CVD and Annealing

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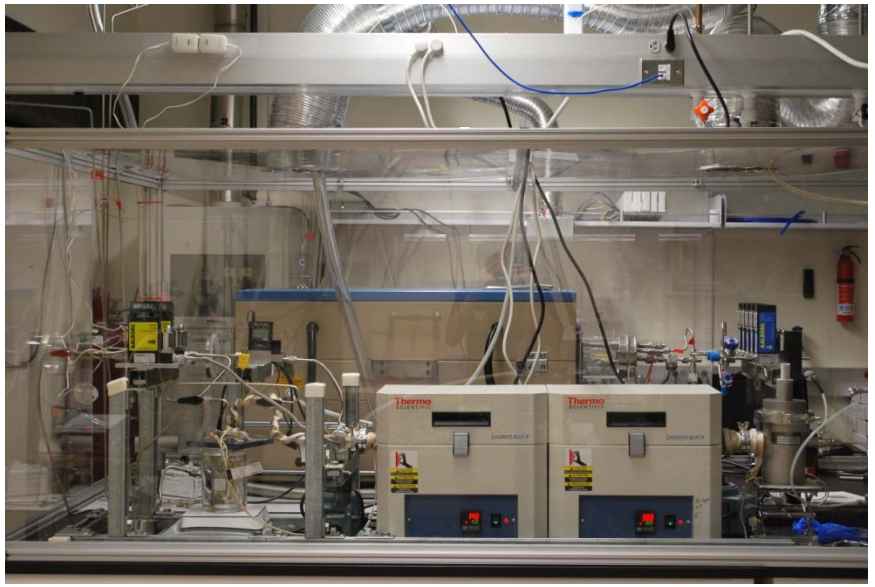
NSF Meeting #1

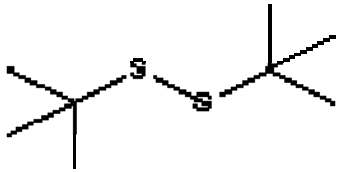
8/3/2010

CVD Setup

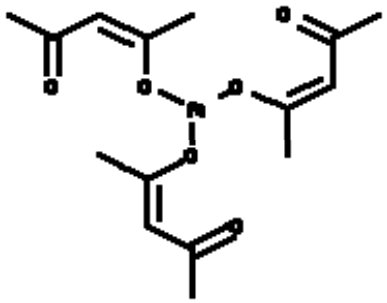
- Ar Carrier Gas
  - Or Ar/H2 mixtures
- Temperatures
  - Reaction: 300-350C
- Flow Rates
- Precursors



Tert-butyl disulfide(TBDS) – liquid

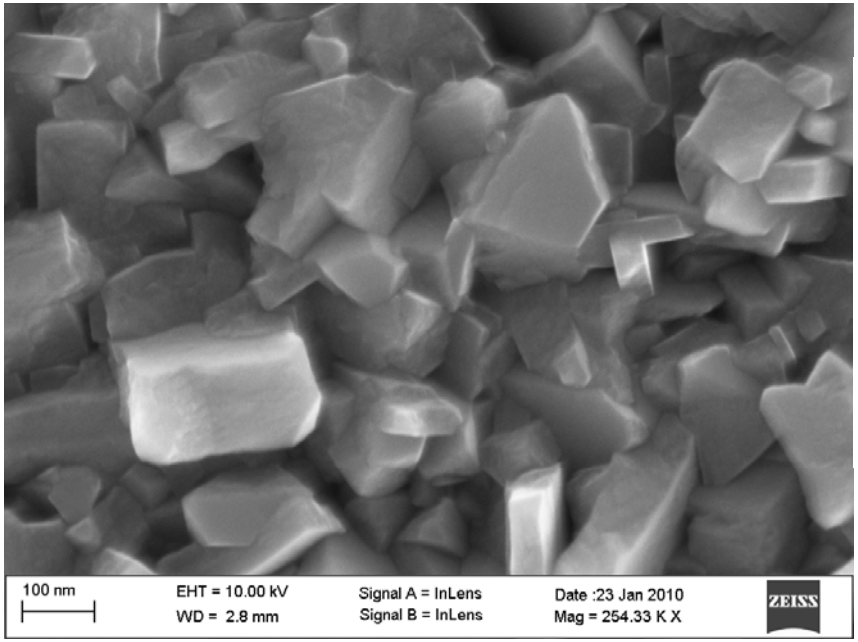


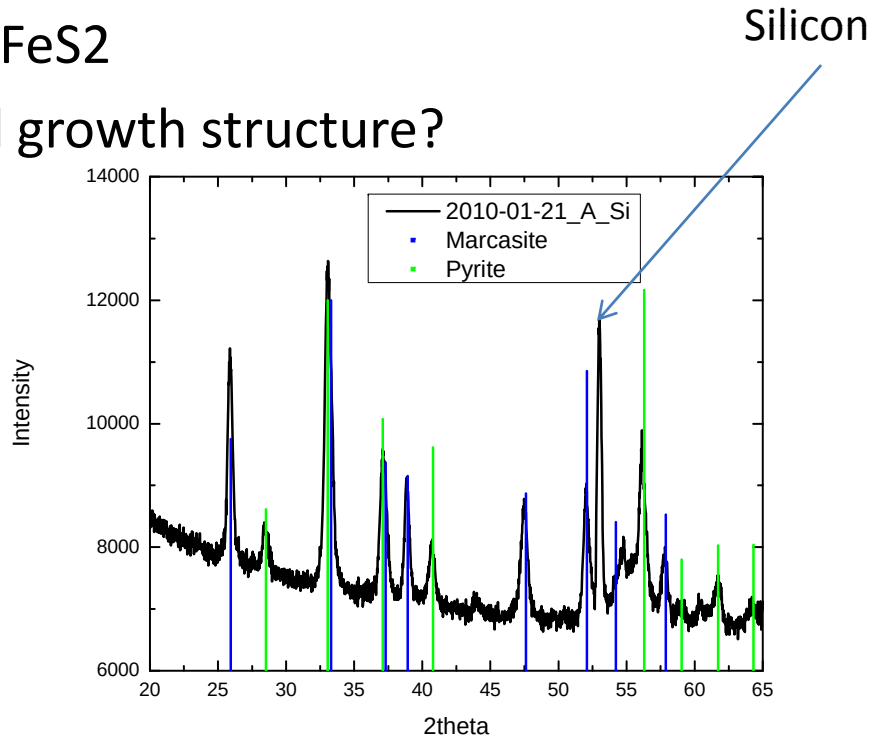
Iron(III) Acetylacetonate - solid



Typical Surface Growth

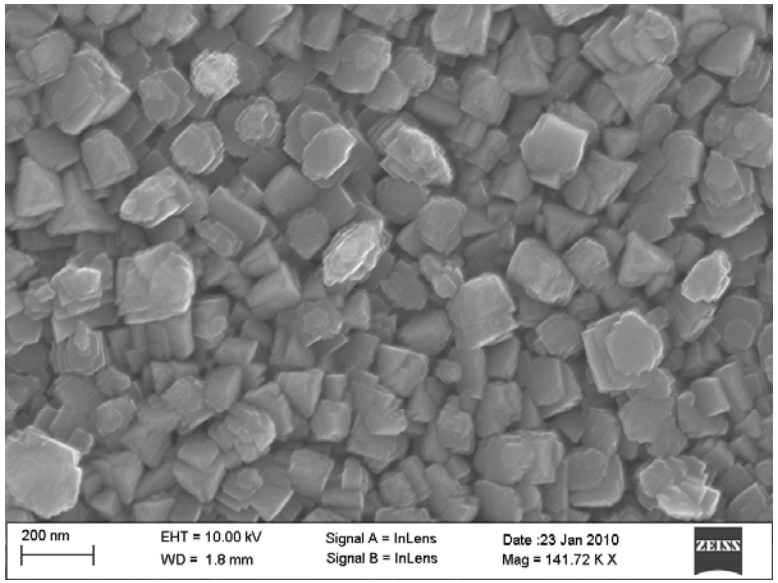
- Good coverage of surface growth over large area
- On quartz and silicon
  - Mostly Marcasite, with some pyrite
    - Marcasite: Orthorhombic FeS2
- Why is marcasite the preferential growth structure?

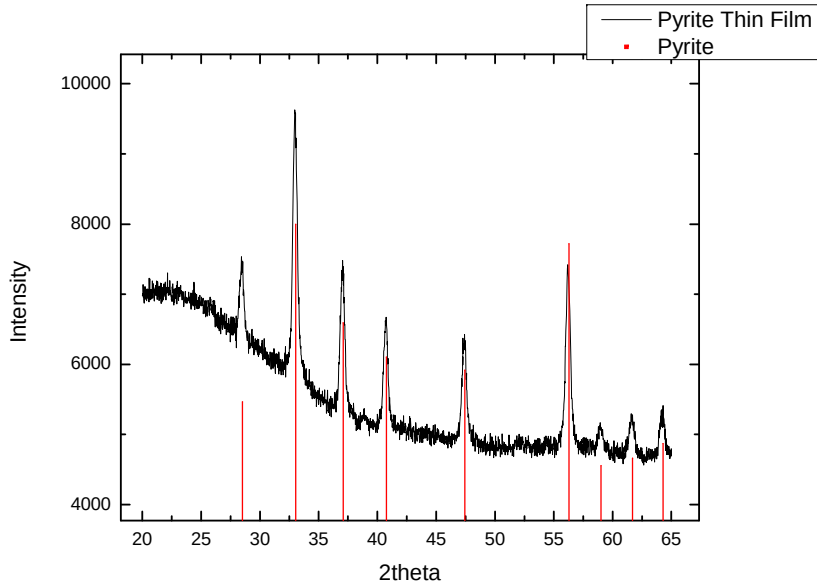




Growth on Glass

- Same conditions as previous reactions on quartz
- Pure pyrite only on glass
  - Many other substrates tried
- XPS indicates lots of sodium leaching into film, which we believe to be the cause.
  - How does this happen?





Various Substrates

- Attempting to find best substrate
  - Ti, Cr, Moly, Si, Quartz, Glass, Ni, Stainless steel alloys, Al, Al alloy…
- Silicon has atomic distances that match to pyrite, yet marcasite still forms
- How does it nucleate? Ideal surface?
- So far Moly and pure Aluminum will survive conditions, but many more tests are needed.
  - Moly will form thin MoS2 layer

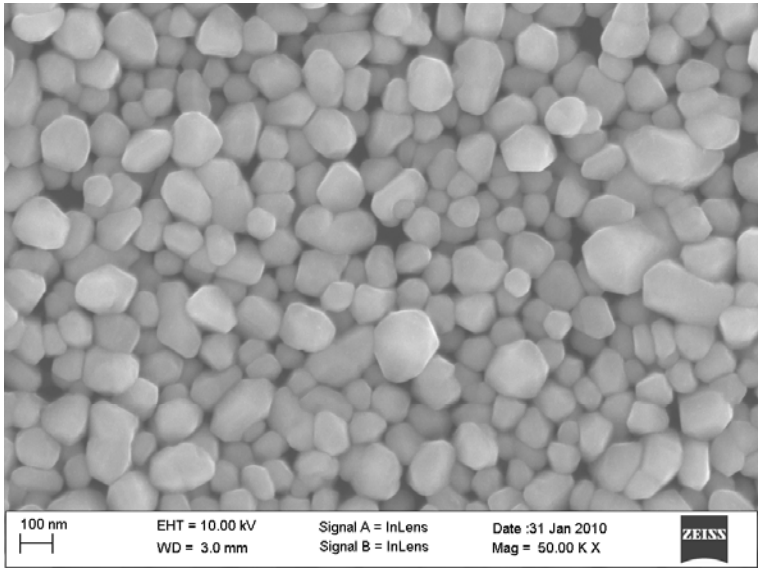
Annealing in Elemental Sulfur

- Conversion from Marcasite to Pyrite above ~450C
  - Dependent upon Time, Temperature, and Sulfur concentration
  - Dependence on Sulfur concentration
    - More sulfur = faster conversion
    - Why?
- Must anneal in Sulfur to prevent sulfur loss. Above 700, still get conversion to pyrrhotite(FeS_{1-x})
- Testing H2S/H2 Annealing furnace

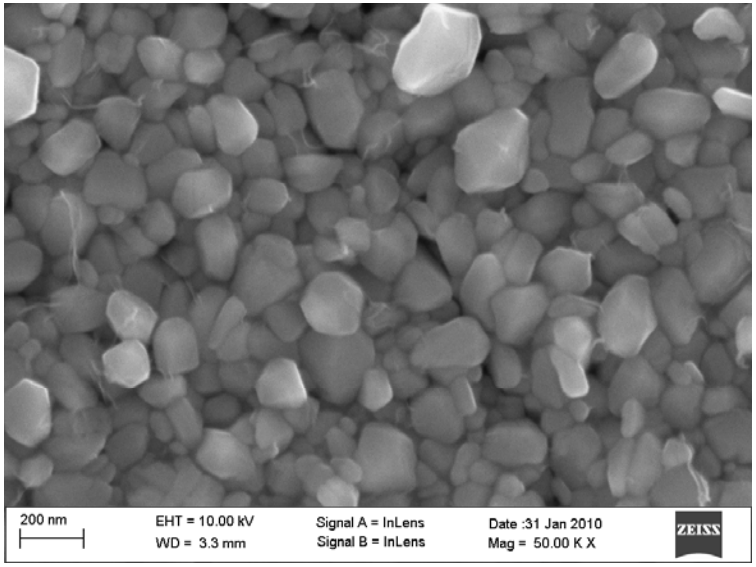
Pinhole/Crack Formation

- Increase in Grain Size during annealing
- However decreases connectivity forming pinholes or cracks
- How do grains decide to form, why do they pull apart?
- Hall Effect setup being tested to determine mobility

500 on Glass



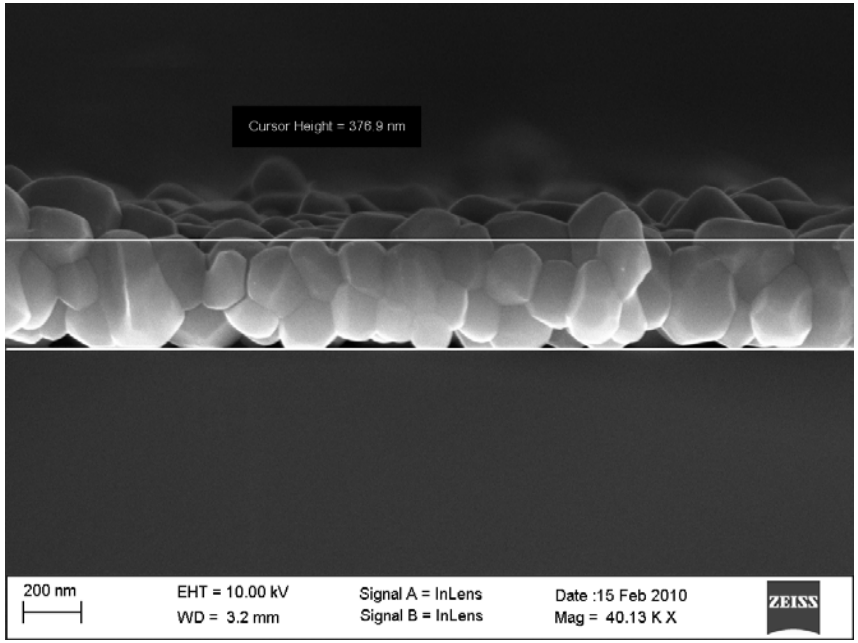
500 on Si

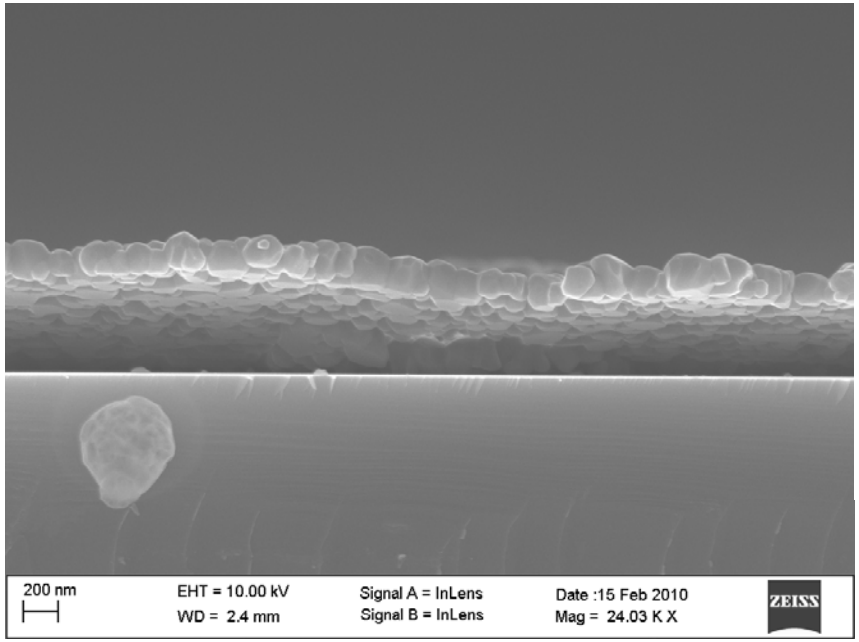


De-wetting

- Very well connected to surface initially out of CVD
- Films tend to de-wet from surfaces when they are annealed
- More experiments needed to find an ideal substrate, and how de-wetting varies

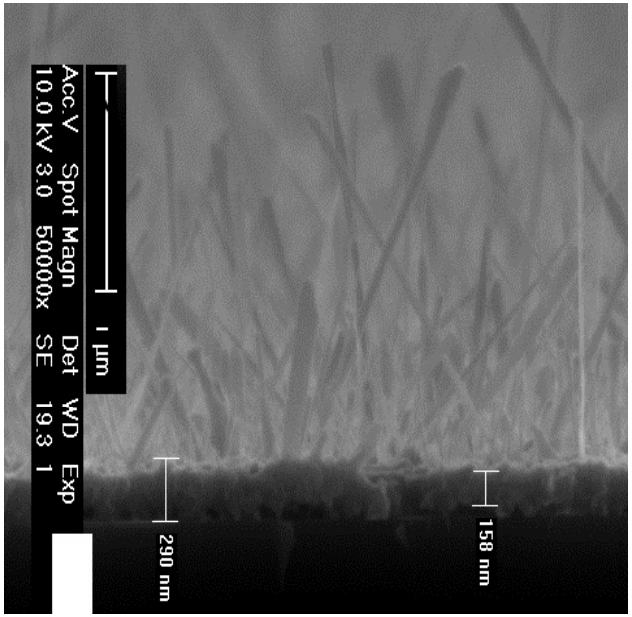
650 on Silicon





Ar+H2 mixture as carrier gas

- Mostly pyrite instead of only marcasite
  - Mechanism previously investigated in literature
- Unexpected Nanowire Formation
  - Not mentioned in any literature
  - More research needs to be done to investigate what they are and how they form
- Not currently desired



Conclusion

- Surface growth of pyrite thin films possible via CVD and annealing in a sulfur atmosphere
- Good grain growth and impurity phase reduction can be see upon annealing
- Many questions remain
  - Growth mechanisms for pyrite/marcasite
  - Substrate dependence of growth
  - Ideal conditions for marcasite converstion
  - How to prevent pinhole/crack formation while maintaining well connected large crystalline pyrite grains.