Chalcogenide Semiconductors

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Introduction

Wide bandgap semiconductors are important for creating power electronics. Some of the most common wide bandgap semiconductors for power electronics are Silicon Carbide (SiC) and Gallium Nitride (GaN) in addition to silicon (Si). However, there are still some materials that have not been explored as thoroughly as these semiconductors for application in power electronics. One such class of material is chalcogenides, which could be potentially good for power devices.

Objectives & Impact of Professor Ravichandran's Research

Though silicon based technology has been improved over the past couple of years, it is reaching its limits. Silicon can't handle very high temperatures nor power levels, and has a higher energy loss. With the research of new wide bandgap semiconductors (chalcogenides), these limitations can be overcome. Chalcogenides are known to exhibit lower effective masses and have a propensity for p-doping. The main goal is to find new chalcogenides that could help improve the performance of power electronic devices and to be able to synthesize these new materials. With this in mind, we need to find how effective these chalcogenides are for power devices by following a figure of merit, called Baliga Figure of Merit (BFOM) which uses the band gap, dielectric constant, and mobility of a material

$$\mathrm{BFOM} = \varepsilon_r \, \mu \, E_g^3$$

Skills Learned

- ❖ Became aware of the different properties materials have and how they each have their own characteristics
- ❖ Learned how Pulsed Laser Deposition works
- ❖ Calculated dielectric constant using Clausius-Mossotti relation for various chalcogenides
- ❖ Used MATLAB to visualize and establish trends between the calculated values and the experimental values of dielectric constant by linear regression

My Work

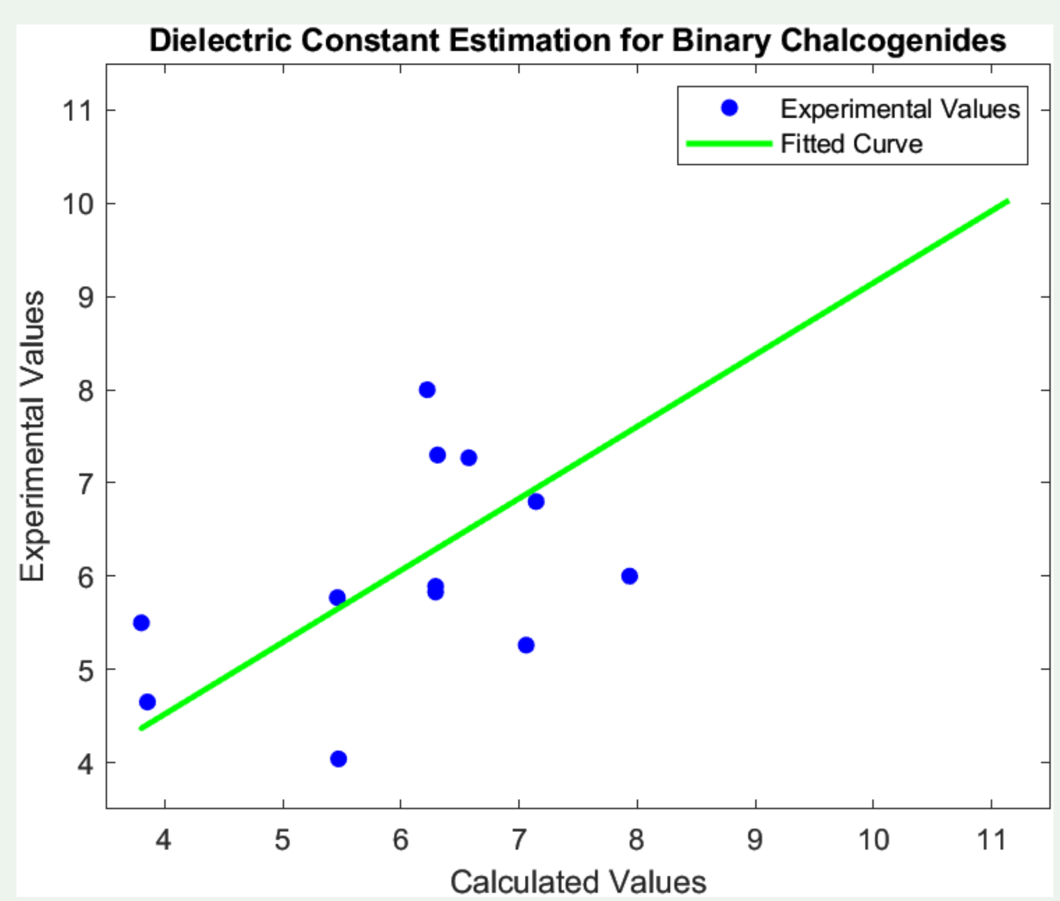

Figure (1) This plot represents the relationship between my calculated values and experimental values for binary chalcogenides. *(PC: Bryan Sanchez)*

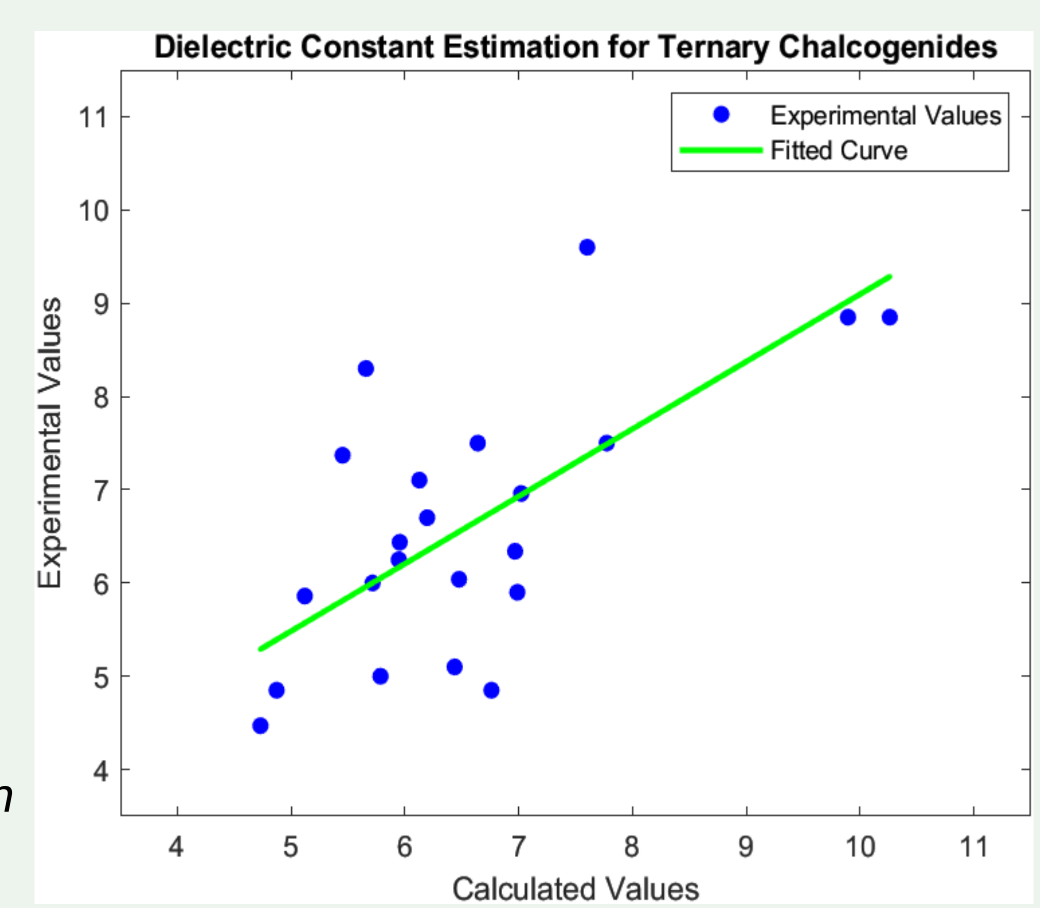

Figure (2) This plot represents the relationship between my calculated values and experimental values for ternary chalcogenides*(PC: Bryan Sanchez)*

Dielectric Constant Estimation

Clausius-Mossotti Equation

$$\alpha_{tot} = \frac{3V}{4\pi}\,\frac{\varepsilon - 1}{\varepsilon + 2}$$

α_{tot}= calculate polarization ,
V = molecular volume,
ε = dielectric constant

Additivity Rule of Polarizability

$$\alpha_{tot} = \Sigma_i n_i a_i$$

How This Relates to My STEM Coursework

SHINE has introduced me and expanded my knowledge in areas I wouldn't have been able to learn in high school. One of those areas being the usage of MATLAB and another the importance of lab safety. I was also able to learn how Pulsed Laser Deposition works. Not to mention, I was able to see how subjects like physics, chemistry, and calculus play a big role in engineering.

Advice for Future SHINE Students

My advice to future SHINE students would be to not be afraid of not knowing everything. As mentioned by others, you take what you want from SHINE, so take advantage of this opportunity and learn as much as you can. That's how you grow and prepare yourself a bit more for the future.

Acknowledgements

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