Surface Modification of CaF_2

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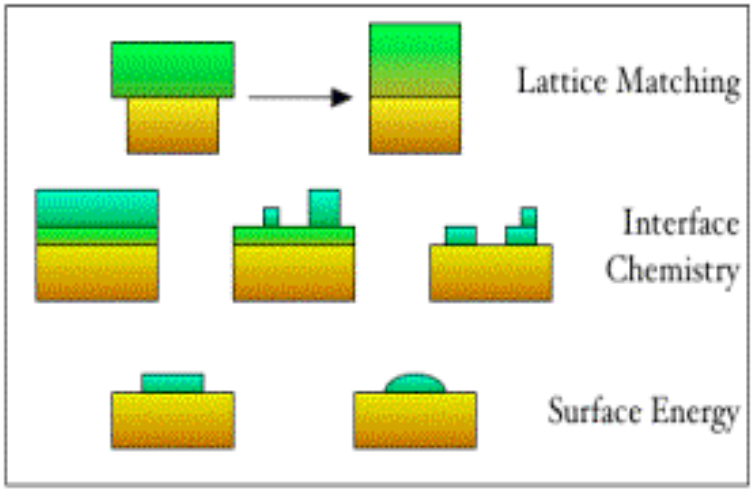
Outline

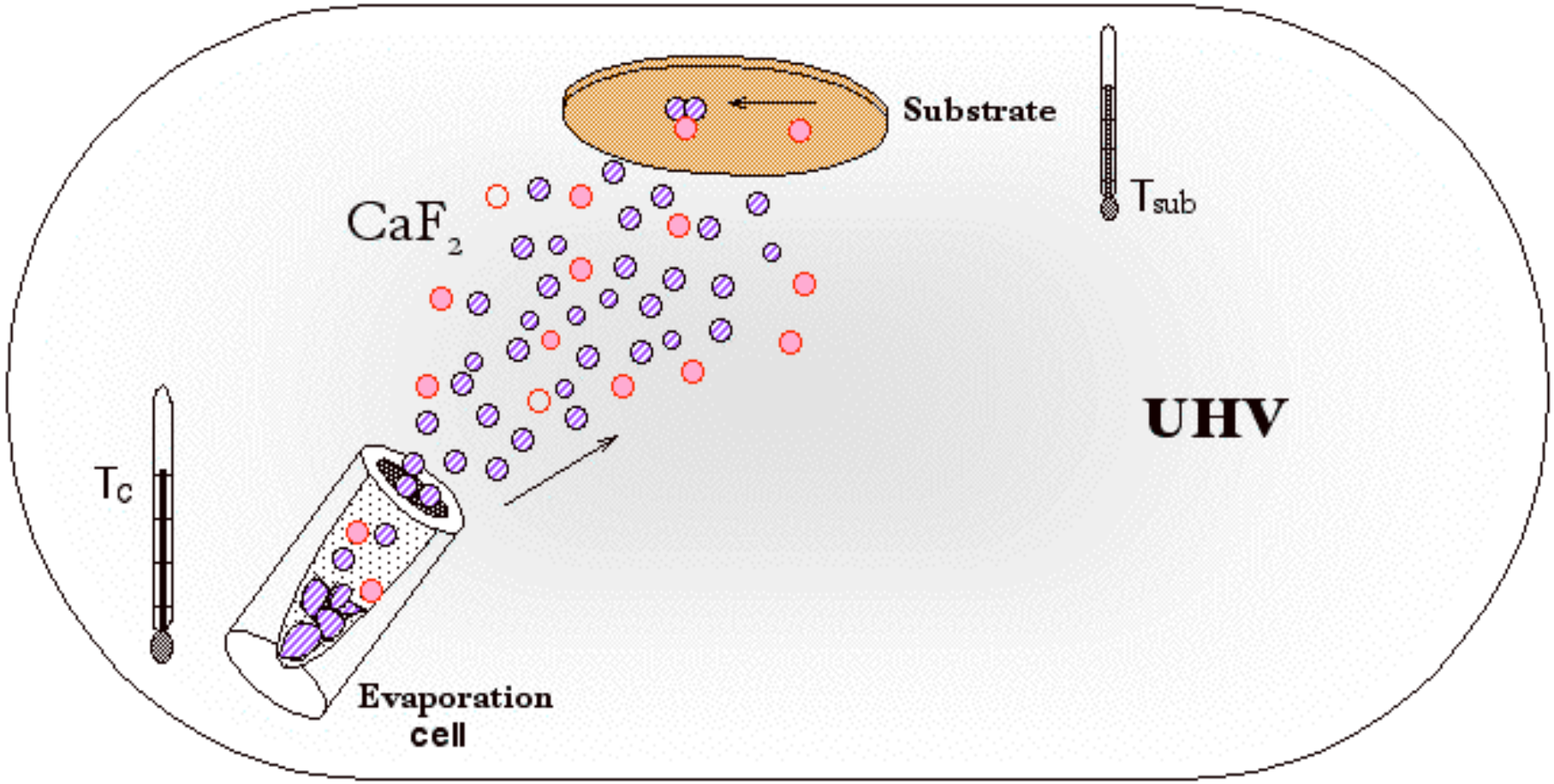
- Introduction
- Background
  - Molecular Beam Epitaxy
  - Apparatus
  - Analysis
- CaF_2
  - Electron Irradiation
  - As Termination

Introduction

- What is Epitaxy/ Epitaxial Growth?
  - The growth of one Crystal on another
- GaSe, AlSe, GaAs, TiO_2, **CaF_2** on Si
- Various factors:
  - Lattice Match
  - Interface Chemistry
  - Surface Energy

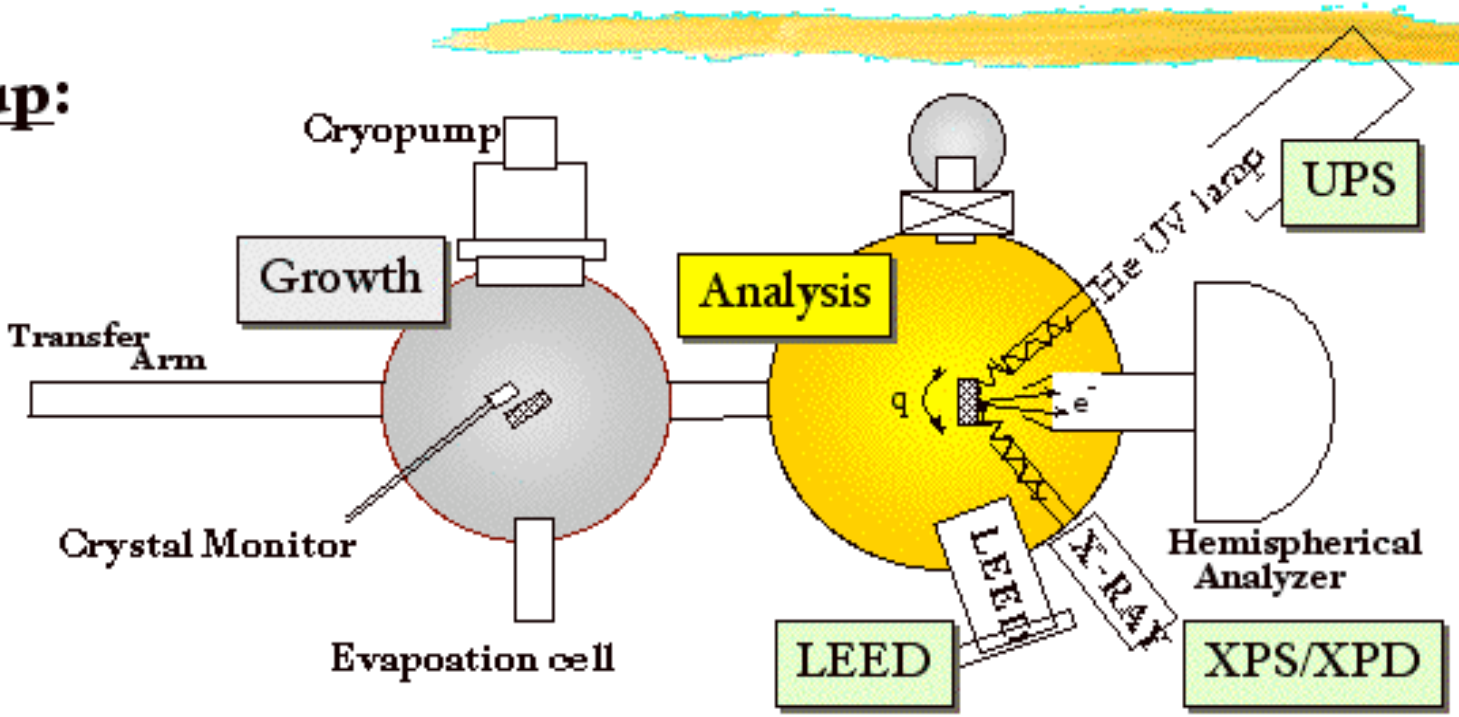


Molecular Beam Epitaxy



The Chamber

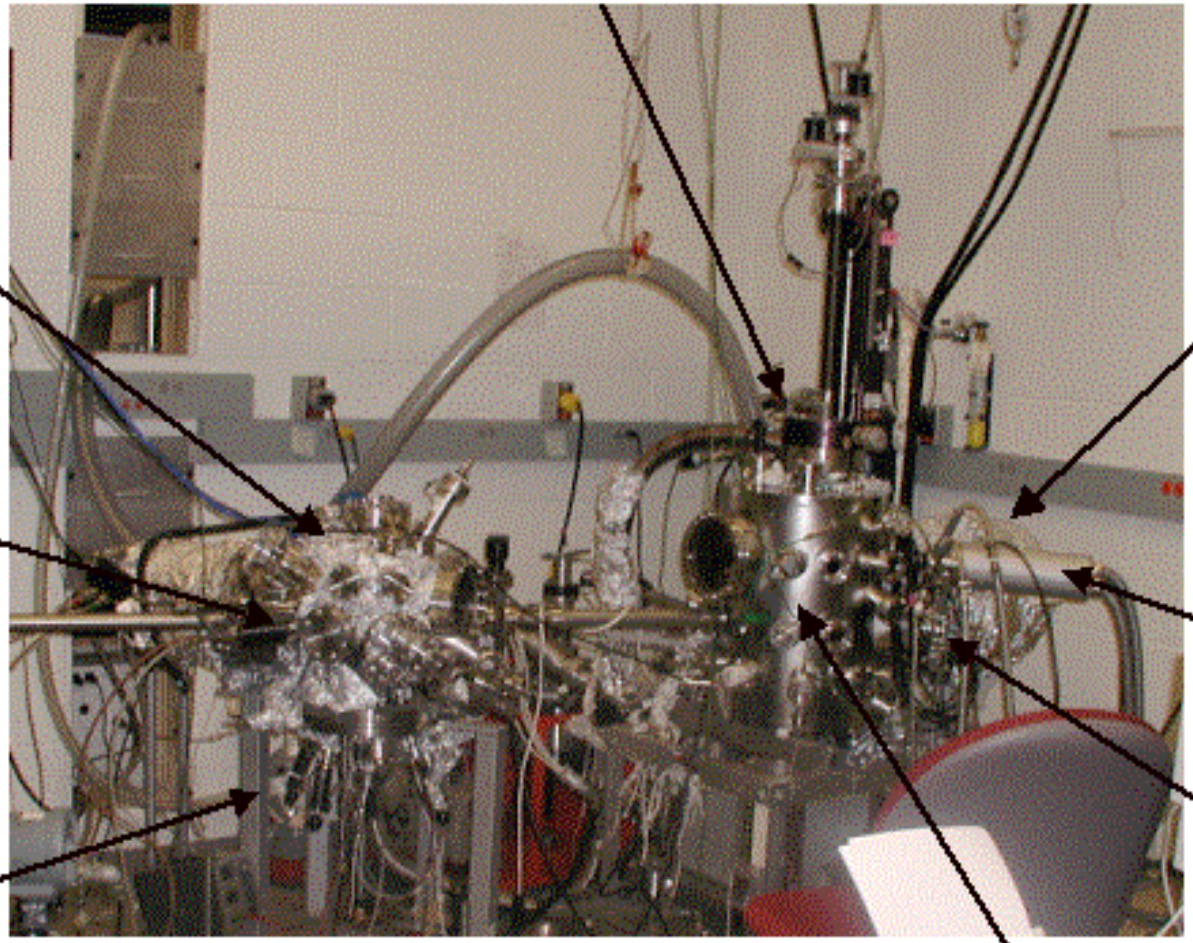
Setup:



- Growth Control —
  - Substrate Temp, T_{sub}
  - Cell flux, Cell Temp.
  - Growth time

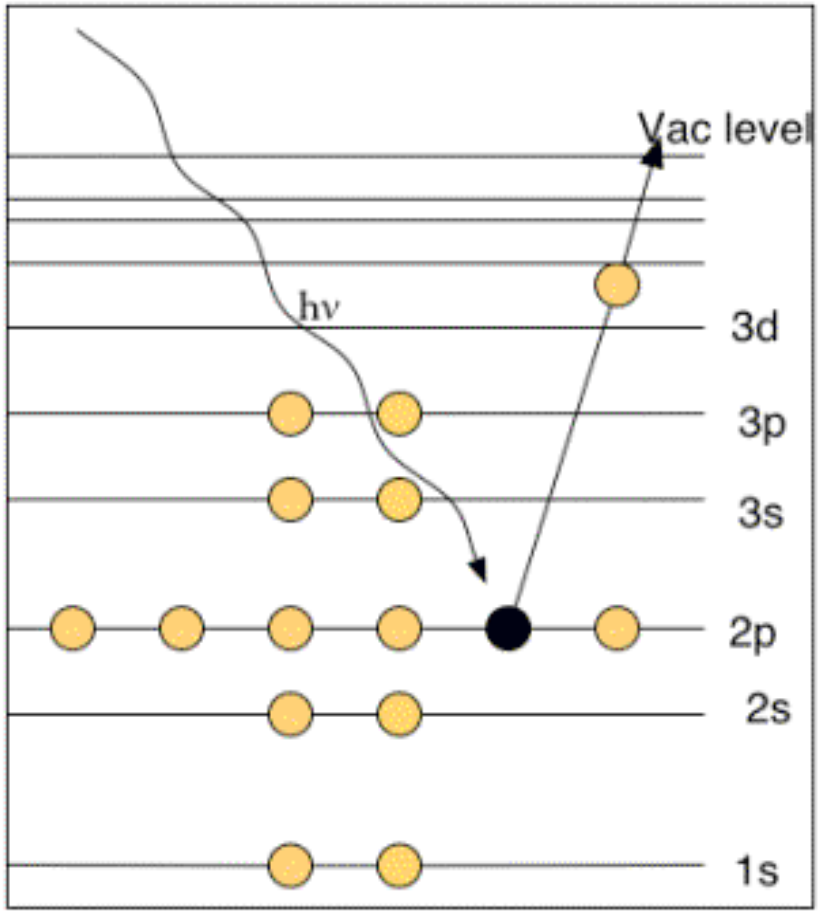
- Analysis —
  - LEED
  - XPS/XPD
  - UPS

The Chamber

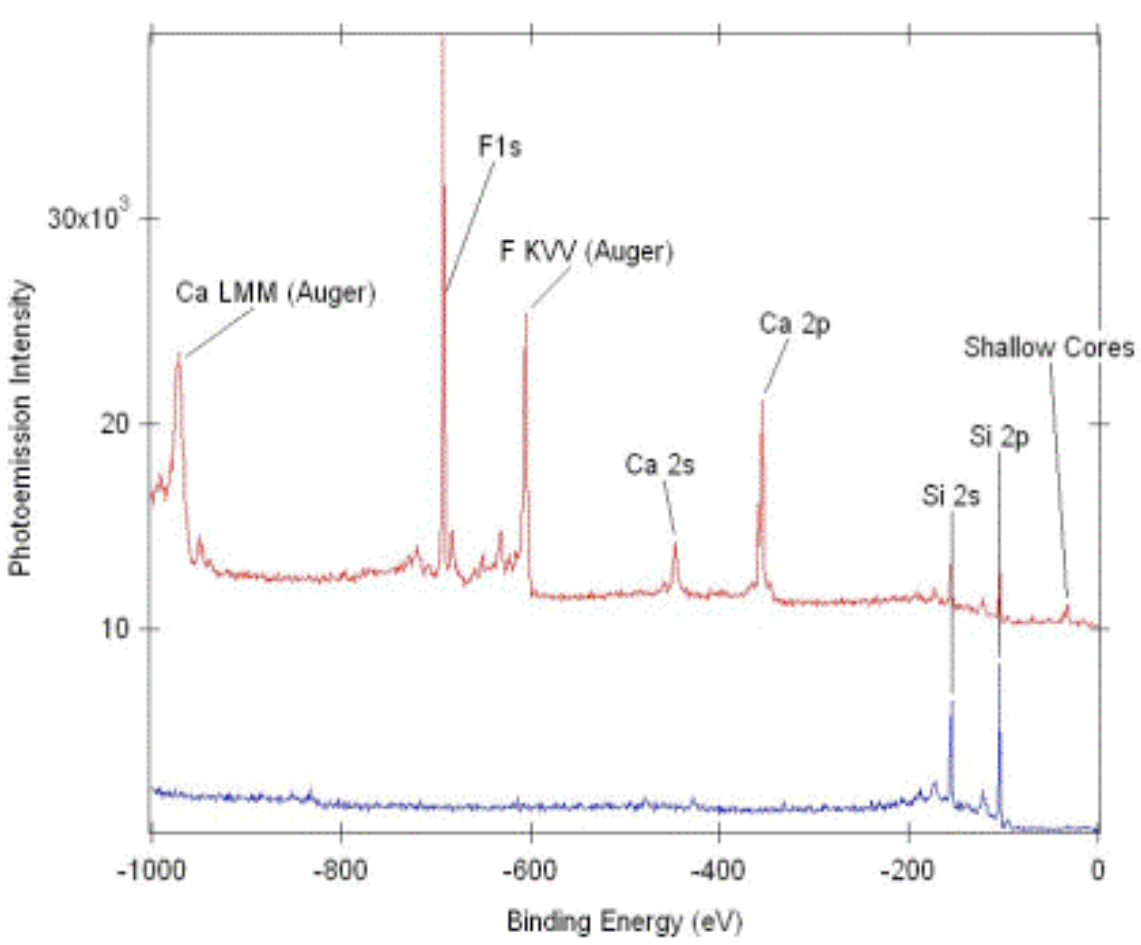

UPS
Growth Chamber
Analyzer
Crystal Monitor
XPS/XPD
Evaporation Cell
LEED
Main Chamber

XPS

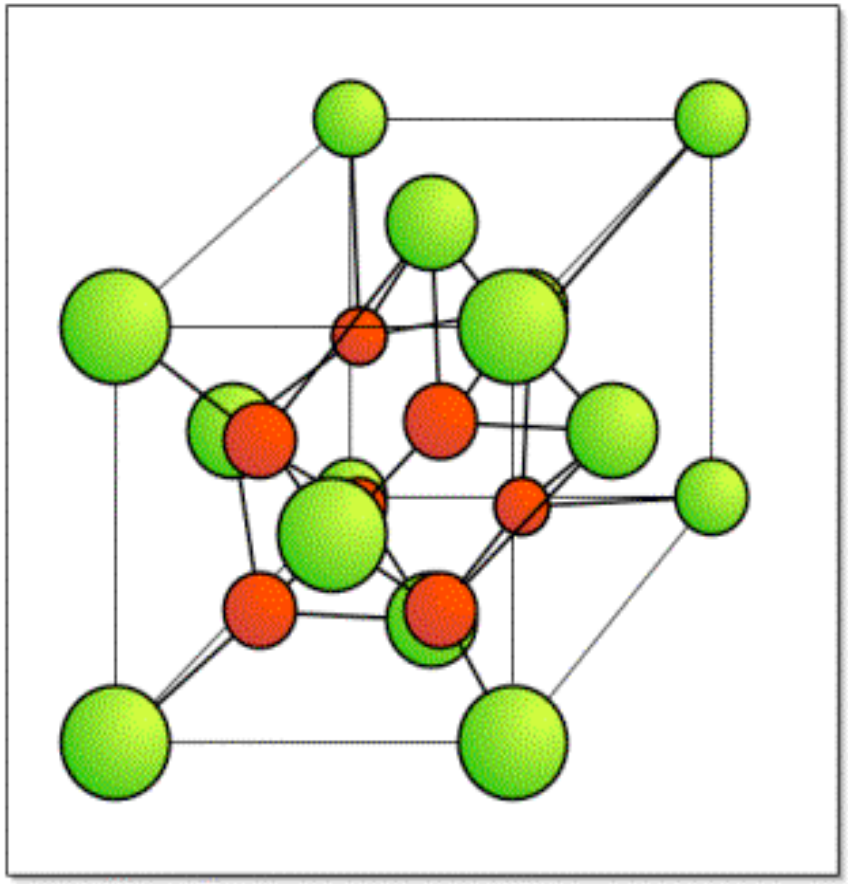
- Incident photons transfer energy to e^- in the crystal
- Photo-electron energies are scanned
- $KE(e^-) = h\nu - BE - \phi_{inner}$



XPS


F1s
30x10^3
F KVV (Auger)
Ca LMM (Auger)
Ca 2p
Shallow Cores
Si 2p
Ca 2s
Si 2s
20
10
Photoemission Intensity
-1000
-800
-600
-400
-200
0
Binding Energy (eV)

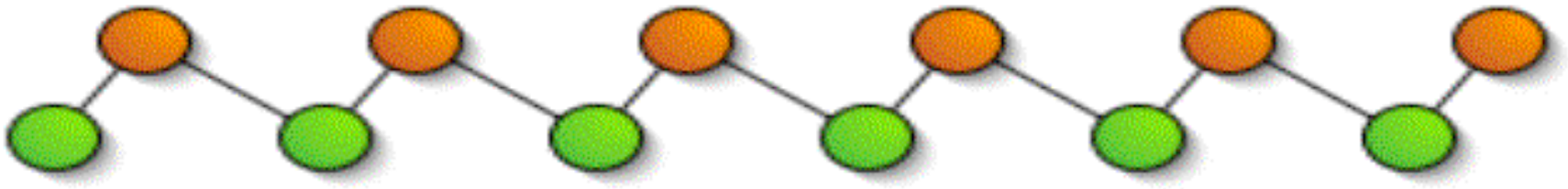
Why CaF_2?



- Ionic Crystal
- Insulator with a great lattice match to Si (0.6% mismatch)
- Quantum wells, Confinement

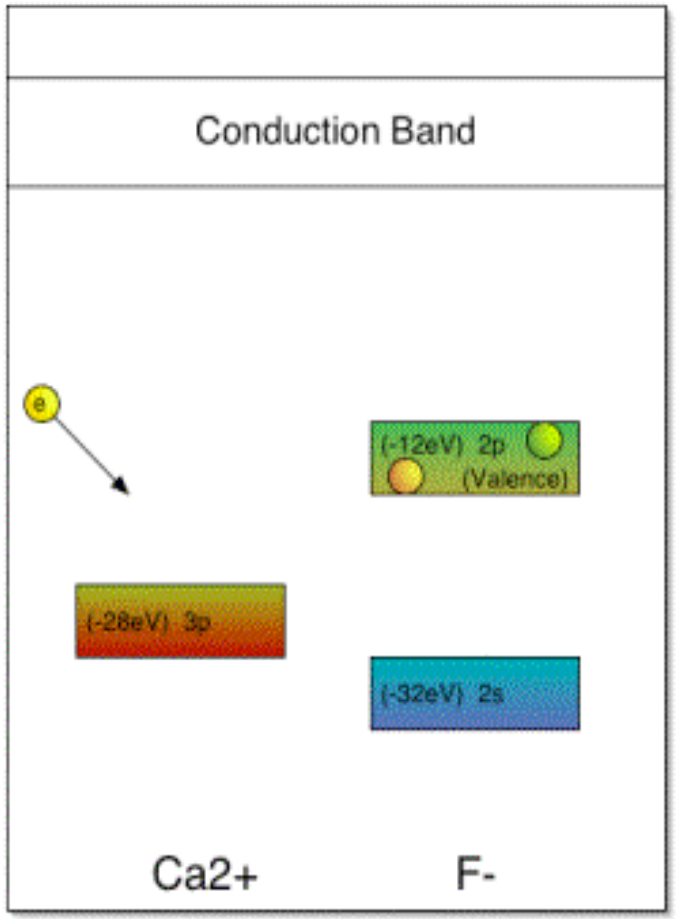
Surface of CaF_2

- Stable in UHV
- No surface reconstruction
- F^- termination is problematic
- Murphy's Law of Epitaxy
  - "If A grows well on B, then B doesn't grow well on A"
  - σ (Si) > 300% σ (CaF_2)



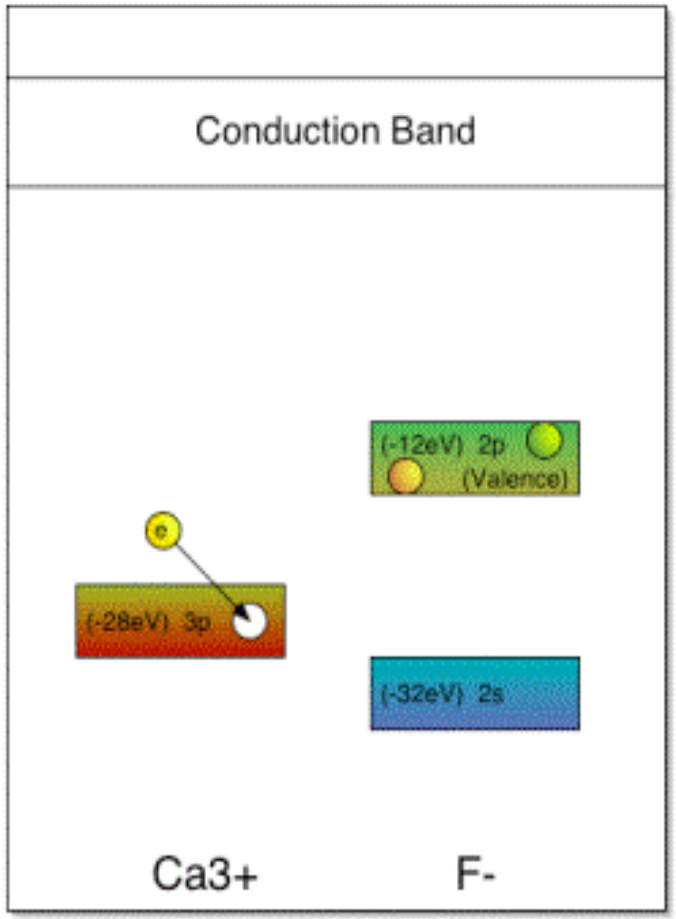
Knotek-Feibelman

- e^- of at least ~40eV are "shot" at the sample



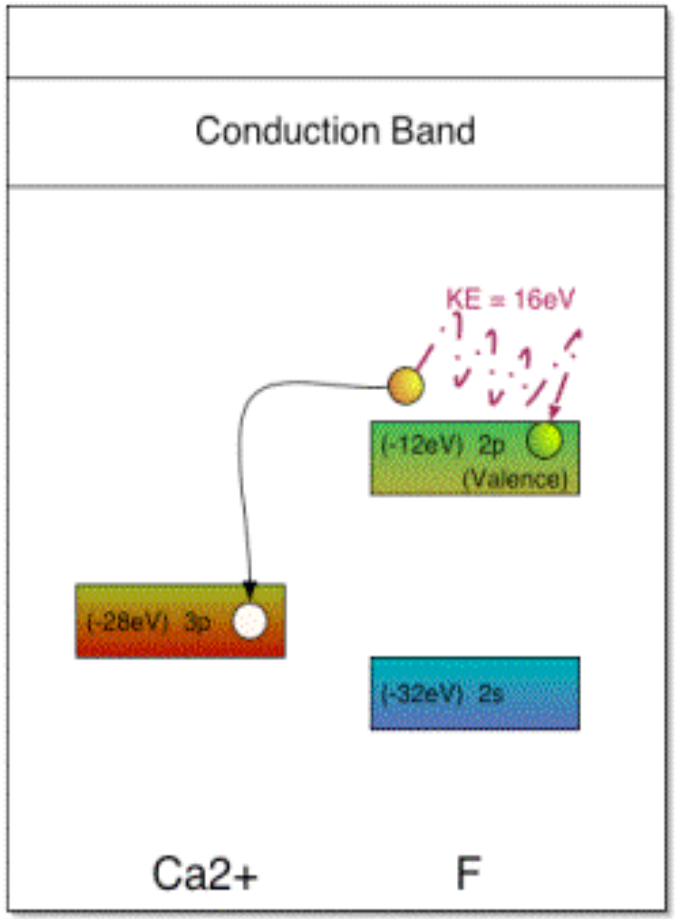
Knotek-Feibelman

- e^- of at least ~40eV are "shot" at the sample
- A hole is created in the Ca 3p band



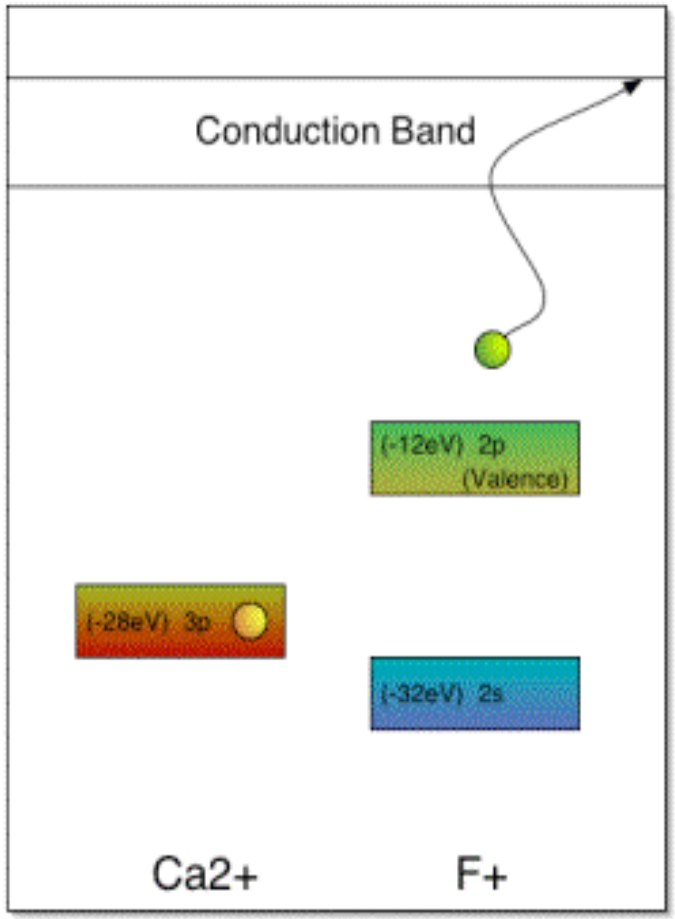
Knotek-Feibelman

- e^- of at least ~40eV are "shot" at the sample
- A hole is created in the Ca 3p band
- An e^- from the F 2p decays into the hole

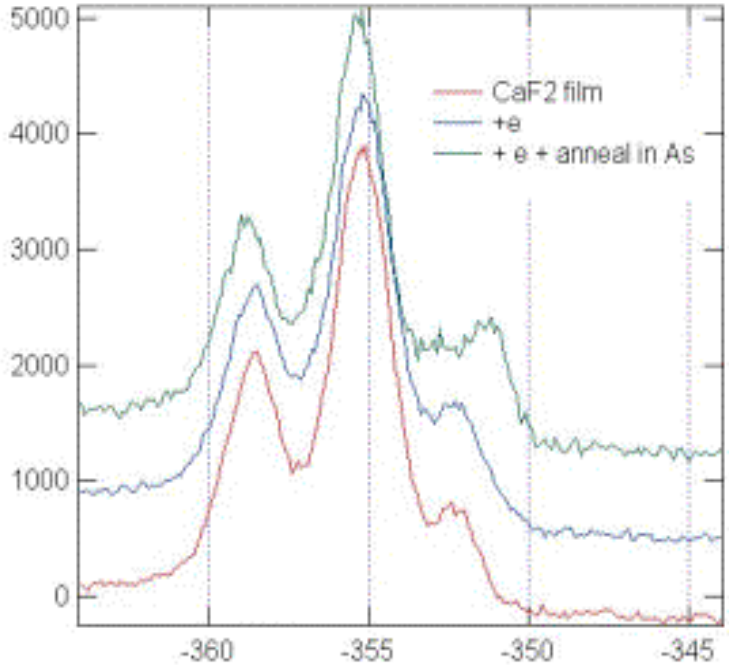


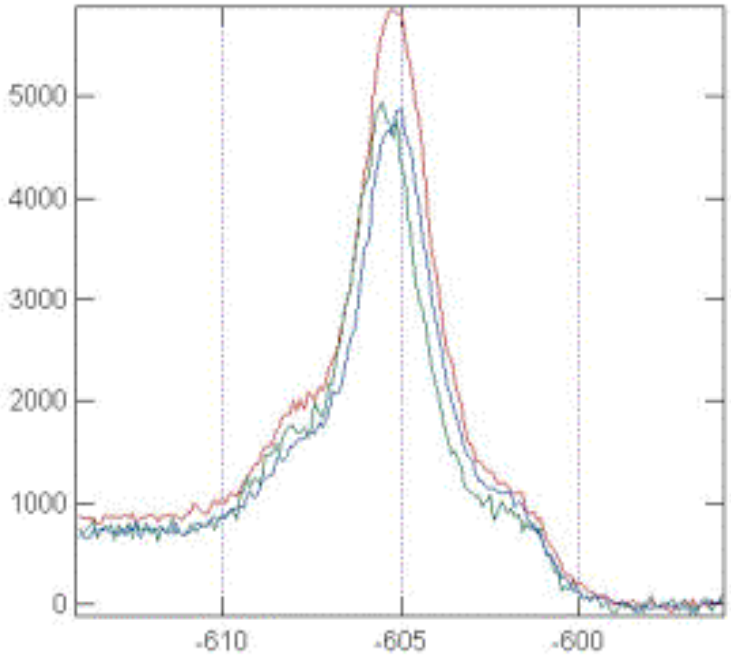
Knotek-Feibelman

- e^- of at least ~40eV are "shot" at the sample
- A hole is created in the Ca 3p band
- An e^- from the F 2p decays into the hole
- An Auger e^- is ejected, leaving the F ion with a net 1+ charge



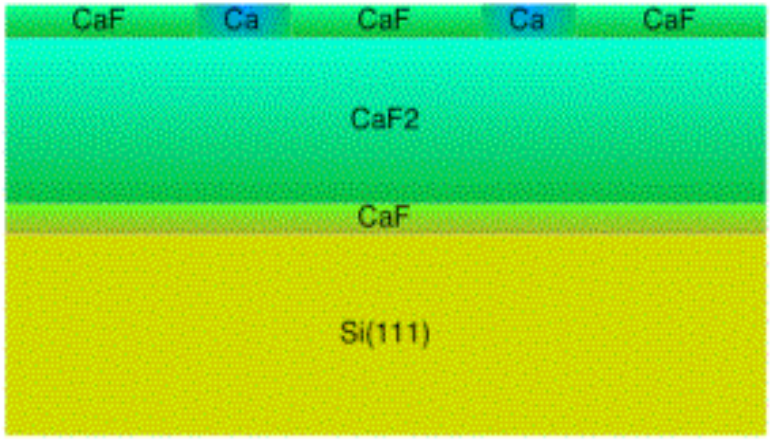
Post Irradiation

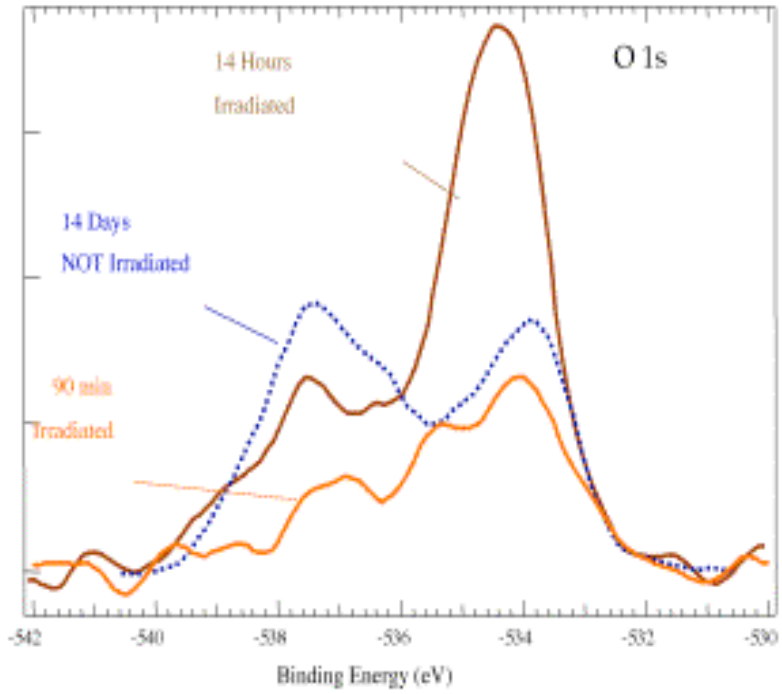




Surface of CaF_2 (post irradiation)

- Ca metal and CaF
- Very Reactive with residual gases in Chamber

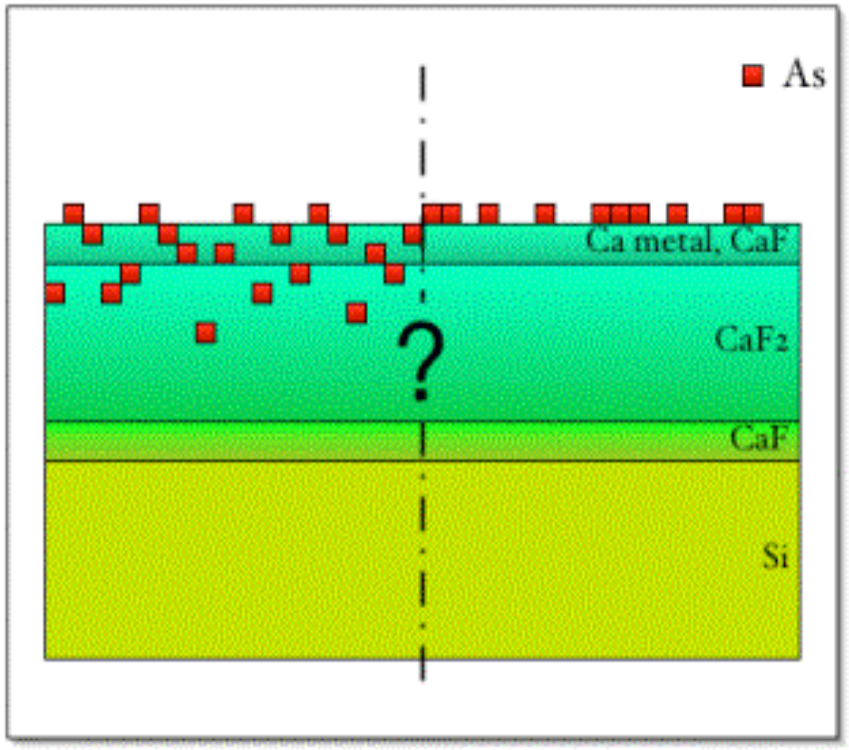




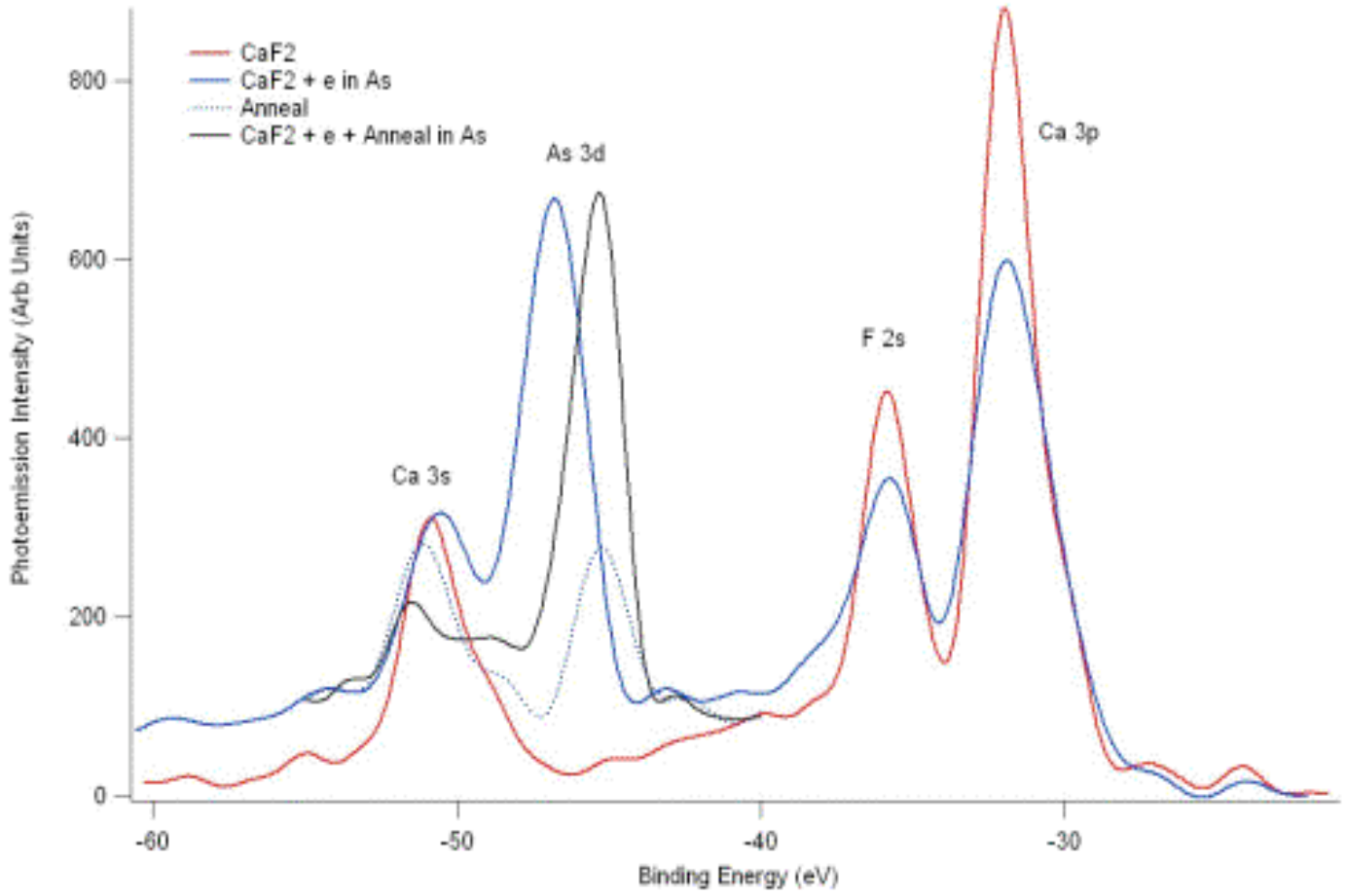
- Passivate Surface: As

The Question

- As works to passivate the surface
- Only sticks to Irradiated Surface
- Where is the As?
  - Surface, only 1/3 ML?
  - Diffused into Crystal?

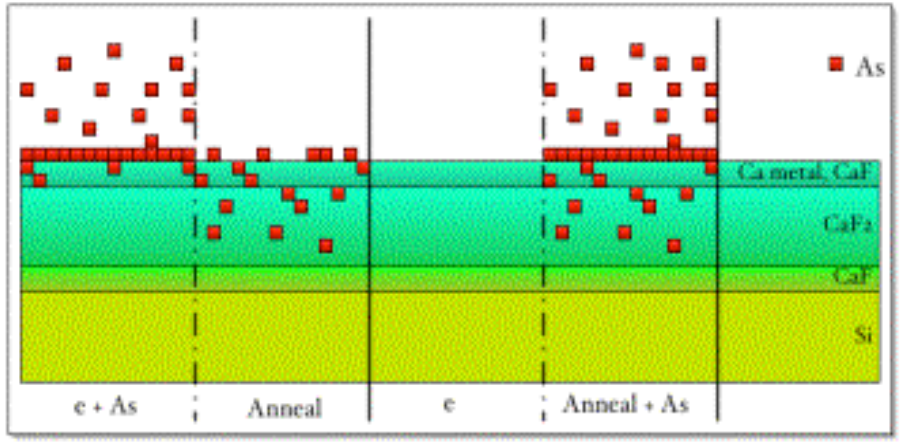


Irradiation with As



"The Answer"

- Irradiated CaF_2 allows for 1 ML of As to be deposited
- Annealing induces diffusion into the Crystal
- When Annealed in As, ML remains



Summary

- MBE allows for controllable growth of Thin CaF_2 Films
- XPS is a relatively fast way to analyze the composition of Thin Films
- ESD, while increasing the Surface energy, creates a highly reactive surface
- As for the As?
  - ML on surface diffuses down with annealing

Acknowledgements

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