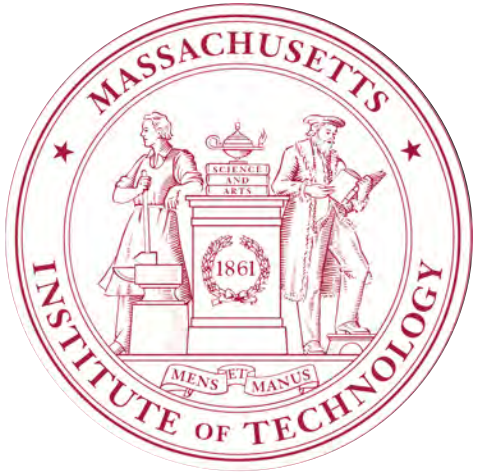
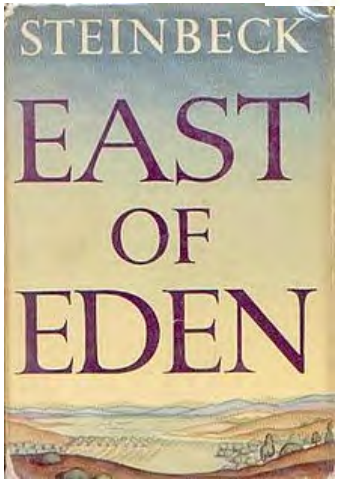


Simon Egner

NSF-REU Summer 2018

About me



TRINITY
Services, Inc.

ILLINOIS

- 48,000 Students
- 50 US States Rep.
- 65 Countries Rep.
- 150+ Majors
- Big Ten
- 6,370 Acres
  - (MIT: 168 Acres)

ENGINEERING AT ILLINOIS

- 13,000 Students

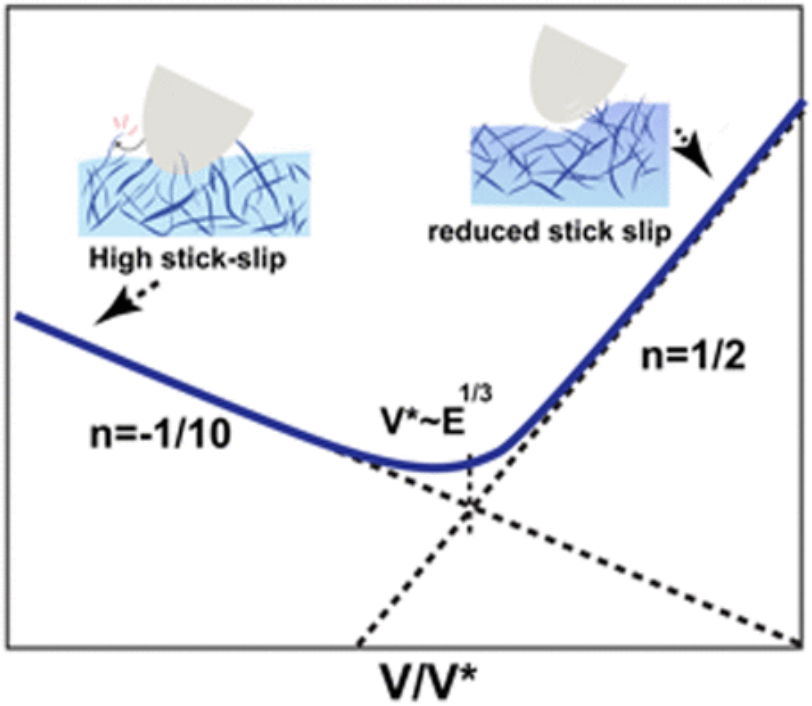
MatSE

the MicrophotonicsCenter @MIT

emat@mit

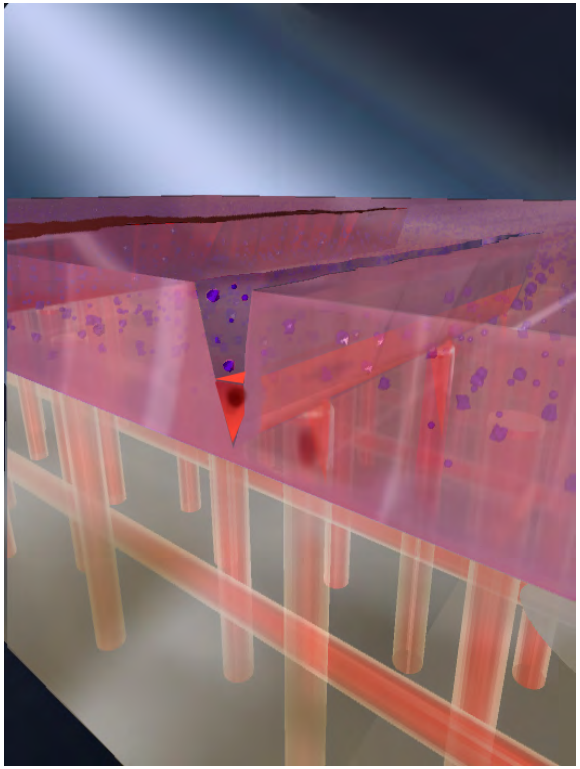
Espinosa-Marzal Lab

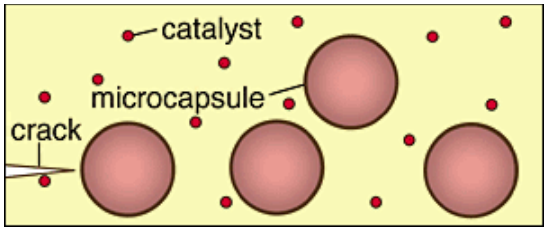
Stick–Slip Friction Reveals Hydrogel Lubrication Mechanisms *Langmuir*, **2018**, *34* (3), pp 756–765

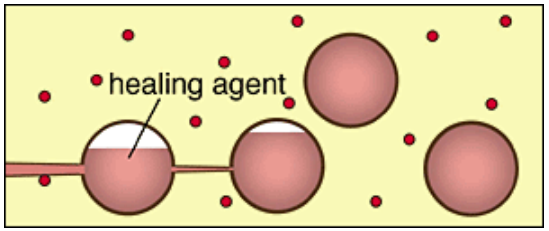


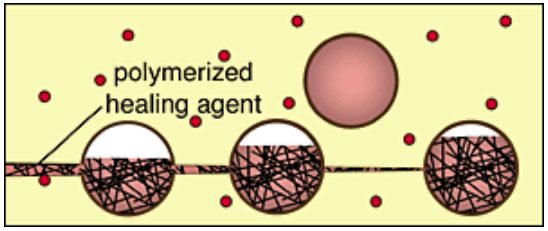
Autonomous Materials Systems - Beckman Institute

Dr. Nancy Sottos

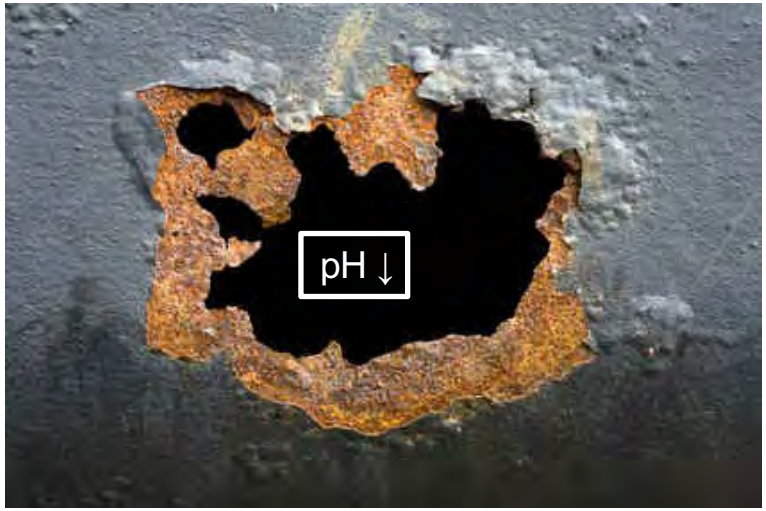


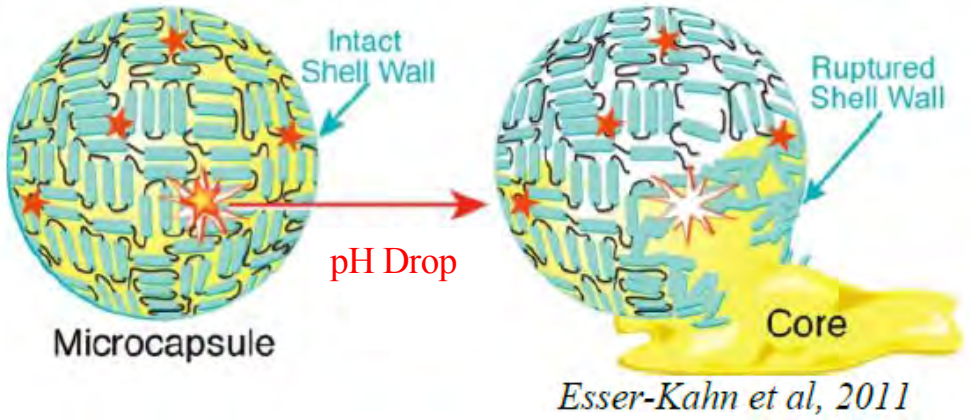




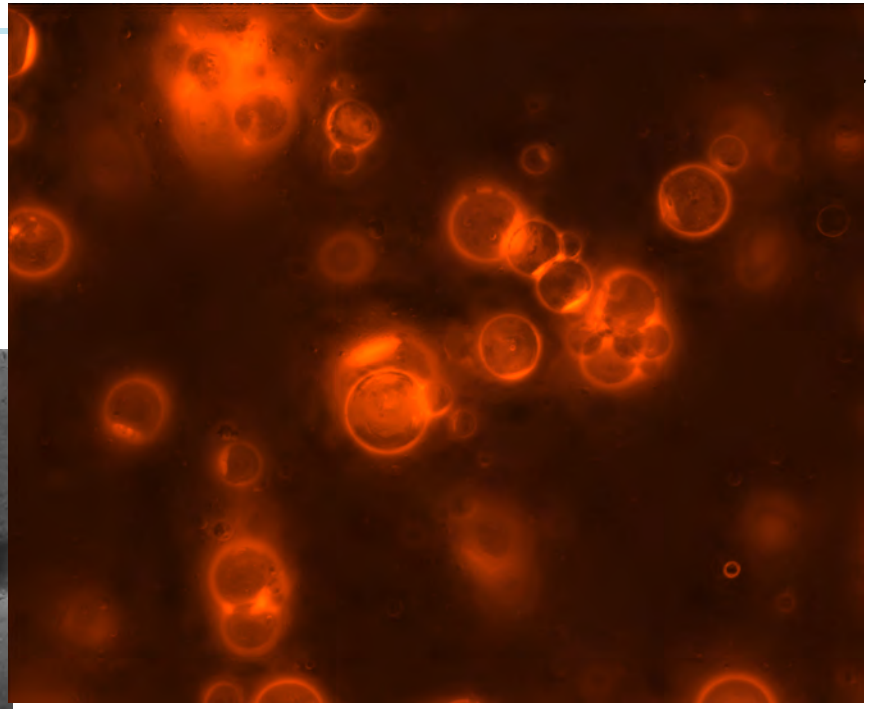


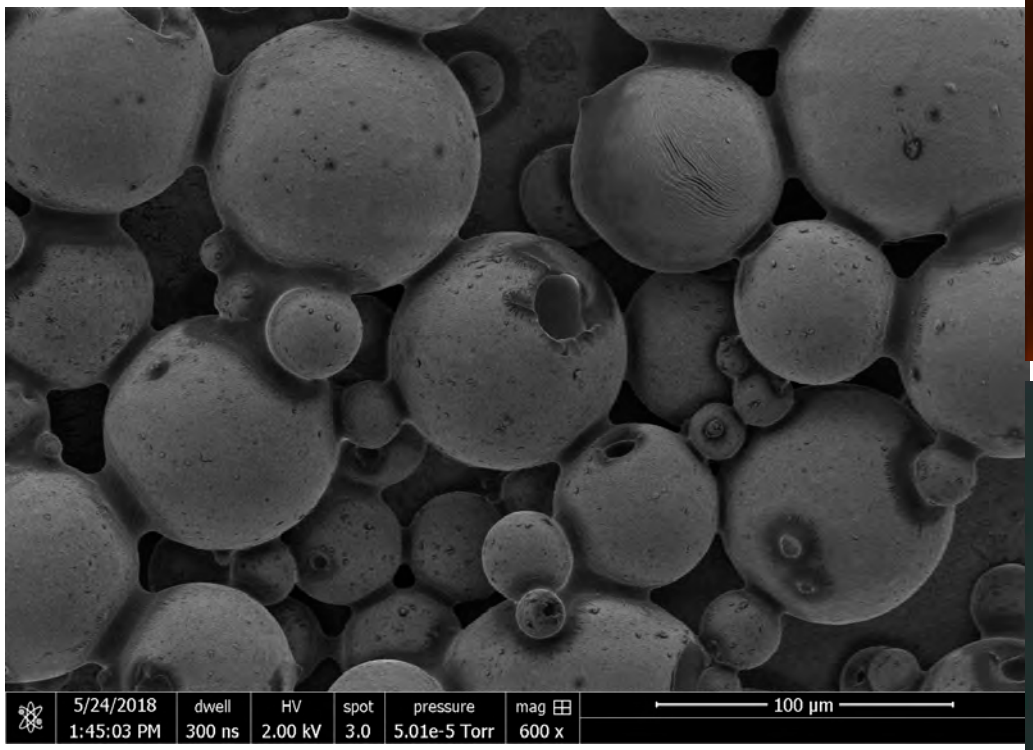
pH Responsive Coatings

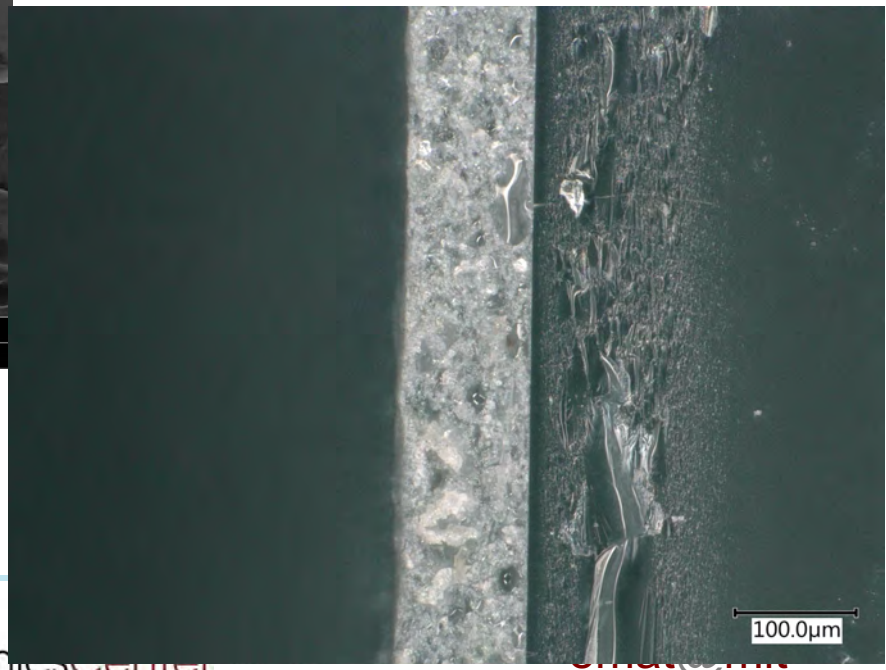




Esser-Kahn et al, 2011




5/24/2018
1:45:03 PM
dwell
300 ns
HV
2.00 kV
spot
3.0
pressure
5.01e-5 Torr
mag
600 x
100 µm

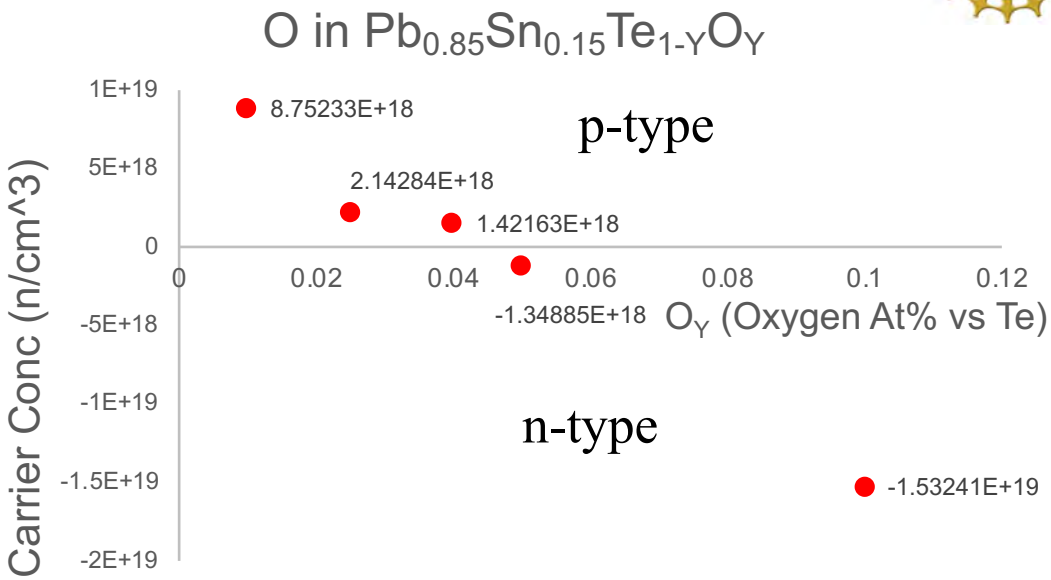

100.0µm

PbSnTe Photodetector

Simon Egner

Objectives

- Tunable detector in mid-IR
  - 4-7 μm
  - Room Temperature
  - High responsivity
  - p-n junction



Strategy/Approach

- Incorporated PbO into the source to reduce carrier concentration
  - Resulted in carrier type change
- Studied PbSnTeO material with various characterization techniques
  - FTIR, XRD, Hall Effect, XPS, Responsivity

Implications/Key Findings

- PbO in source changes from p-type to n-type
  - Post dep O sensitization typically leads to increase in p-type
- O preferentially binds Sn in bulk
- Less Sn than targeted
  - Oxygen bonding prevents evap.

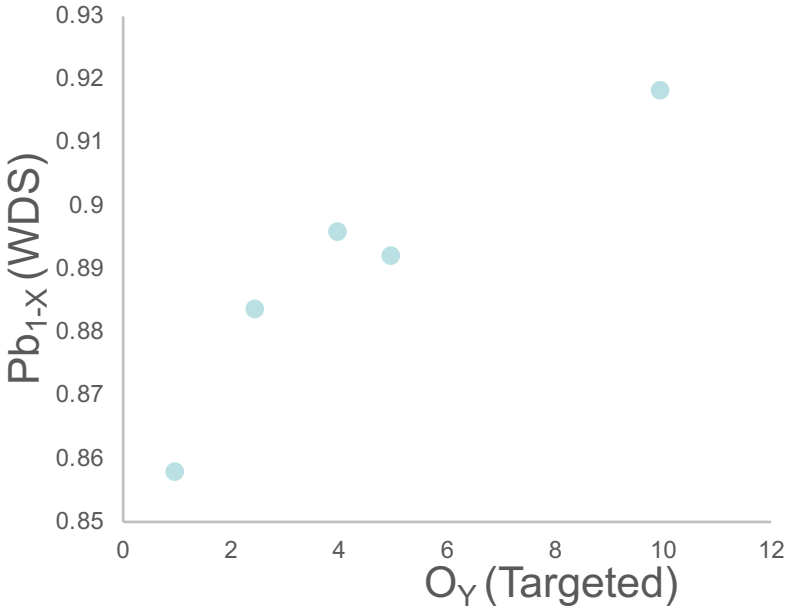
Key Points for Discussion Today

- Effect of PbO in source
- Calculation of band gap
- PbO affect on crystal structure
- Oxygen binding to Sn in the bulk

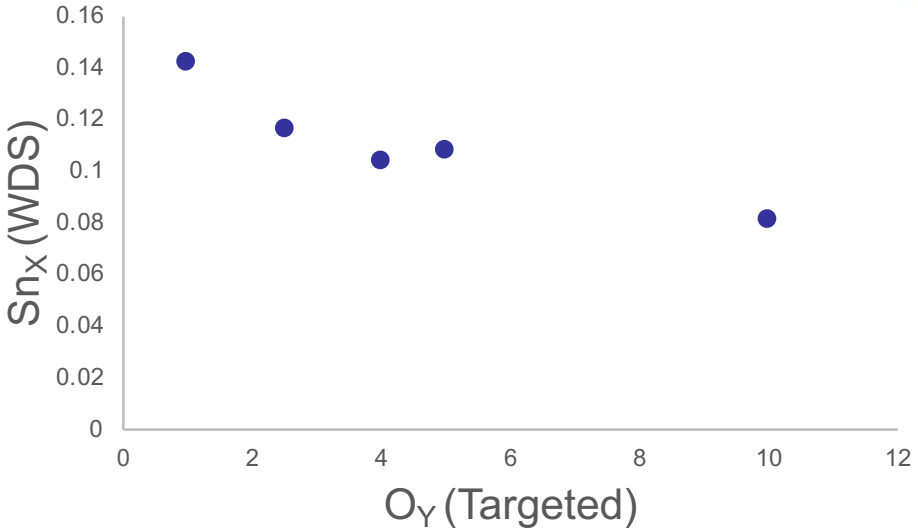
Thermal Evaporation Samples

- Target: $Pb_{0.85}Sn_{0.15}Te_{1-Y}O_Y$
  - PbTe, SnTe, PbO
- WDS to determine actual material composition

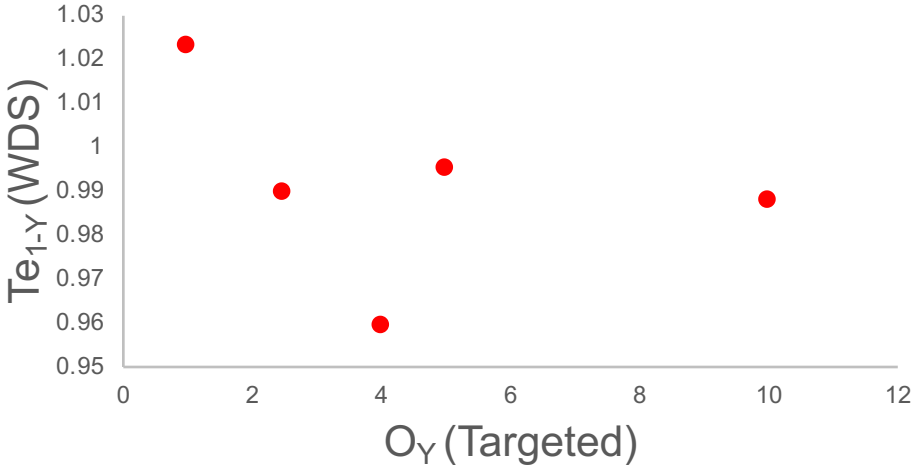
Pb in $Pb_{1-X}Sn_XTe_{1-Y}O_Y$



Sn in $Pb_{1-X}Sn_XTe_{1-Y}O_Y$



Te in $Pb_{1-X}Sn_XTe_{1-Y}O_Y$



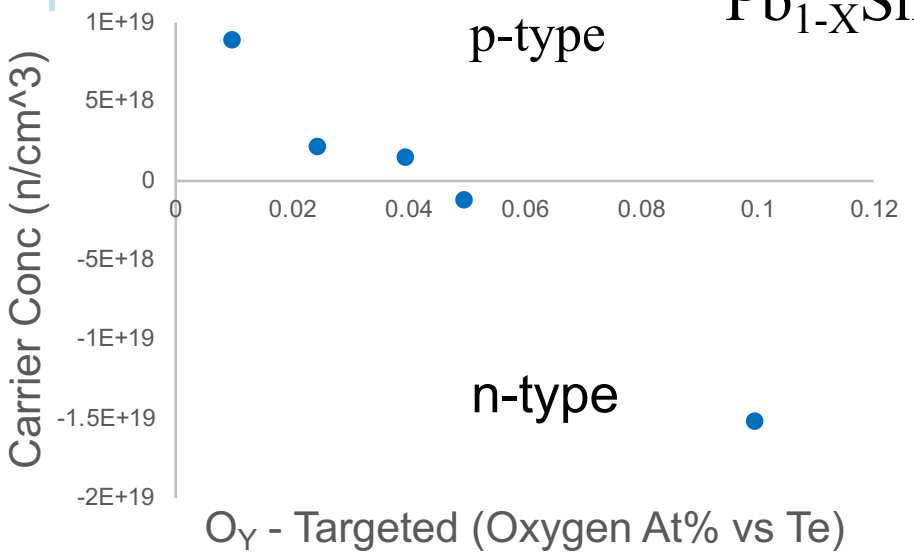
- PbO reduces Sn composition
  - SnO $T_m = 1080^\circ C$

Sample Summary

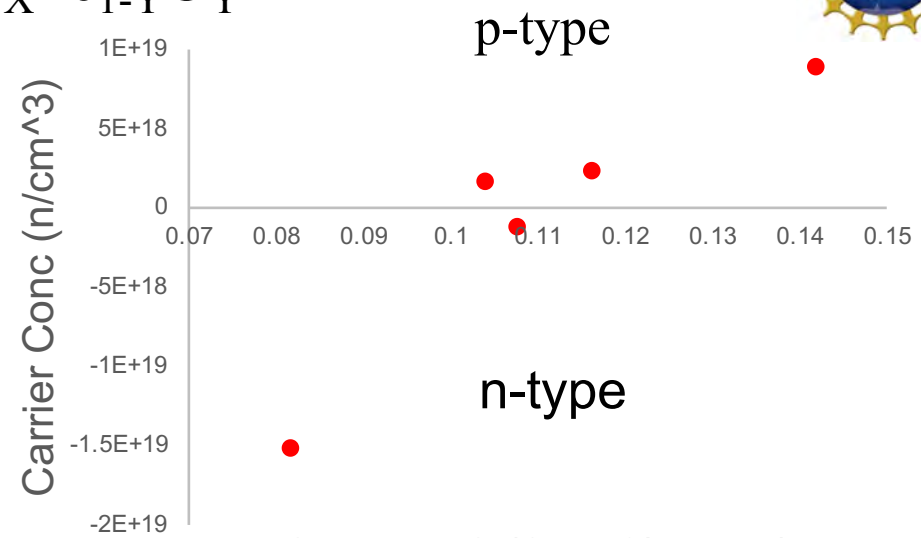
Target	WDS
$Pb_{0.85}Sn_{0.15}Te_{0.99}O_{0.01}$	$Pb_{0.86}Sn_{0.14}Te_{1.02}O_{?}$
$Pb_{0.85}Sn_{0.15}Te_{0.975}O_{0.025}$	$Pb_{0.88}Sn_{0.12}Te_{0.99}O_{?}$
$Pb_{0.85}Sn_{0.15}Te_{0.96}O_{0.04}$	$Pb_{0.90}Sn_{0.10}Te_{0.96}O_{?}$
$Pb_{0.85}Sn_{0.15}Te_{0.95}O_{0.05}$	$Pb_{0.89}Sn_{0.11}Te_{1.0}O_{?}$
$Pb_{0.85}Sn_{0.15}Te_{0.90}O_{0.10}$	$Pb_{0.92}Sn_{0.08}Te_{0.99}O_{?}$

4-Probe Hall Effect – Carrier Concentration

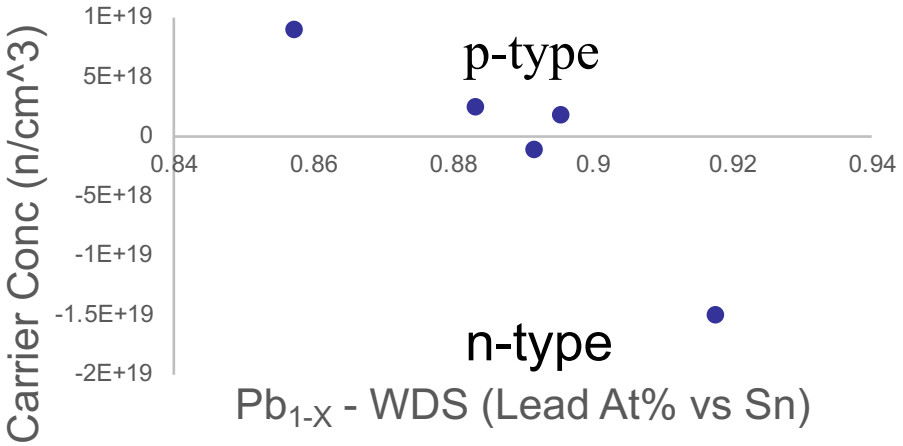
$Pb_{1-X}Sn_XTe_{1-Y}O_Y$



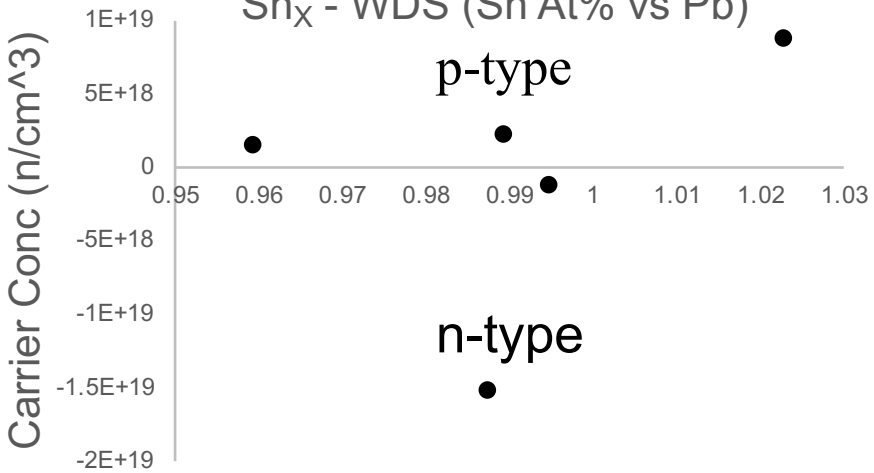
O_Y - Targeted (Oxygen At% vs Te)



Sn_X - WDS (Sn At% vs Pb)



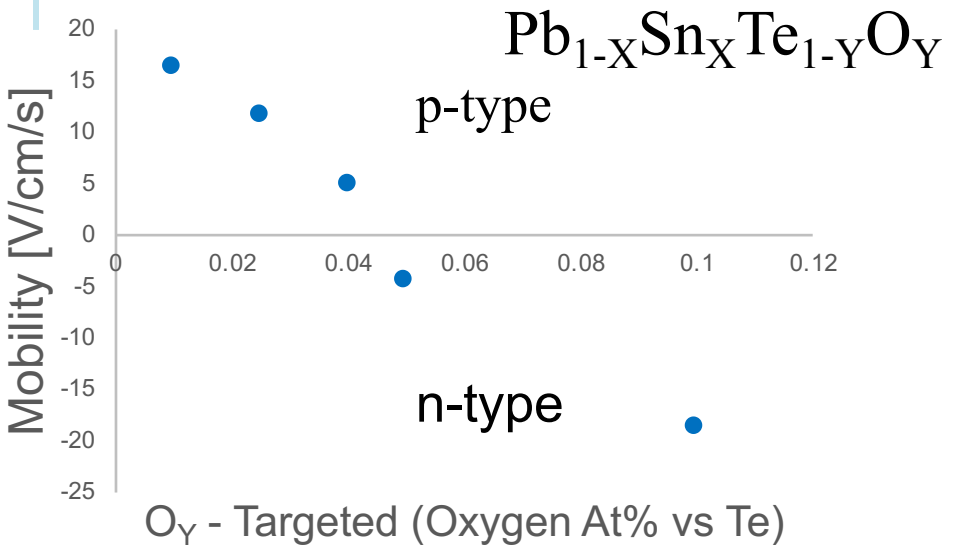
Pb_{1-X} - WDS (Lead At% vs Sn)



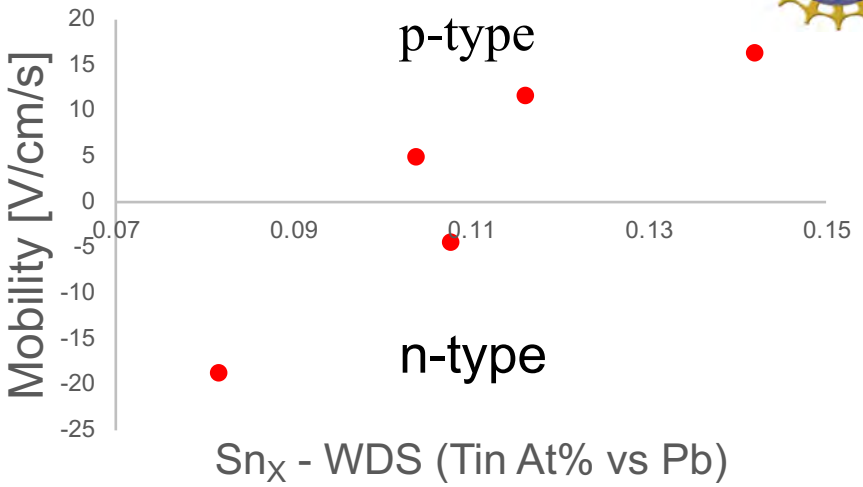
Te_{1-Y} - WDS (Tellurium At% vs O)

- Te composition unrelated to carrier conc.

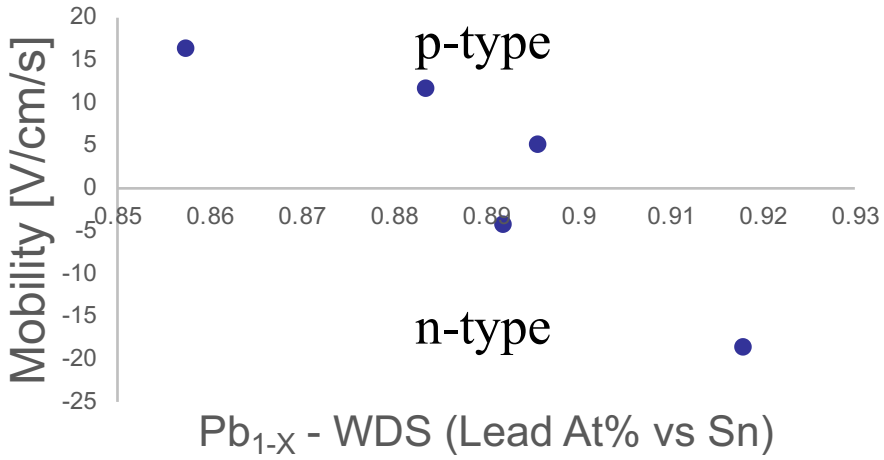
4-Probe Hall Effect – Mobility



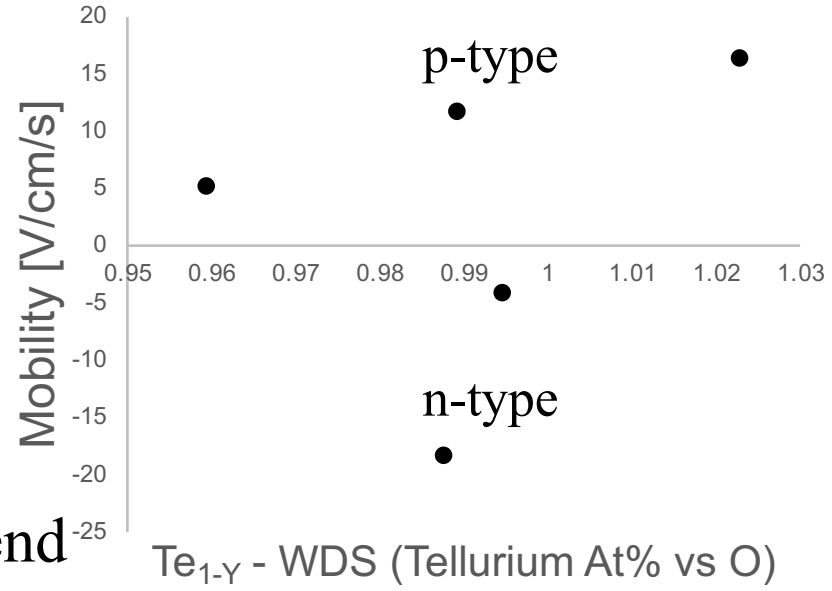
O_Y - Targeted (Oxygen At% vs Te)



Sn_X - WDS (Tin At% vs Pb)



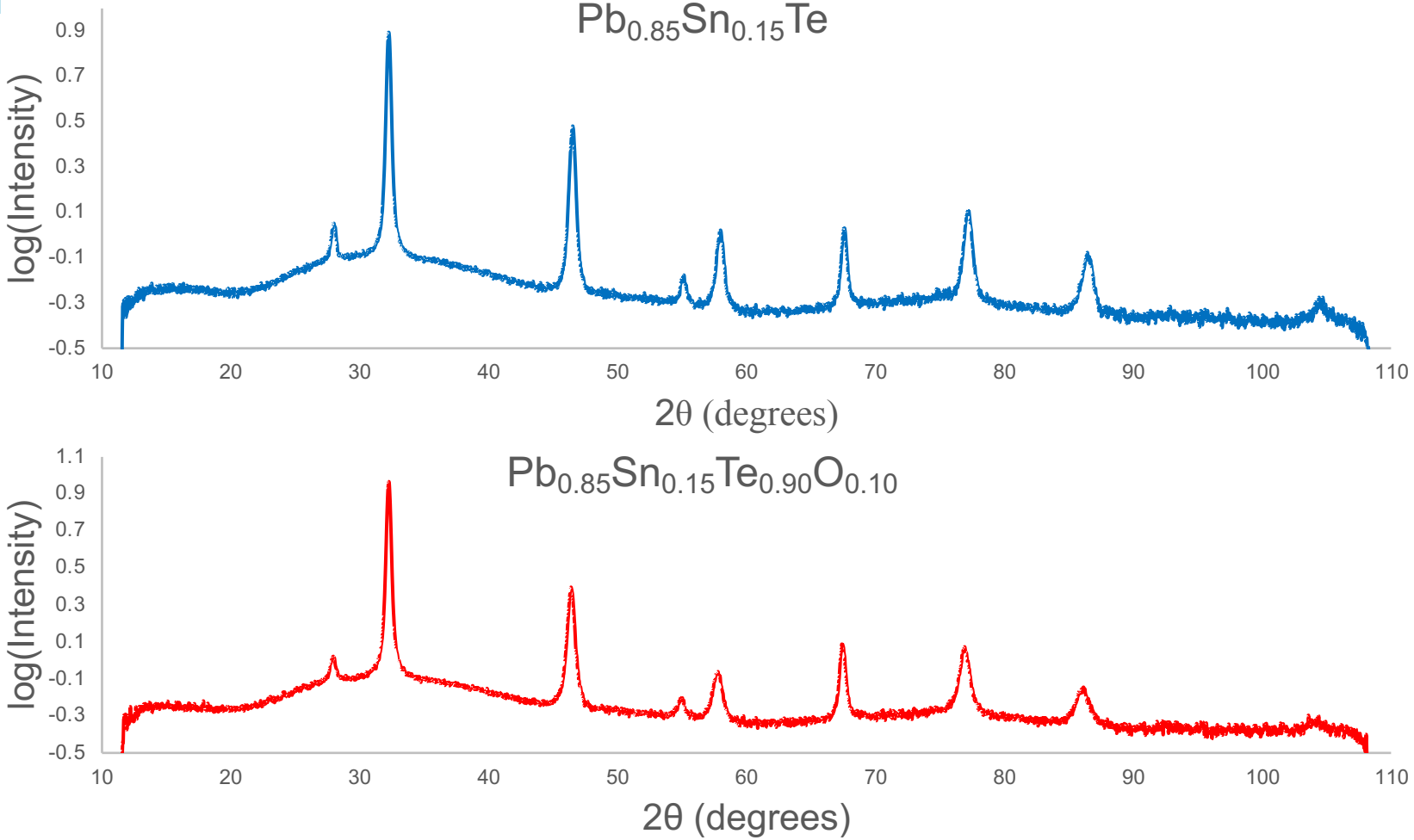
Pb_{1-X} - WDS (Lead At% vs Sn)



Te_{1-Y} - WDS (Tellurium At% vs O)

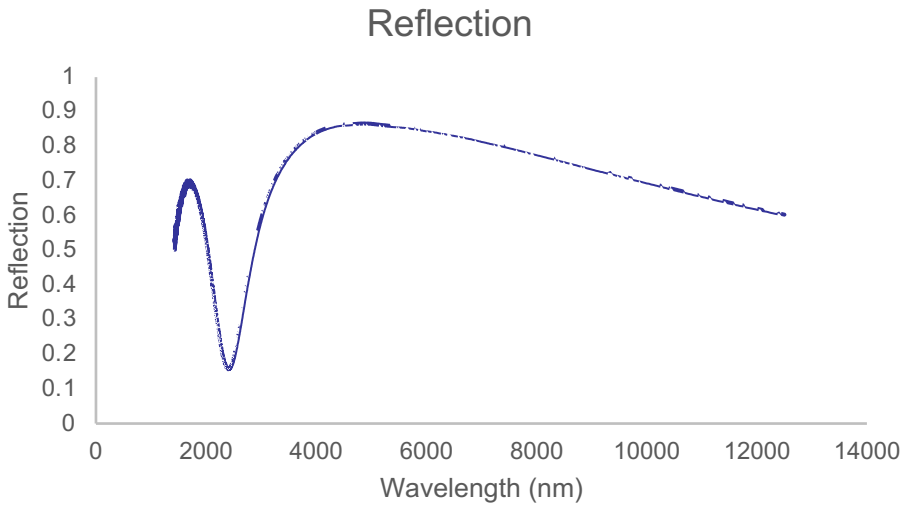
- Mobility matches carrier conc trend

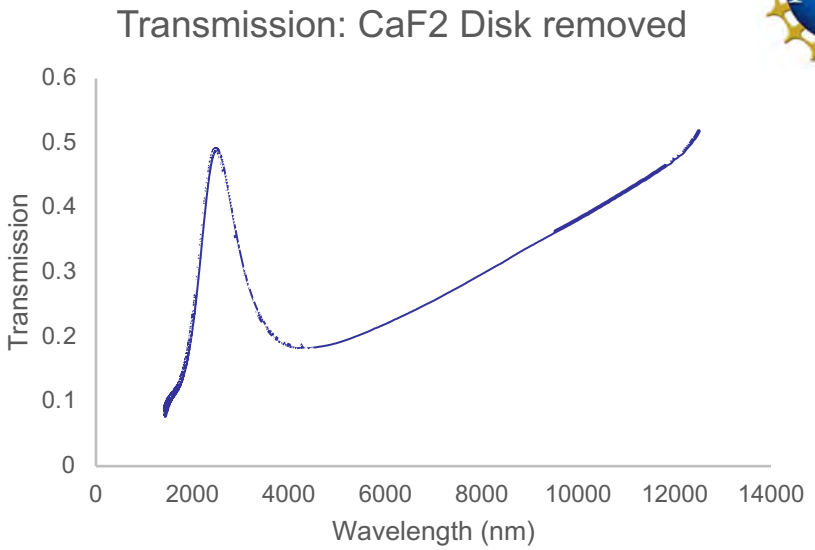
Polycrystalline Structure - XRD

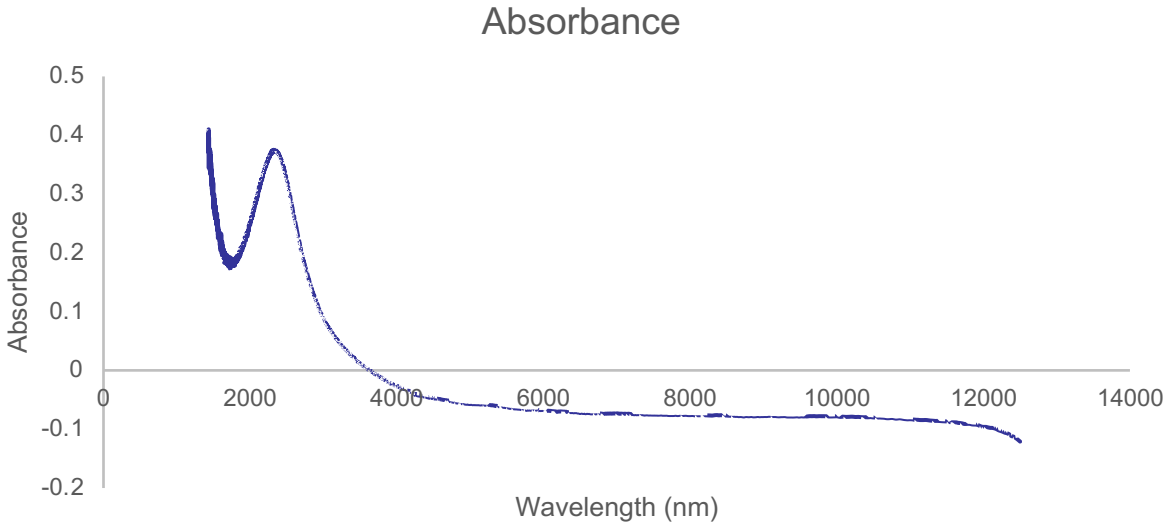


- PbO does not greatly affect crystal structure

Band Gap – FTIR





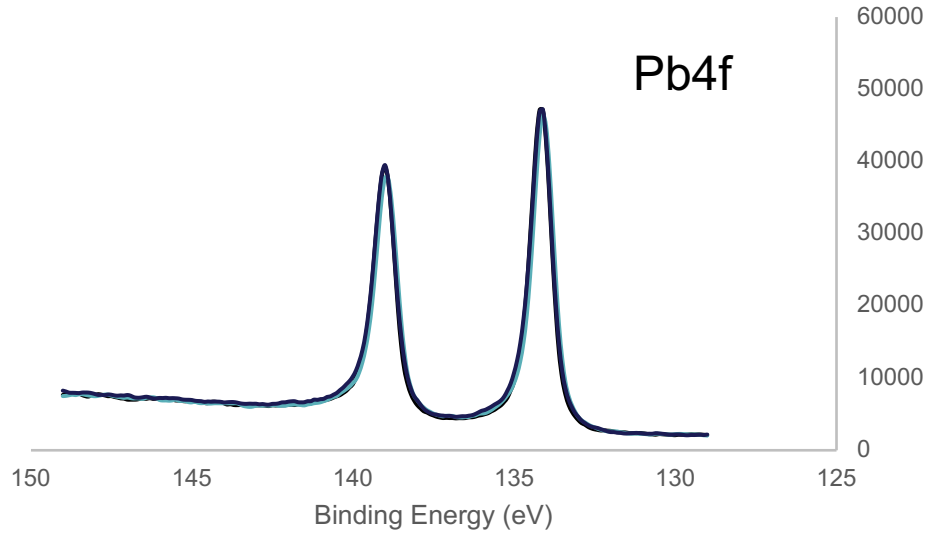


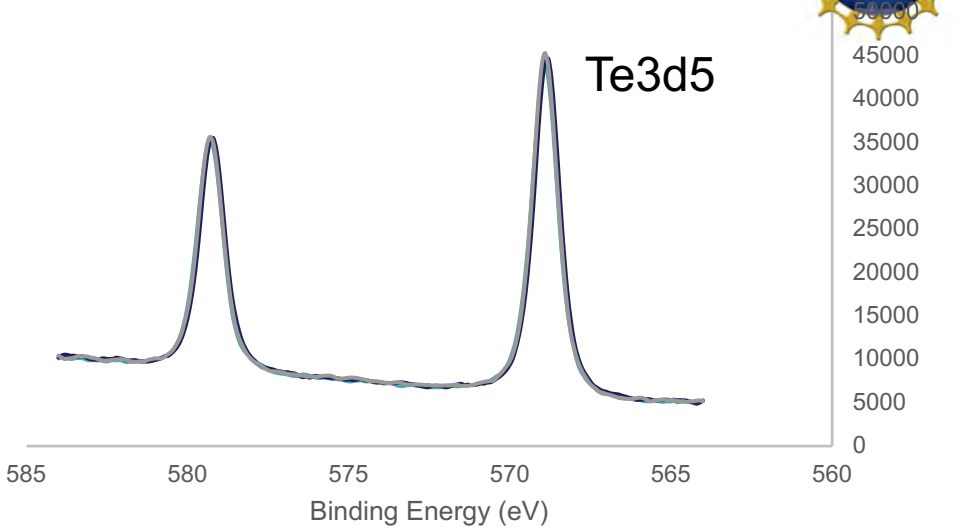
Found from interference peaks

n @ 1749nm = 5.59

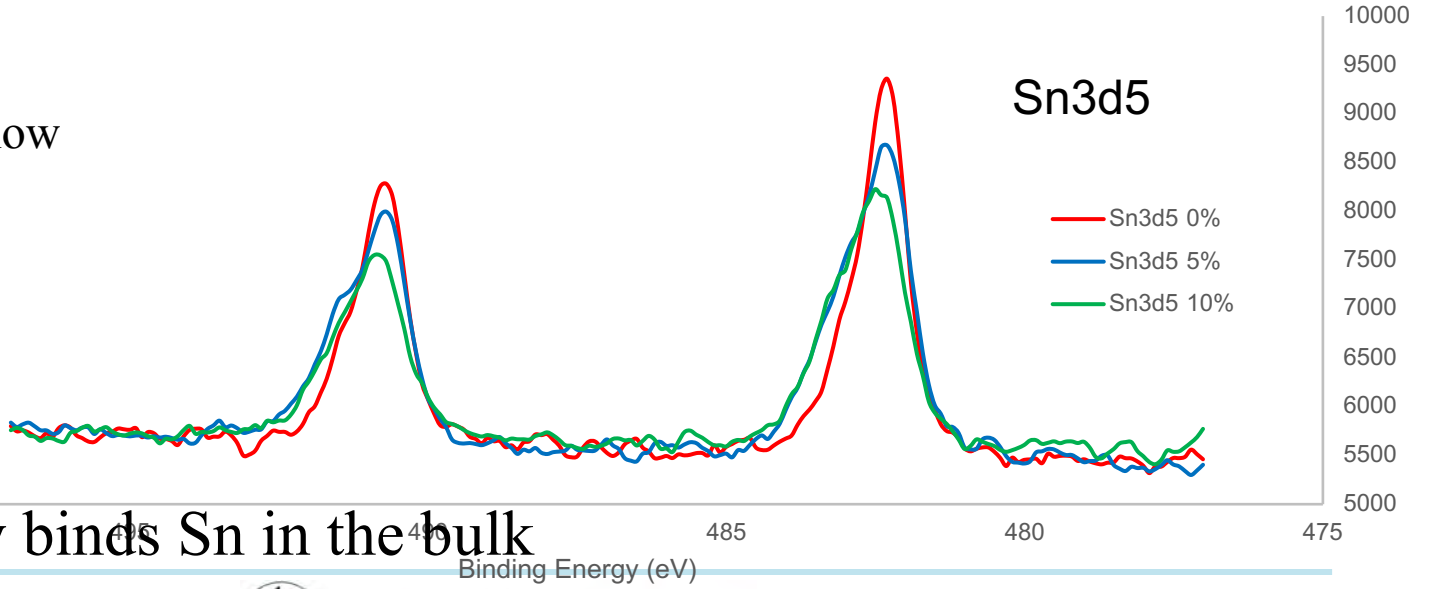
n @ 2417nm = 5.39

Depth Profiling XPS





- Higher binding energy peaks show oxygen binding



- O preferentially binds Sn in the bulk

Accomplishments & Plans

- Able to tune carrier concentration and type with PbO
- Discovered oxygen in the source leads to Sn bound oxygen in the bulk
- Future experiments with TEM to determine bulk oxygen location
- New deposition method that separates SnTe from PbO
- Investigate what variables account for carrier concentration change
  - O
  - Te vs. PbSn

Thank you

Questions?