Film characterization and solar cell fabrication plans

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Pyrite Meeting

January 11, 2011

Hall Effect

- Electronic Characterization of thin film properties
  - Resistivity
  - Establish majority carrier type
  - Majority carrier concentration
  - Majority carrier mobility
- Important to verify p or n type for our planned p-n junction
- Changes in physical properties can indicate quality of film or level of doping.

Hall Effect – Basics

- Magnetic field forces charges to build up on the same side of substrate, until the forces balance.
- This creates a voltage perpendicular to current flow.
- Sign and magnitude of Hall Voltage indicate p vs n type,

carrier concentration,

and mobility.

- $F_{y,Lorentz} = F_{y,Electric}$
- $n = IB/qdV_H$
- $\mu = 1/ne\rho$

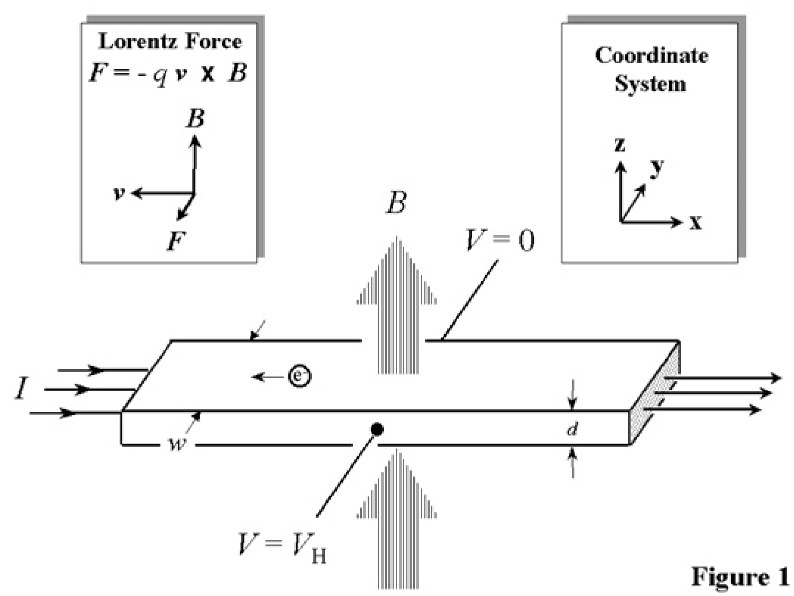


Figure 1

Hall Effect

- Currently no reliable hall effect setup on campus.
- Plans to collaborate with Professor Jianlin Liu at UC Riverside.

Photothermal Deflection Spectroscopy(PDS)

- Very sensitive method for measuring optical absorption.
  - Orders of magnitude more sensitive than optical reflection and transmission.
  - Do not have to worry about scattering effects.
- Possible to measure defect levels within the bandgap
  - Which can help to guide our research to reduce sulfur defects and improve the photovoltage of solar cell devices.
- Collaborating with Craig Taylor at Colorado School of Mines.

PDS

1. When an intensity modulated(chopped) pump beam is absorbed in the sample, periodic heating occurs.
2. This heat is transferred to the surrounding medium at the surface of the sample.
3. Heating of the medium causes a change in the index of refraction.
4. The change in index of refraction causes a deflection in the probe beam, detected at the position sensor.

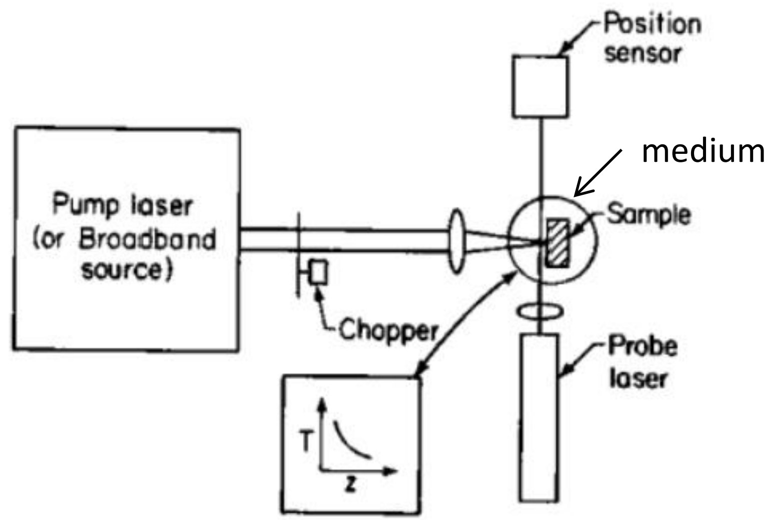
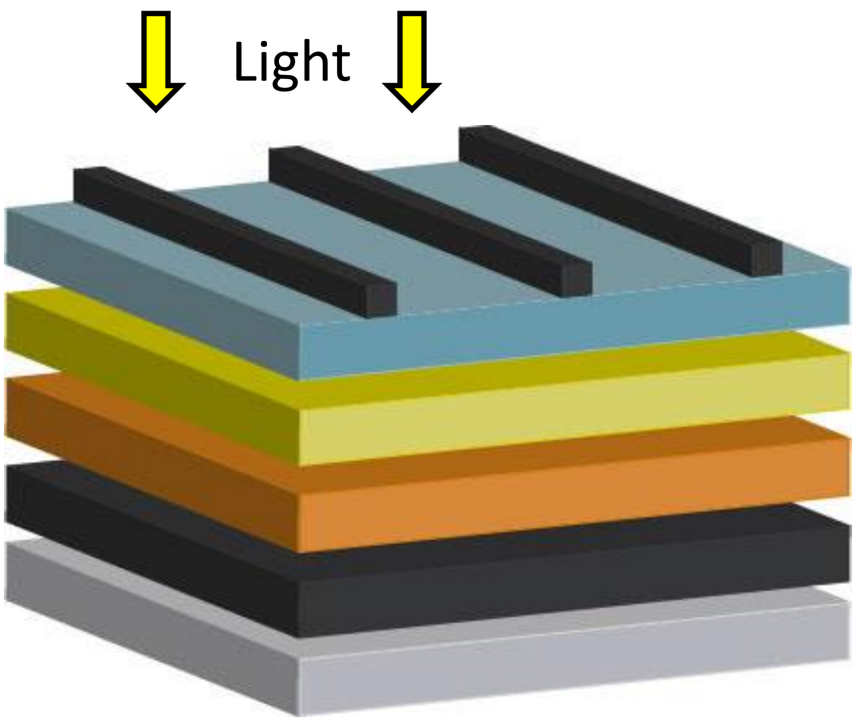


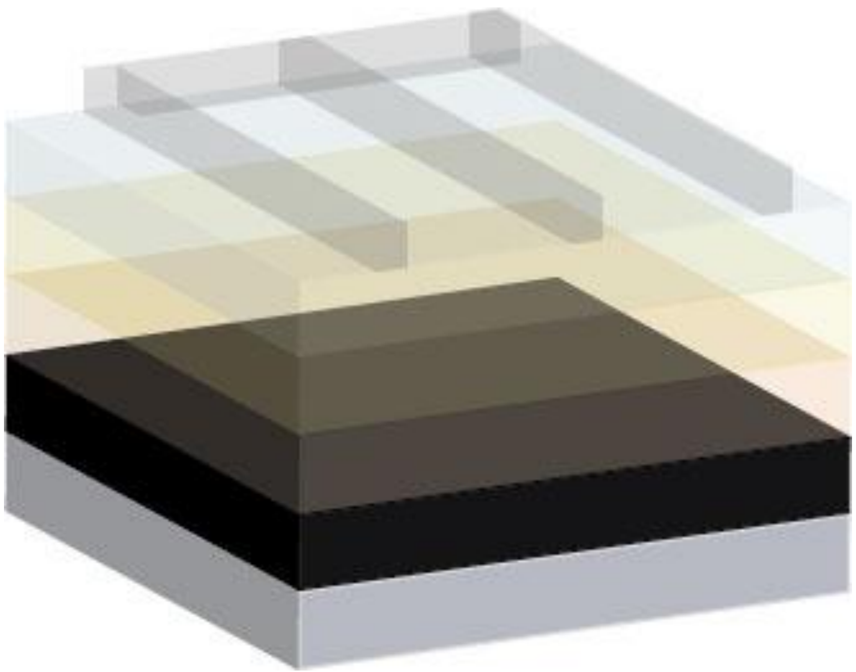
FIG. 1. The experimental arrangement.

Pyrite Solar Cell Substrate Configuration

- Highest efficiency CdTe/CIGS devices use this "substrate" configuration.
- Can also have "superstrate" configuration

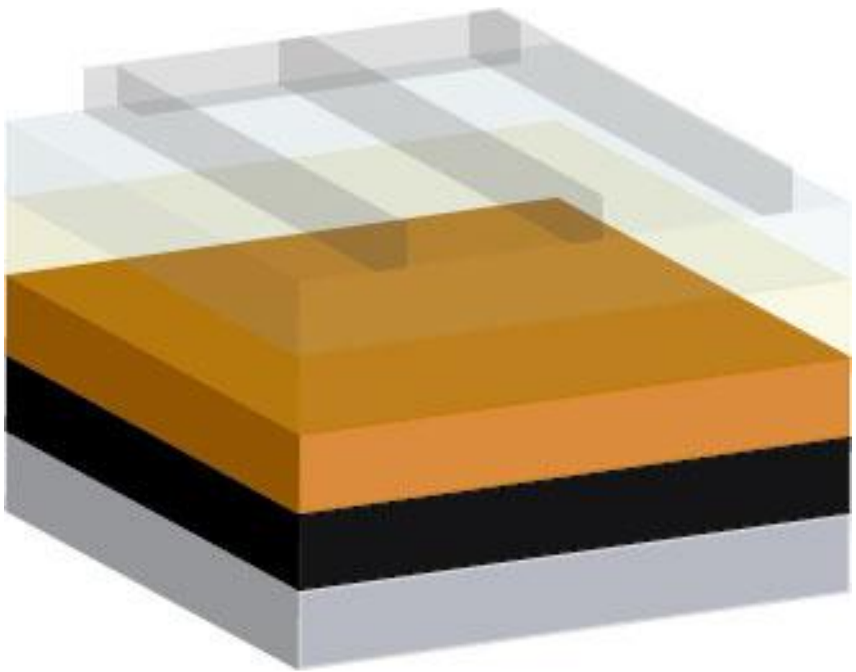


Fabrication – metal back contact



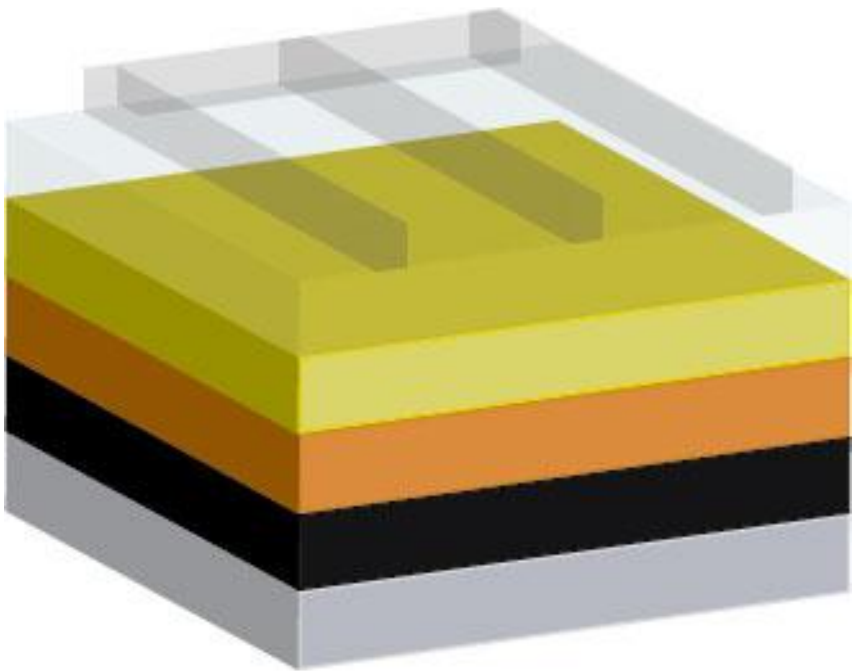
- Start with soda lime glass substrate
  - Maybe apply sodium diffusion barrier layer (ZnO or SiO2)
- Sputter coat 500-1000nm of Molybdenum
  - Will survive high temperature sulfur processing
  - Assuming it makes an ohmic contact with pyrite

Fabrication – p type pyrite



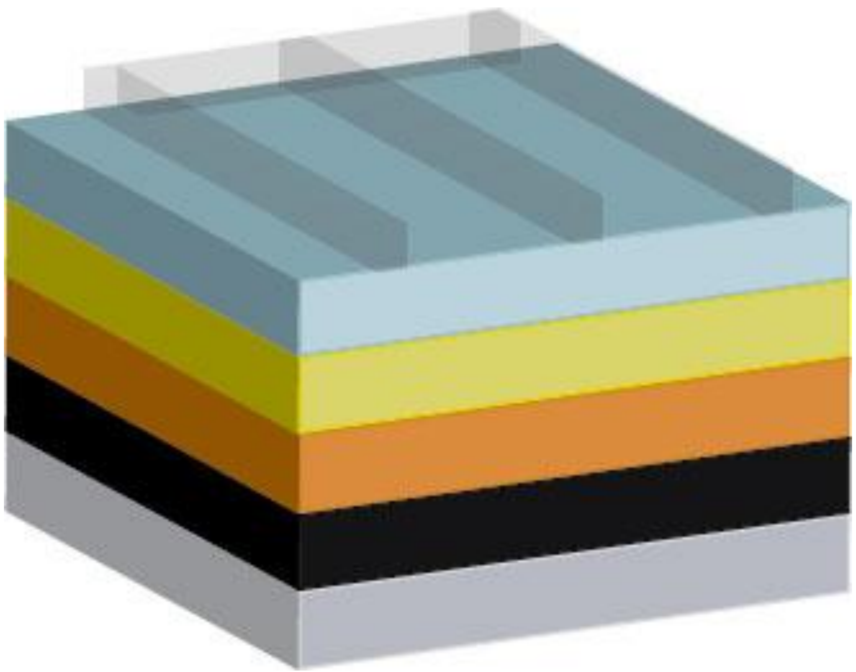
- Deposit p-type pyrite layer
- CVD, quantum dots, molecular inks
- Anneal in sulfur or H2S
  - Because of annealing we are currently confined to substrate configuration
- 100-2000nm, to be determined

Fabrication – n type layer



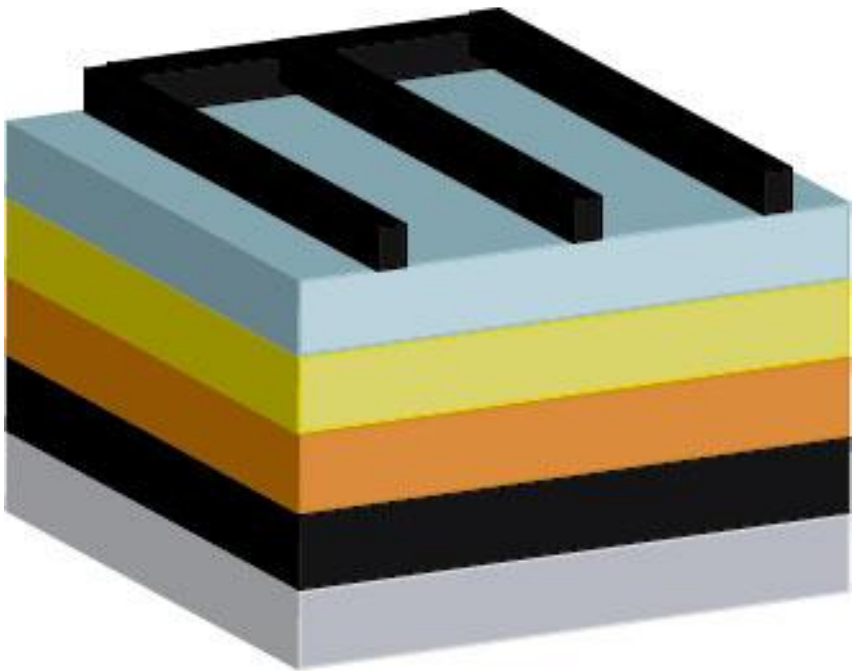
- Deposit n type CdS or ZnS to form the pn junction
  - CdS: 2.4 eV bandgap
  - ZnS: 3.5 eV bandgap
- CdS typically used in CIGS/CdTe, but ZnS might work better with pyrite.
- Grown by Chemical Bath Deposition (CBD) or Atomic Layer Deposition (ALD)
- ~50nm

Fabrication – Transparent Conducting Oxide



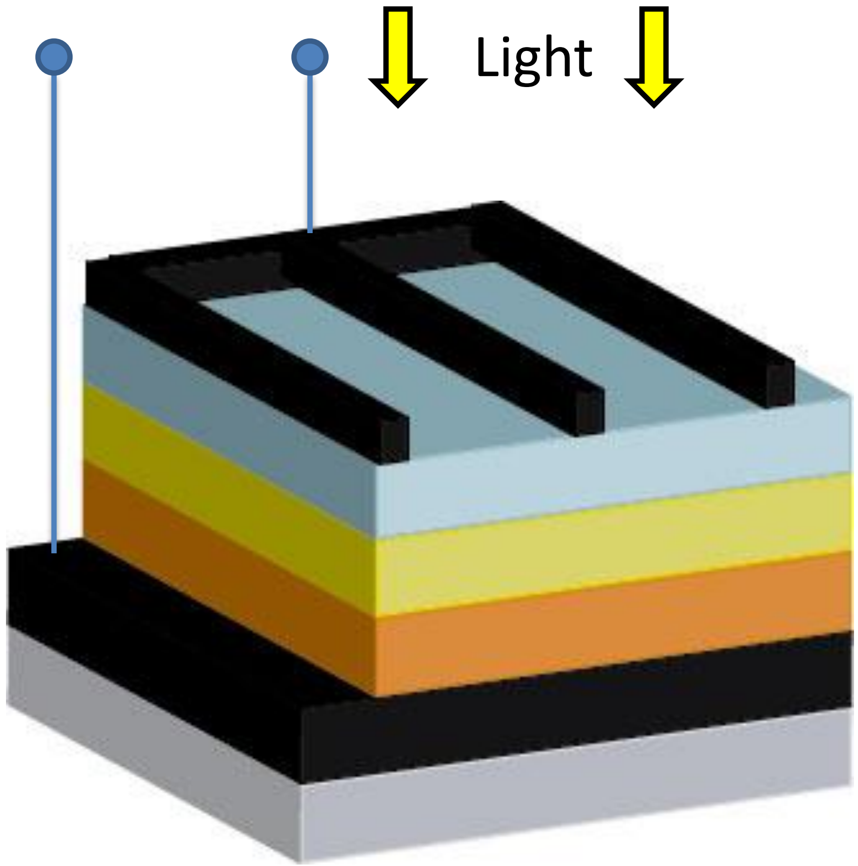
- Top contact must be conducting and transparent.
- Typical: ITO, FTO, or ZnO:Al
- 150-700 nm
- We will sputter coat ITO/AnO:Al or use ALD to grow ZnO:Al
- Often put a layer of intrinsic ZnO and then ZnO:Al in CIGS/CdTe

Fabrication – Metal collection grid



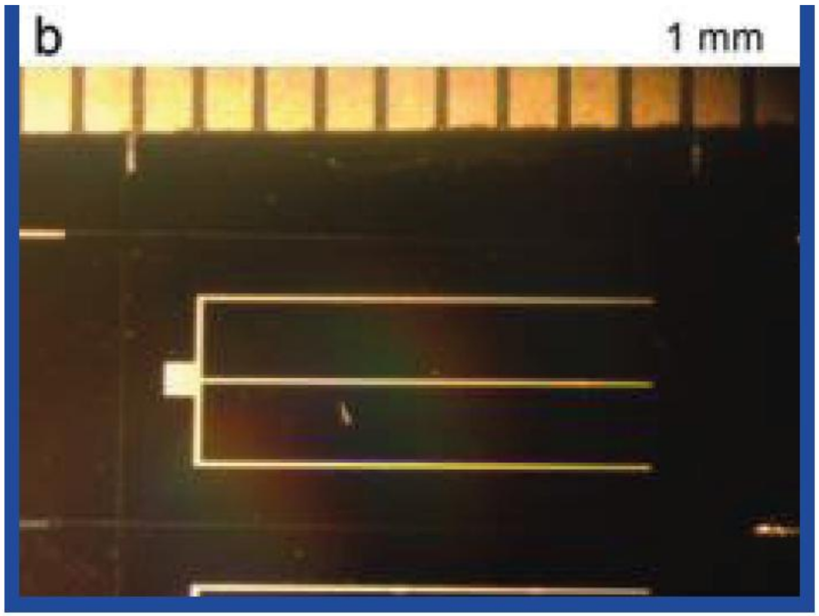
- Use shadow mask to thermally evaporate metal grid on top of TCO.
- Metal grid helps extract carriers from TCO
- In CIGS/CdTe typically 50nm of Ni then 2-4um of Al.

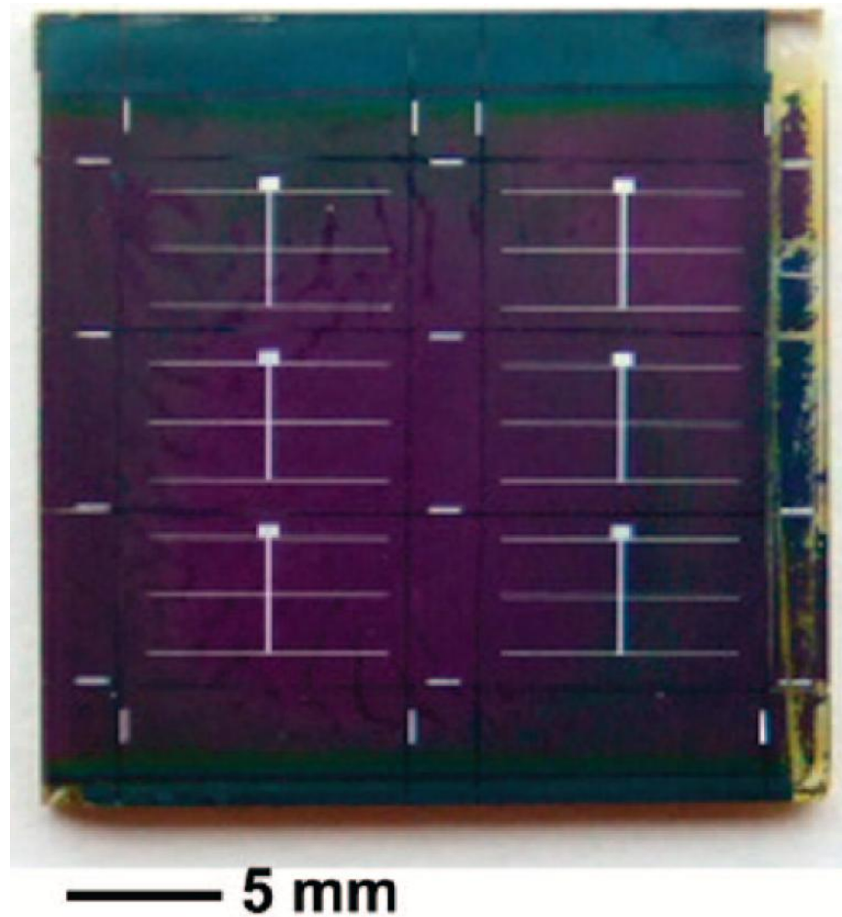
Measure Solar Cell Properties



- Expose Mo layer and make contact to Mo and to metal grid on top.
- Apply AM1.5g solar simulator and measure diode properties.
- Solar cell area: .16 cm^2
  - Defined by optical mask
- Original glass slide 1in by 1in
- 6 devices on each slide

CIS Devices by Mitzi and Hillhouse





Conclusion

- Hall effect is a critical experiment for us to determine film properties
- PDS will be a useful technique to guide or research trying to passivate surface defects
- Our solar cell fabrication plans will initially follow the same steps as CIGS/CdTe