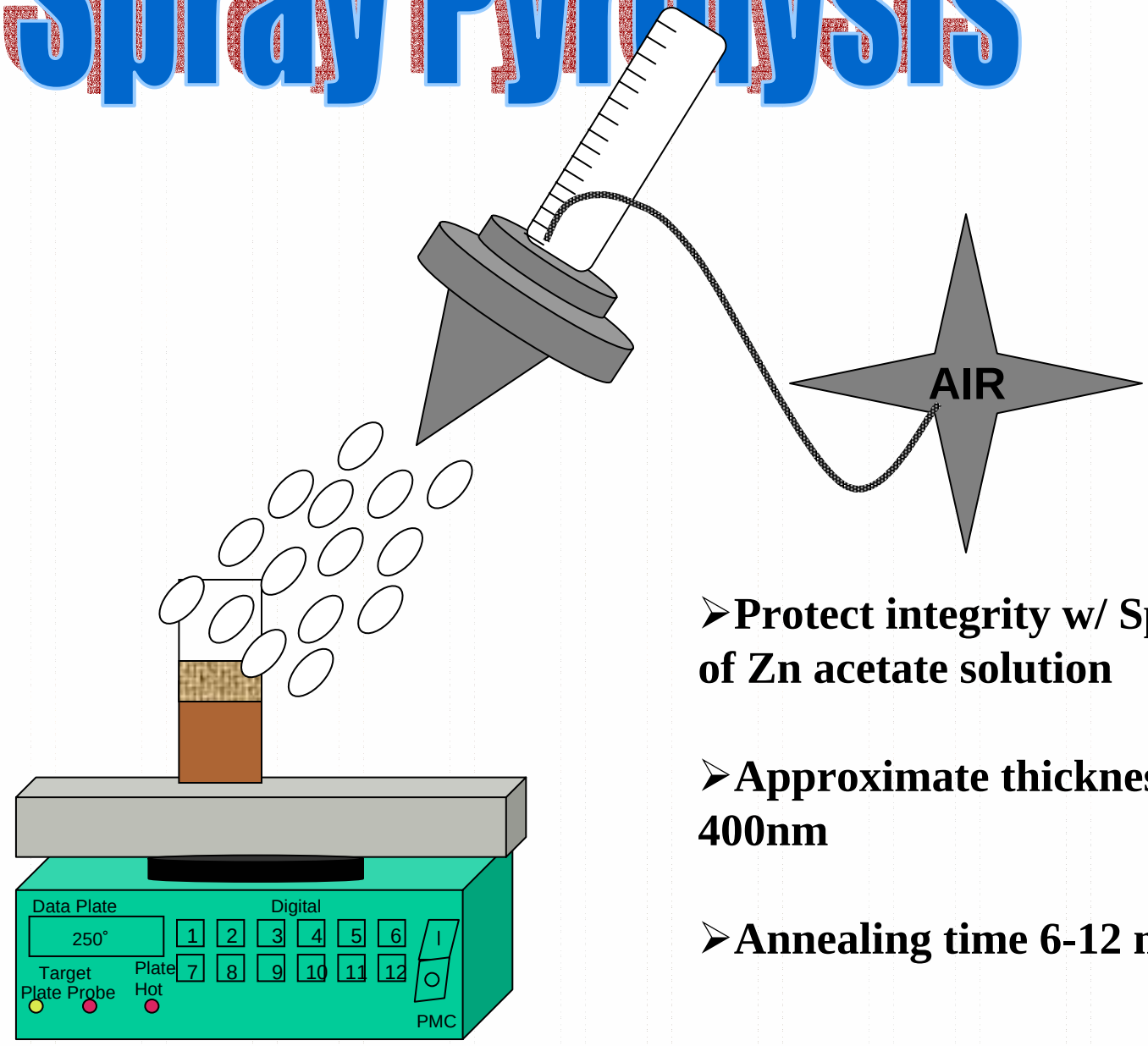
Synthesis of Materials



- Deposit Cu_2O on FTO substrates
- Cu_2O easily reduces or oxidized
- Current proportional Cu_2O deposited

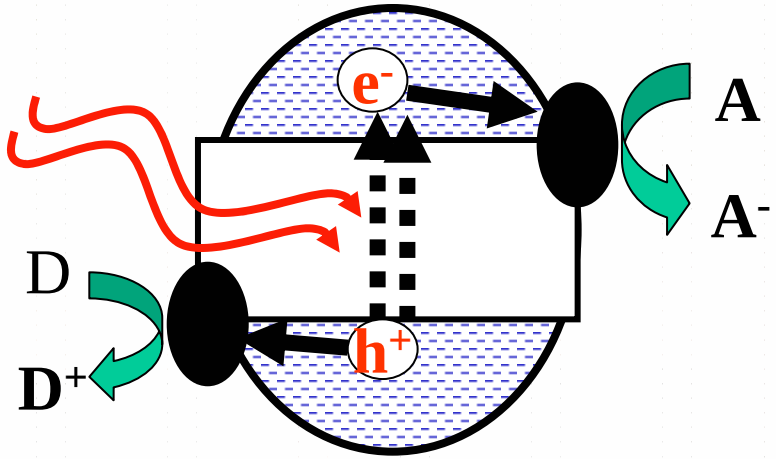
Electrodeposition

Spray Pyrolysis



- **Protect integrity w/ Spray Pyrolysis of Zn acetate solution**
- **Approximate thickness 200nm-400nm**
- **Annealing time 6-12 minutes**

Photocatalyst Screening



Zero-bias photocurrent as a function of time

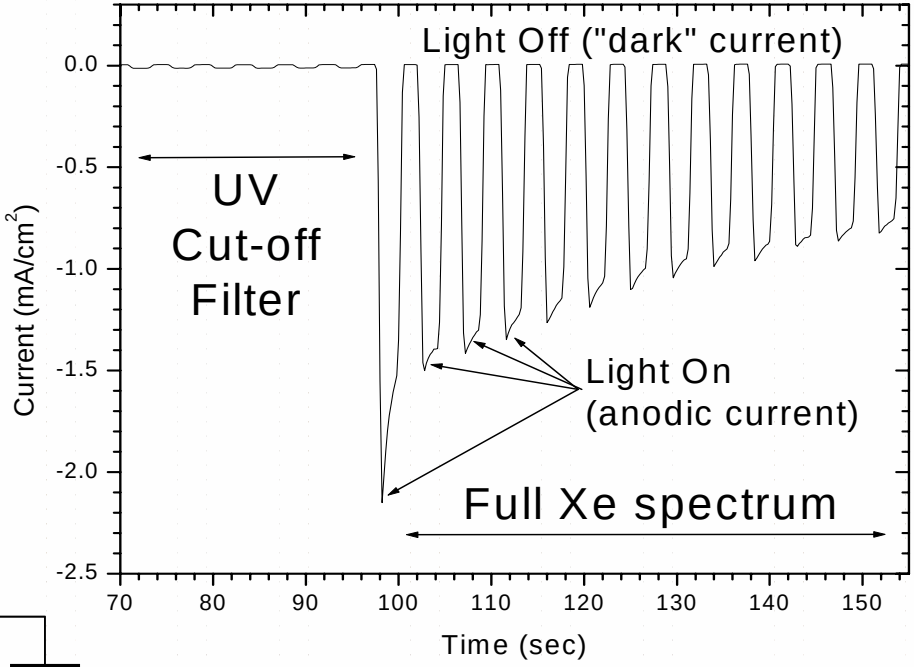
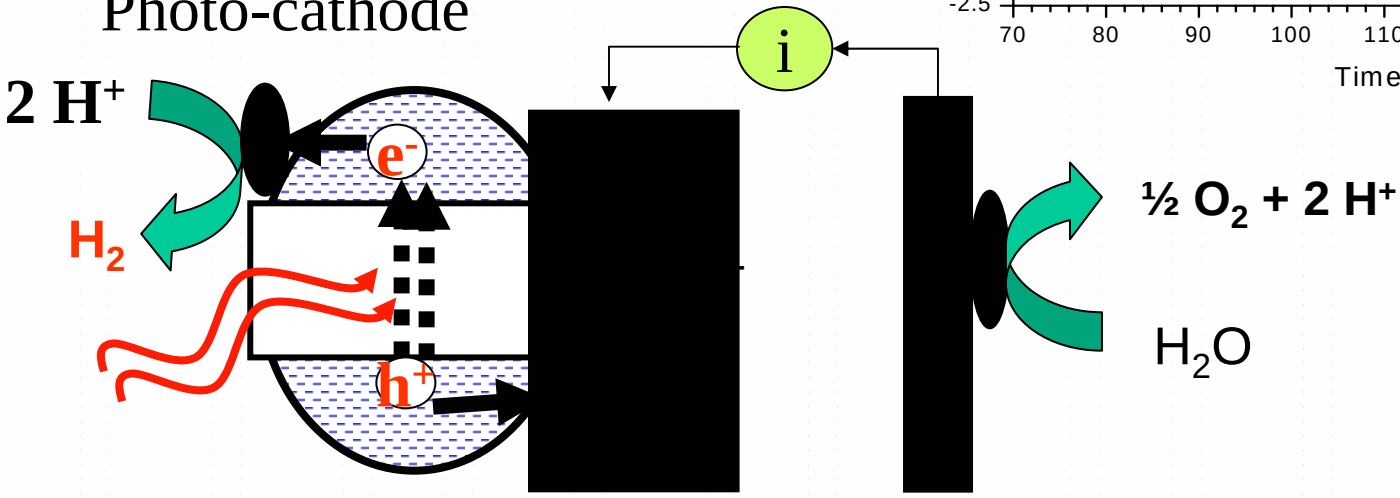
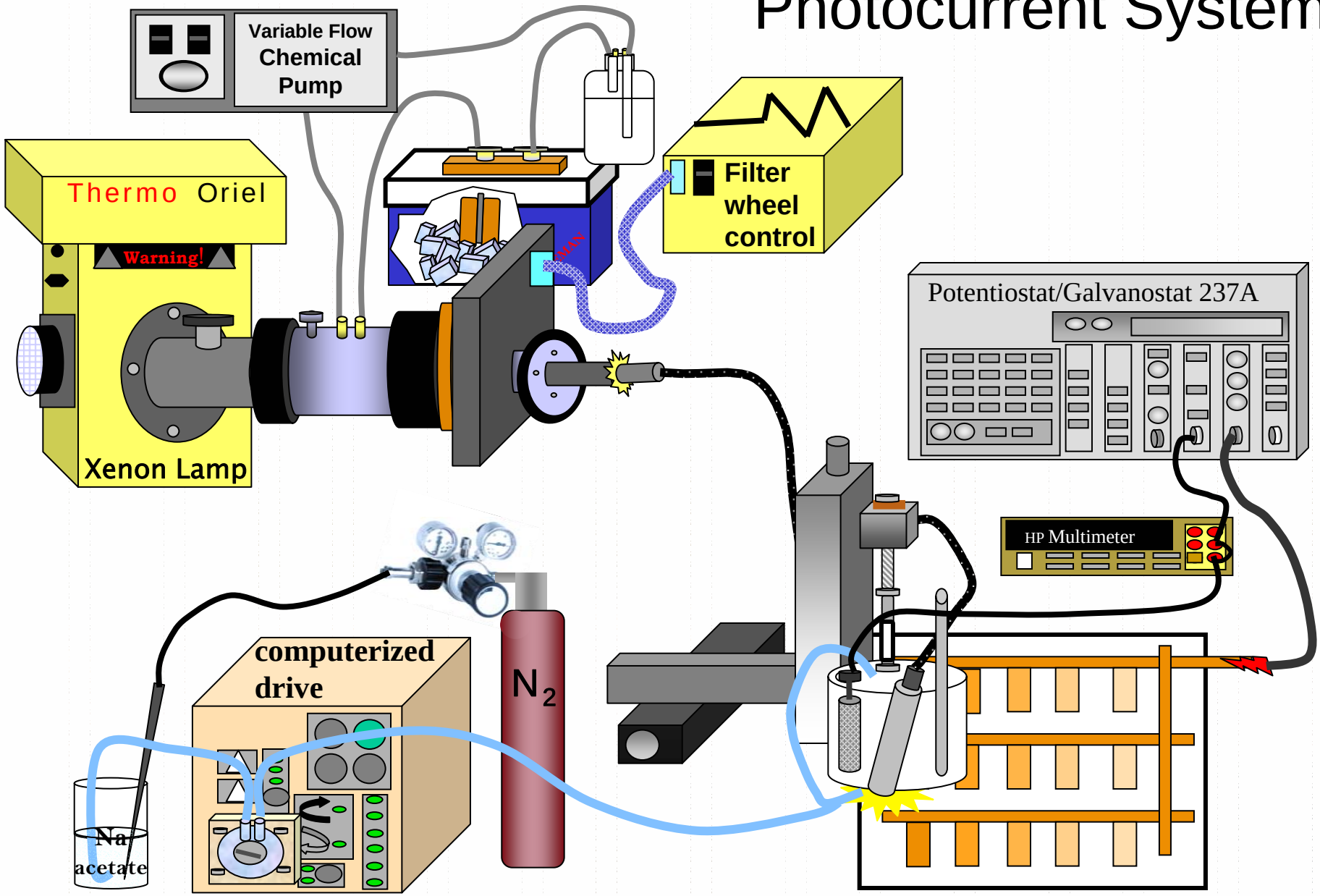
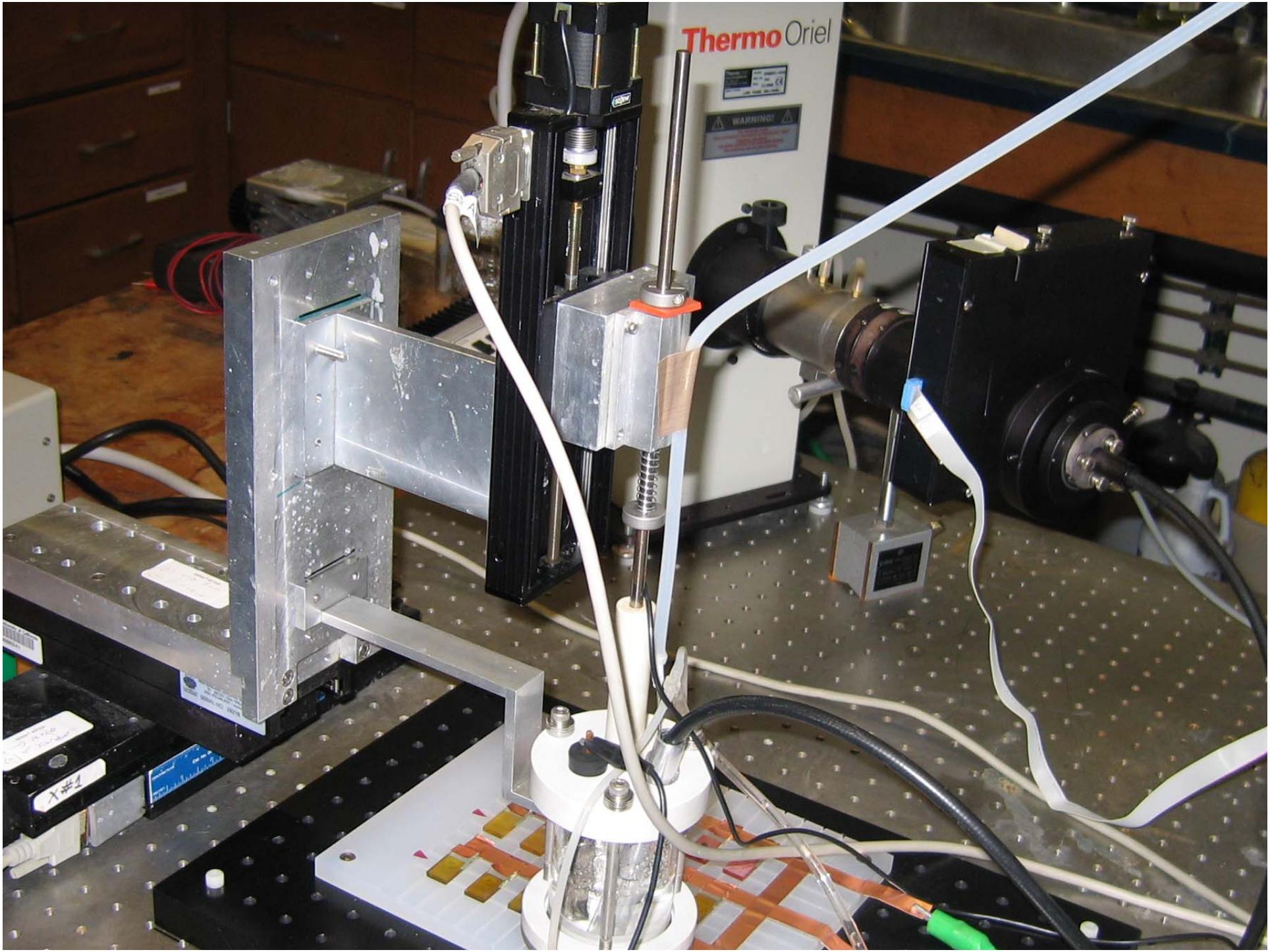


Photo-cathode



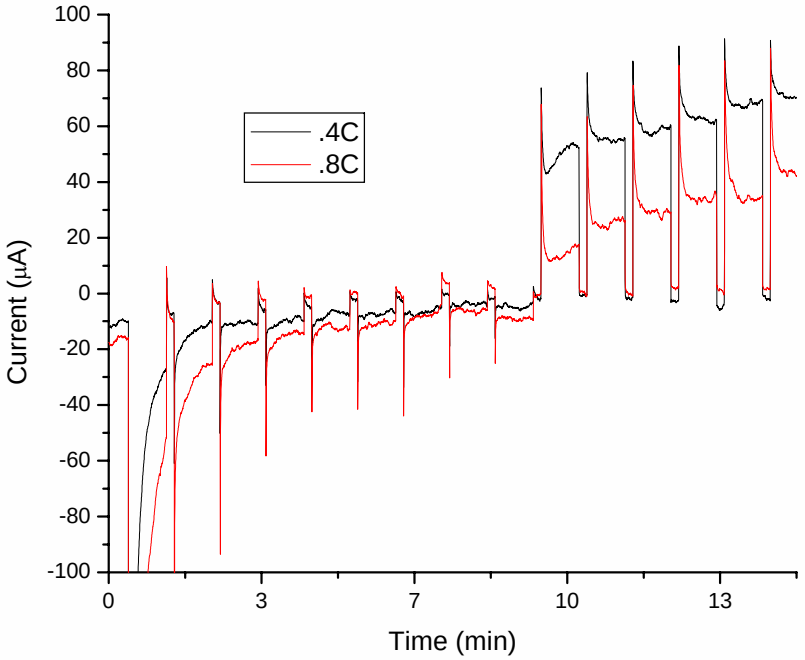
Photocurrent System



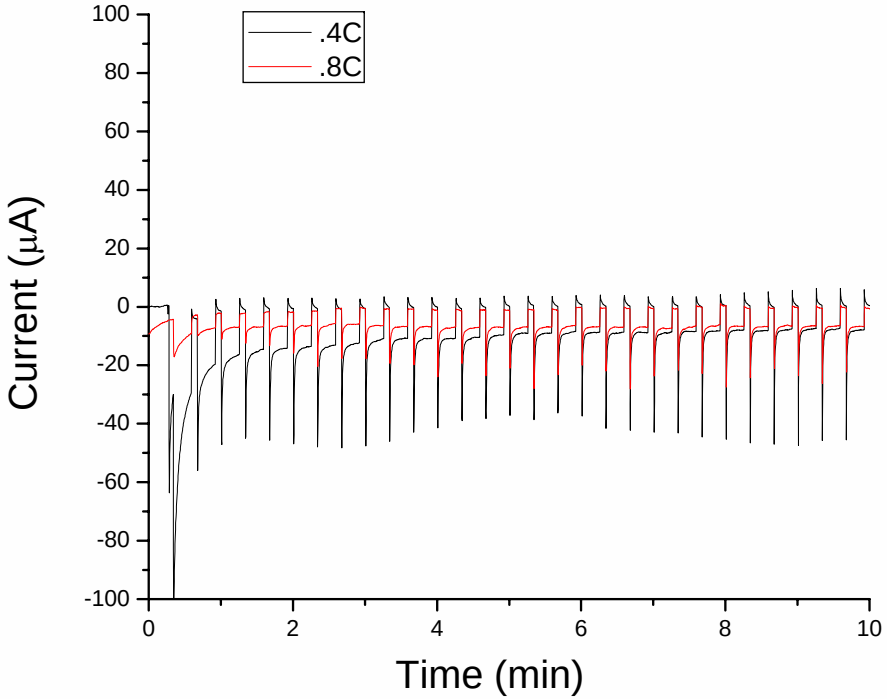

Thermo Oriel
WARNING!

Controlled Spray Pyrolysis Parameters:

- 9.0 pH
- Annealed 175˚C, 4hrs
- -300 mV bias
- ------- .4C -------.8C



Cu_2O w/ ZnO

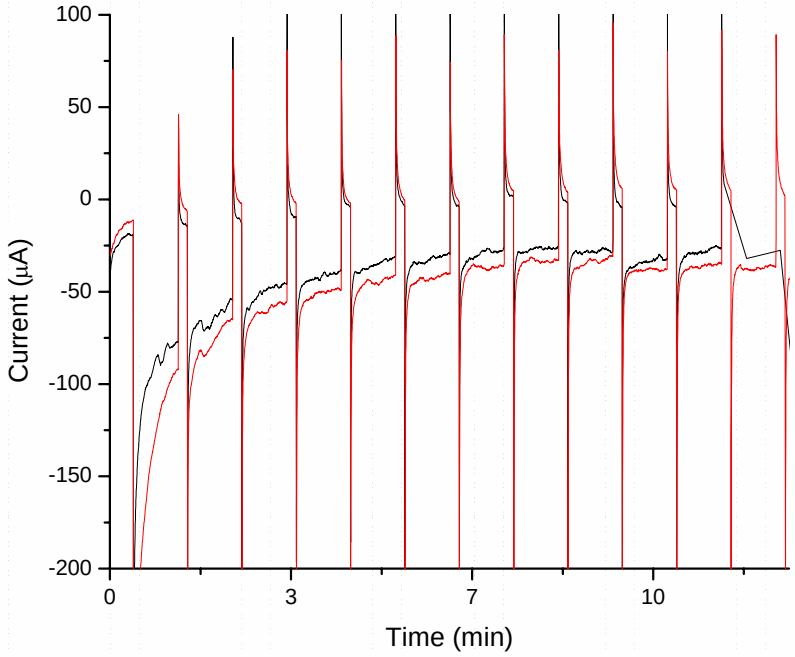


Cu_2O only

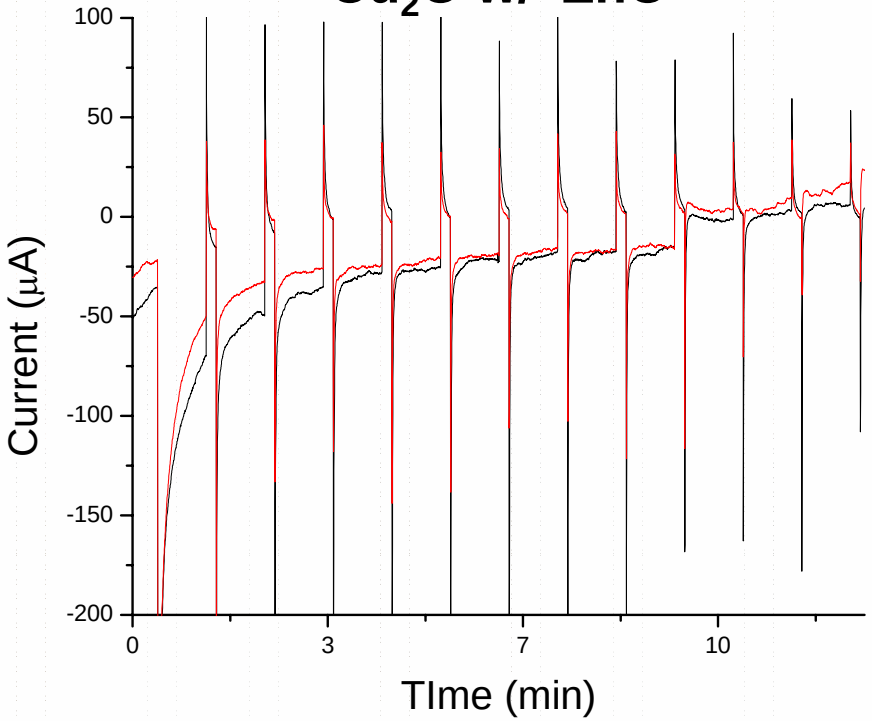
Controlled Spray Pyrolysis Parameters:

- 9.0 pH
- Annealed 175˚C, 4hrs
- -300 mV bias
- Post annealed, 300˚C. 4hrs
- ------- .4C -------.8C

Cu_2O only



Cu_2O w/ ZnO



Our Findings...

- **ZnO films can be synthesized on electrodeposited Cu_2O by spray pyrolysis**
- **Oxidation improved the photocurrent of the Cu_2O**
- **ZnO may protect Cu_2O from photocorrosion, depending on thickness**
- **Thicker ZnO layer causes anodic behavior**
- **Thicker Cu_2O layer reduced the amount of photocurrent, electrons have too far to travel**
- **Annealing after spray pyrolysis improved the conductivity of the Cu_2O**

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Future Works:

- Use applied potential during photocurrent between -0.3V and -0.425V
- Make thinner ZnO layers (e.g. use more dilute spray solution)
- Try higher annealing temperature for Cu_2O
- Refine higher-pH electrodeposition
- Measure thickness of ZnO and Cu_2O layers using profilometer
- Characterize ZnO/Cu_2O made by Atomic Layer Deposition (collaboration with Prof. Steve George at University of Colorado)