Synthesis and Characterization of Chalcogenide Perovskites

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Summer High School Intensive in Next-Generation Engineering

Introduction

Perovskites are a class of materials that have been subject to intense research in recent years due to their versatile chemical and physical properties. Perovskites have a unique crystal structure (general formula ABX_3). Their specific structural composition allows perovskites to display a variety of interesting properties, i.e. superconductivity, that make them optimal for use in photovoltaics.

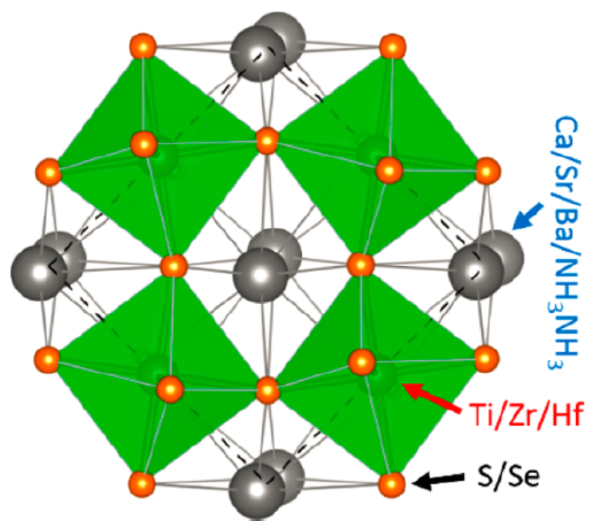

Fig. 1: Structure of a perovskite
PC: Sun et al., 2015, "Chalcogenide Perovskites for Photovoltaics", published in Nano Letters (pubs.acs.org/NanoLetters)

Objective & Impact of Professor's Research

Professor Ravichandran's research focuses on the synthesis and characterization of oxide and chalcogenide perovskites. Specifically, my PhD mentor's work centers around transition metal perovskite chalcogenides. We aim to find a series of perovskites that has ideal properties for solar-cell materials, such as optical absorption or a specific direct band gap.

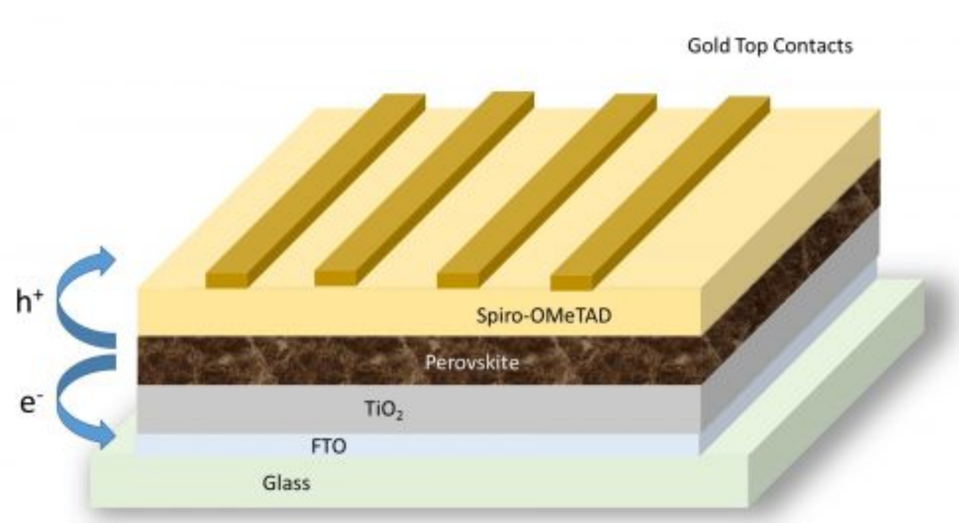

Fig. 2: Cross section of a perovskite solar cell
PC: Clean Energy institute (https://www.cei.washington.edu/education/science-of-solar/perovskite-solar-cell/)

Process

We found an optimal chemical process that was cost-efficient and time-efficient.

$$BaS + Zr + 2S \xrightarrow{I2} BaZrS3$$

The reaction was catalyzed by I2 and took place at an elevated temperature (1000°C).

1. In the glove box, we weighed powders with the goal of achieving 1g of product. The powders were then mixed and ground in a mortar. Some samples were doped with Thulium.

Fig. 3: Chemicals in the glove box
PC: Elizabeth Kim

2. The amalgam of chemicals was then transferred and sealed in a quartz ampoule, then taken out of the glove box.

3. The powders were essentially "cooked" in a furnace at 1000°C over the course of several days.

Fig. 4: Furnace
PC: Elizabeth Kim

4. The final product was extracted, removed of impurities like glass shards, then ground and pressed into a pellet.

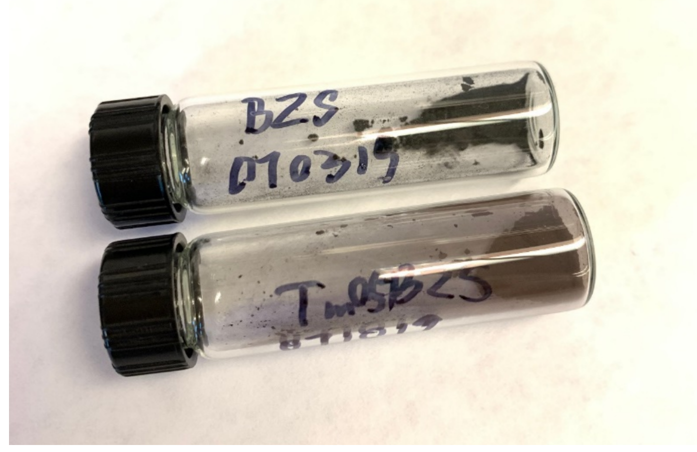

Fig. 5: BZS and TmBZS products
PC: Elizabeth Kim

Characterization

XRD (X-Ray Diffraction)

We used X-ray diffraction techniques to characterize the morphology of the compounds.

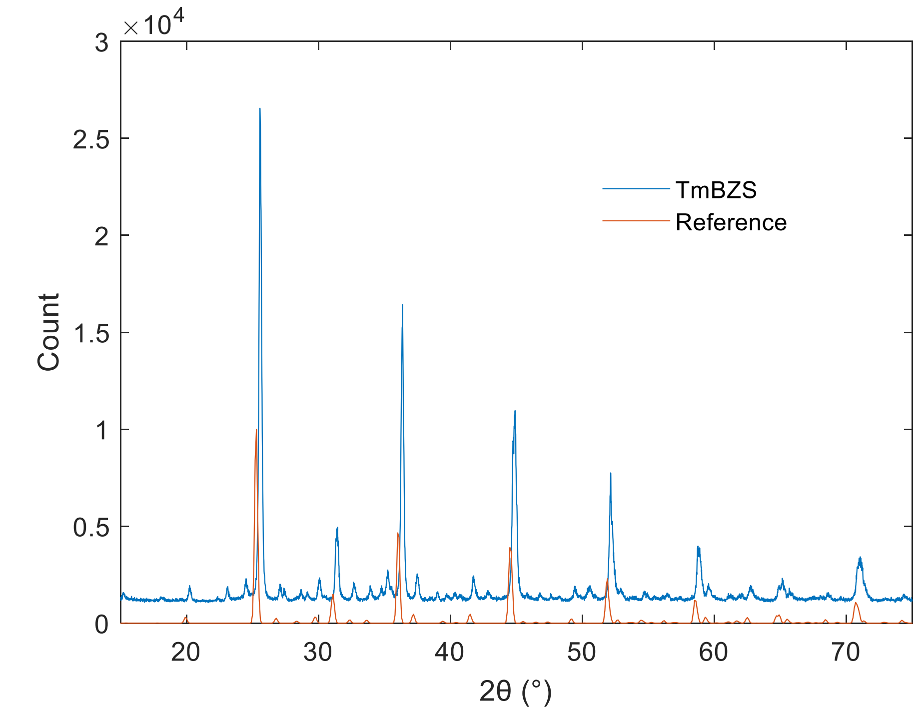

Fig. 6: XRD data. Each peak represents an element.
PC: Elizabeth Kim

Photoluminescence

Using Raman microscopy, we characterized the photoluminescence (PL) of the compounds. We used the data to compare the doped and undoped samples, to see if the Tm doping made a difference in the compound.

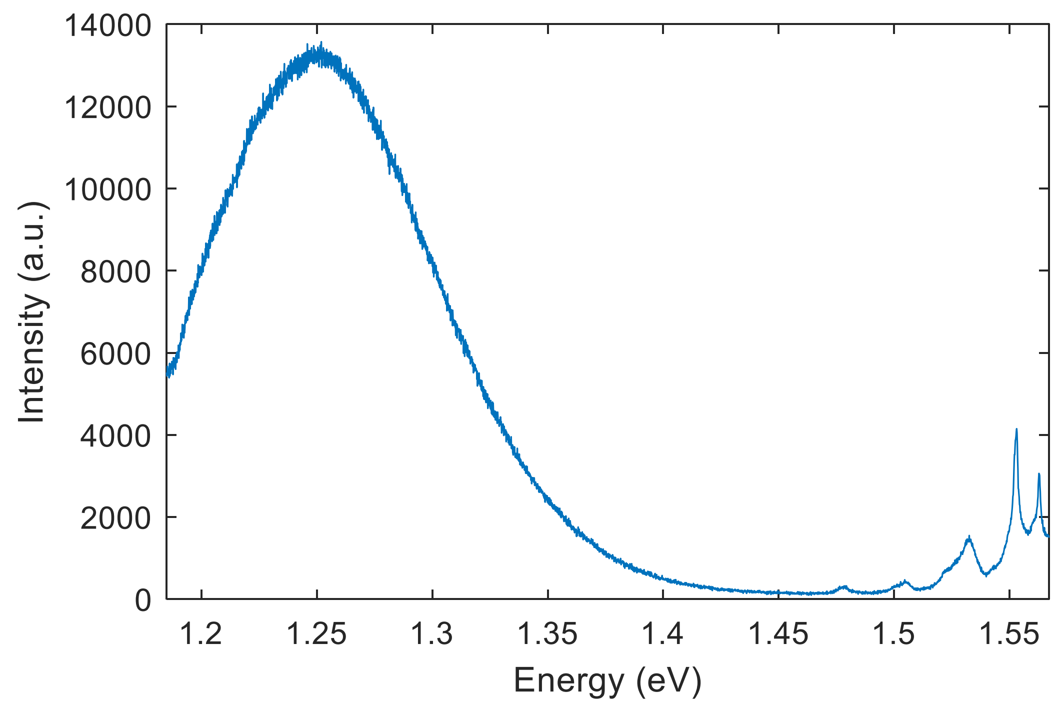

Fig. 7: Photoluminescence data.
PC: Elizabeth Kim

Skills Learned

During the course of my SHINE experience, I learned many skills including (but not limited to):

- Utilizing MATLab for plotting/analyzing data
- Handling dangerous chemicals in a lab setting with a glove box
- Properly cleaning equipment with ethanol and acetone

Next Steps

The next steps would involve finding potential applications for the compounds. It could be used to produce a thin film, which could be used in photovoltaic devices.

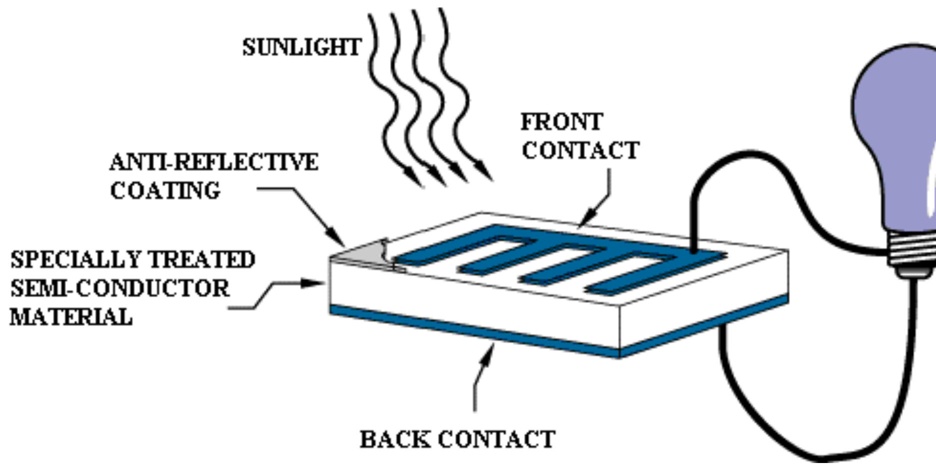

Fig. 8: A photovoltaic (solar) cell
PC: NASA

Acknowledgements

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