

Quantifying Elemental Diffusion Within Semiconducting Diodes Due to Thermal Stresses

Daniel Abreu, Electrical Engineering
Mentor: Nicholas Rolston, Assistant Professor
School of Electrical, Computer and Energy Engineering



Research question: What other avenues can be taken to measure and characterize semiconductor devices?

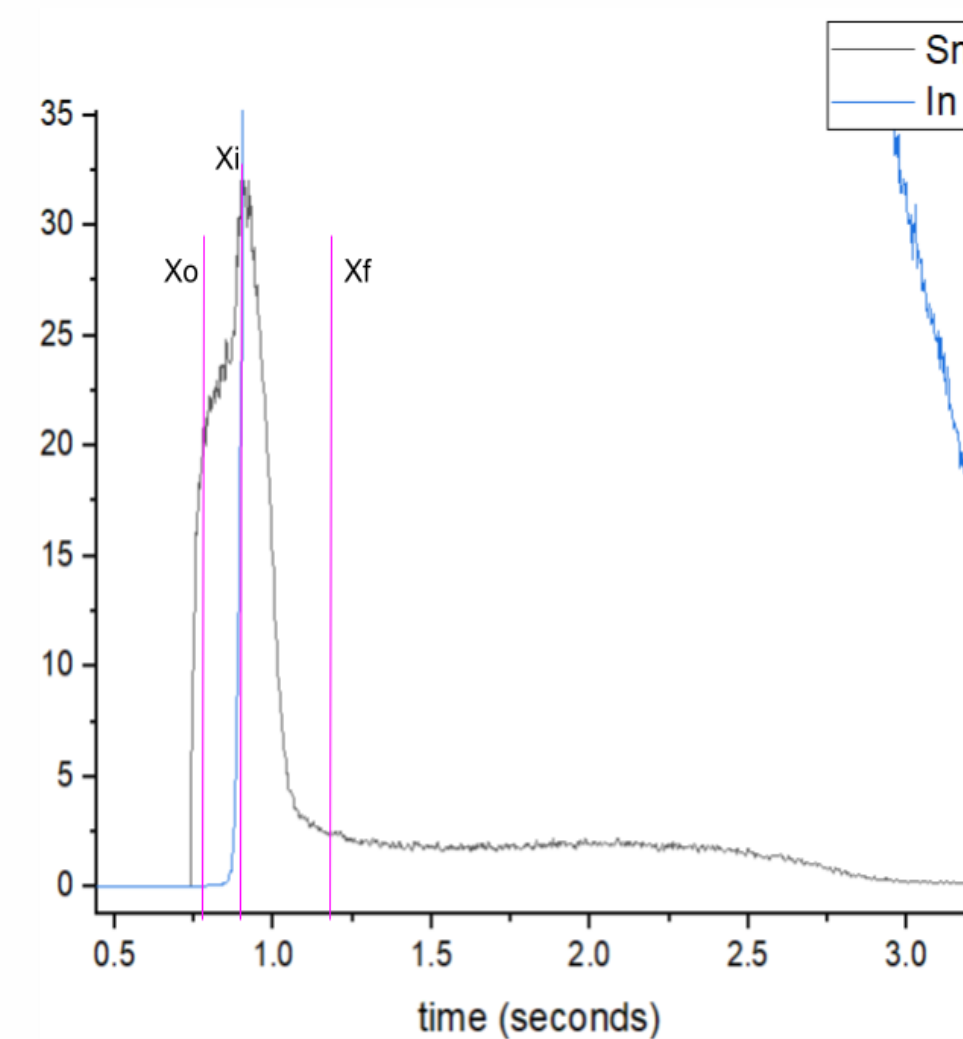
Methods:

- Use GD-OES to take relative measurements that can be used to compare data over different aging periods
- Look at the relative levels of Sn and Indium over the time of the experiments to see the diffusion between the material
- Compare “diffusion ratios” across the different time periods to measure changes [1].
- Three samples were aged in air while three others were aged in nitrogen to simulate different conditions

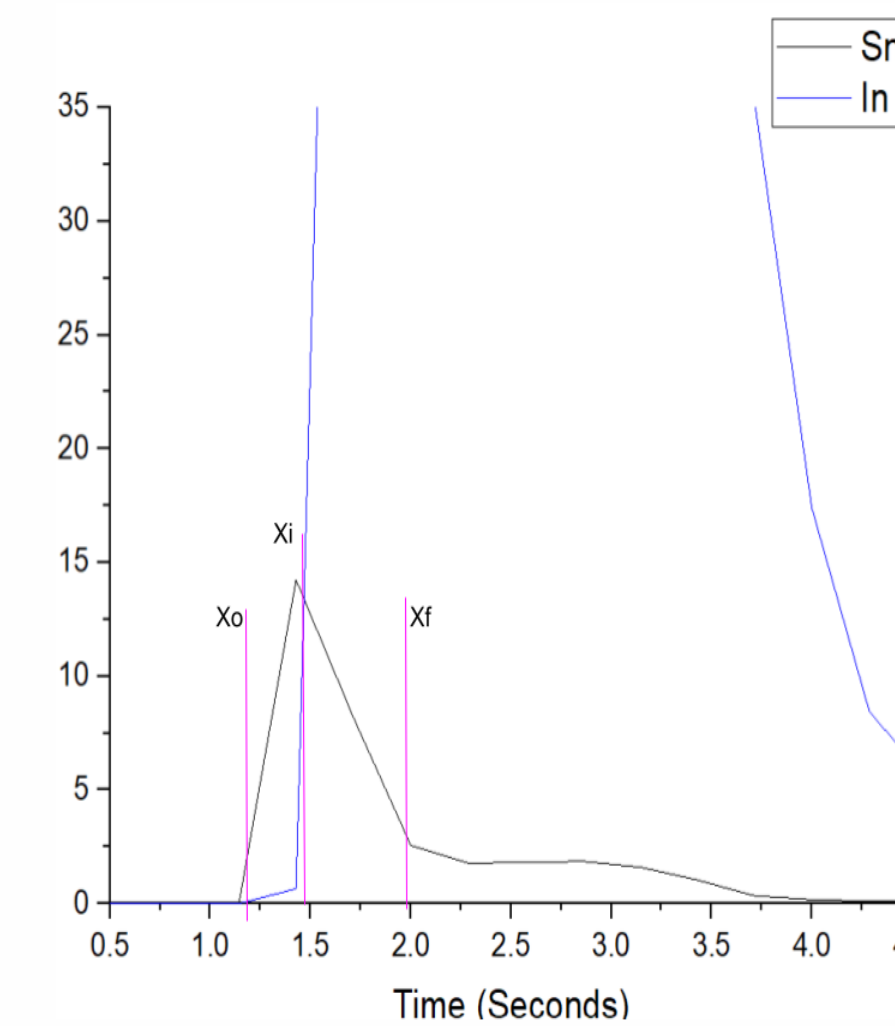
Diffusion Ratio¹:

- $\frac{X_i - X_o}{X_f - X_o}$
 - X_i is the time where Sn and In intersect
 - X_o is time where Sn starts to “climb”, usually taken as where the derivative of Sn was greatest
 - X_f is a value just before Sn plateaus, usually taken as where the derivative of Sn is -1
 - **The lower the number, the more indium has diffused into tin**

GD-OES Graph of Sample 1 Week 0



GD-OES Graph of Sample 1 Week 3



Sample Calculations and Example Changes Over Time

Sample	Diffusion
Week 0 (Air)	0.361
Week 3 (Air)	0.035
Week 0 (N ₂)	0.349
Week 3 (N ₂)	0.0043

What Is GD-OES?:

- GD-OES stands for Glow Discharge Optical Emission Spectrometer.

How Does It Work?:

- GD-OES uses plasma to take either the surface or depth profile of a sample and measures the relative compositions of various elements as it works into the sample over time via measuring the intensity of the unique emission spectra of elements.

Future Work:

- Make sure time precision stays consistent throughout future experiments.
 - Inexplicably, the recipe changed after week 0, causing larger time steps in samples taken as seen in the graph on the right.
 - Because of the increase of the timestep, values can vary in accuracy and reliability
- Do C-V measurements in parallel with GD-OES measurements

Sample Cross Section Pre-Aging

