Structural Characterization of Thermally Aged Perovskite Solar Cells

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Introduction

Research Question

- How does the structure of perovskite solar cells change after experiencing various thermal conditions in varying amounts of time?

Objective

- The objective of the research is to structurally characterize thin films of perovskite solar cells (PSC) by measuring the orientation of atoms after different stages of aging. By using an x-ray diffractometer (XRD), PSC films--that have undergone aging through placement of differing temperatures--are measured to investigate the changes in crystalline structure for the film.

Impact

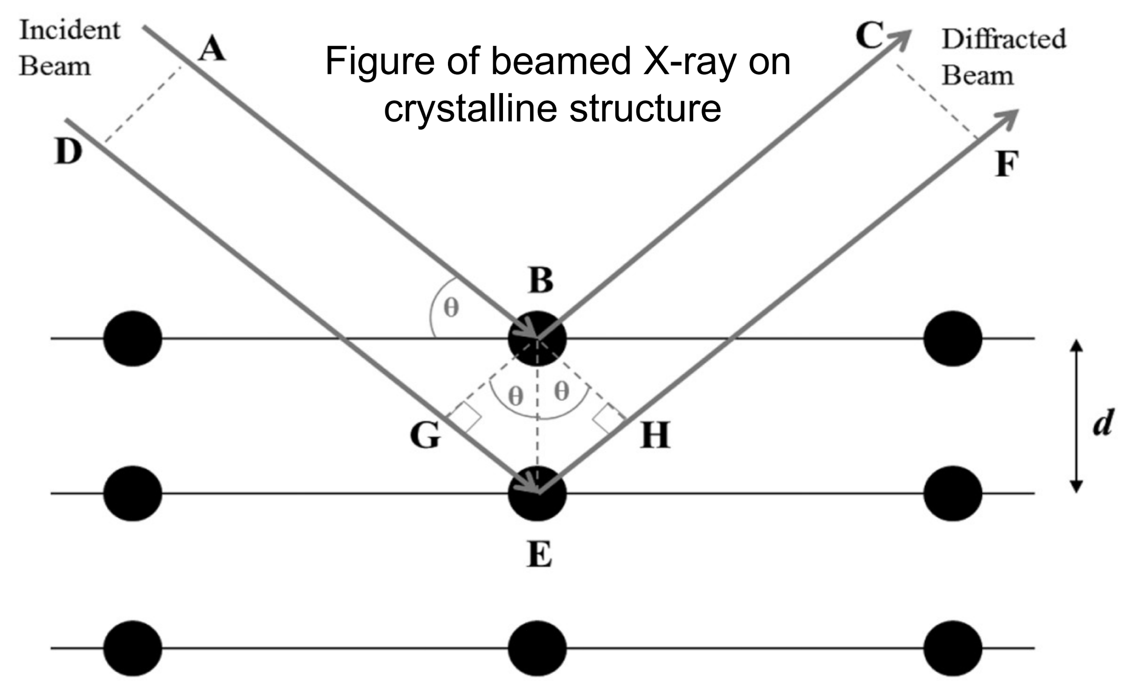
- Uncovering the structure property relationship of perovskite solar cell materials using X-ray diffraction and crystallinity measurements.

Procedure

The procedure measures the aging of 2 sets of samples with differing composition per set:

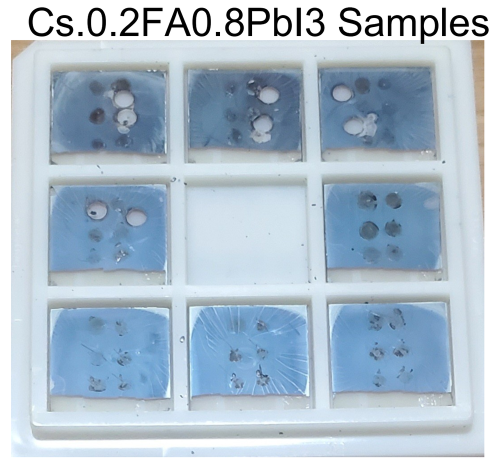
-Place 4 of the 8 perovskite samples of the CH3NH3PbI3 composition under a hot plate in 45°C heat, and the other 4 in 65°C heat.
-Both 45°C and 65°C samples must have 1 sample each aged for 24 hrs, 48 hrs, 72 hrs, and 96 hrs.
-Once all samples are aged, charge the X-ray diffractometer for XRD measurement.
-Measuring each sample one at a time—open the doors of the diifractometer and place the sample on the stand.
-Close doors and active optic alignment through Smart Lab Studio II software for correct placement of the X-ray.
-Active sample alignment for correct sample positioning.
-Begin XRD measurement as the X-rays revolve around the sample for different angle positioning—measures crystalline structure.
-Once XRD measurement in completed—record data, plot the data, and analyze the peaks.
-Repeat procedure for Cs0.2FA0.8PbI3 sample set.

Figure of beamed X-ray on crystalline structure

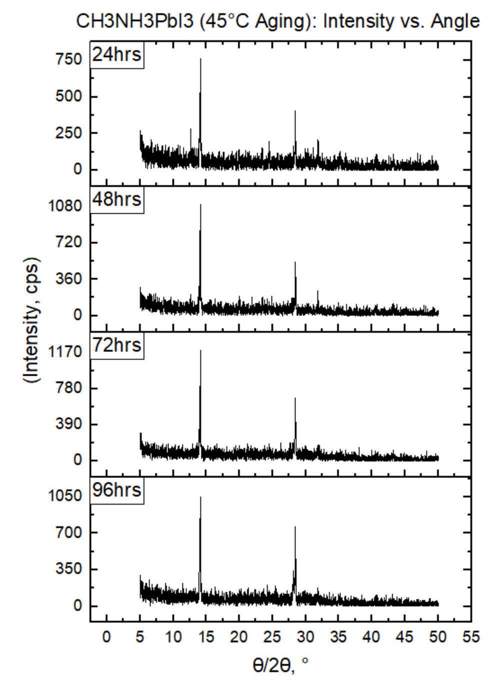


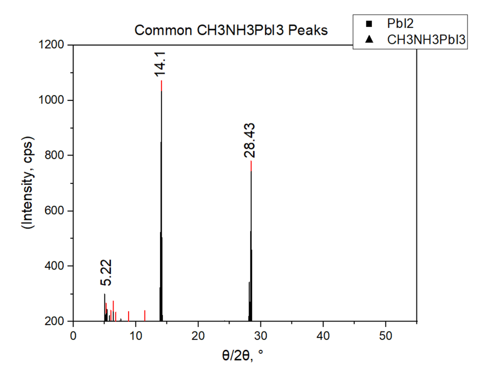
Rigaku X-ray Dffiractometer

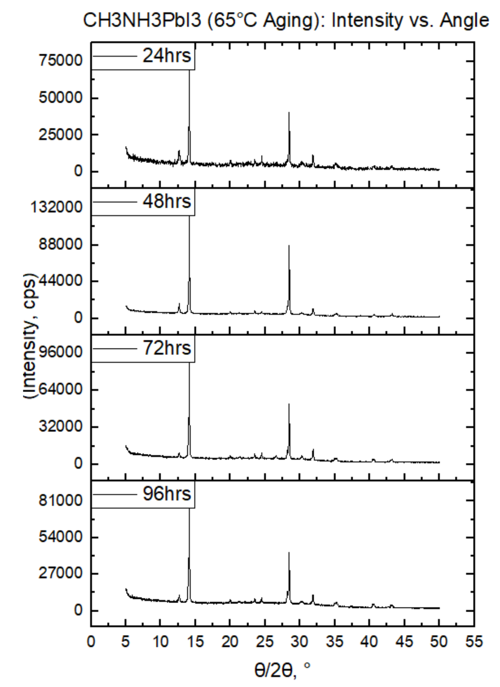
Cs.0.2FA0.8PbI3 Samples

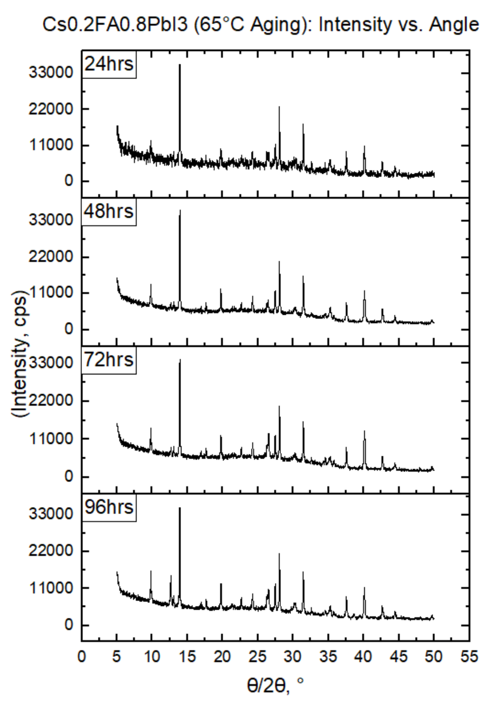


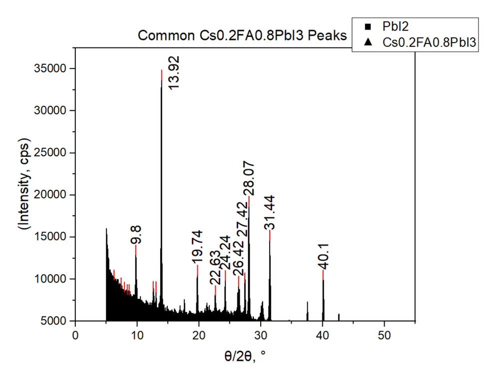
Data/Results

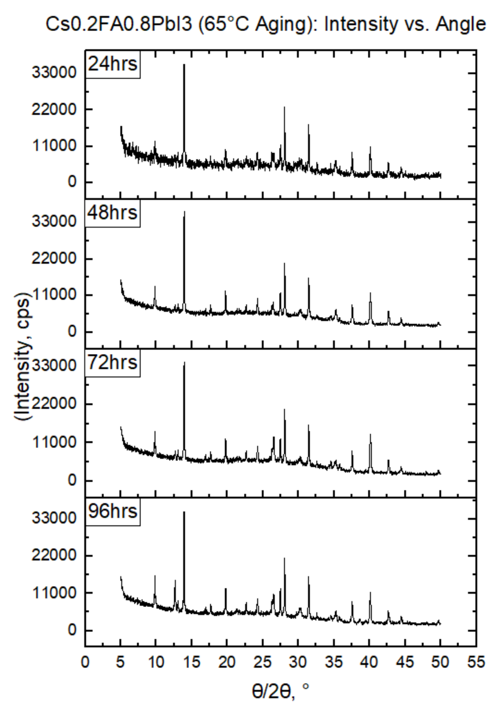












The figures above showcase the intensity spikes of the perovskite samples after aging:

- Figures 1&2 display CH3NH3PbI3 samples that contain 2 layers of a crystalline structure—though both contain smaller peaks. These peaks symbolize the increase in ion migration, as the crystalline structure begins to degrade and lose its layered figure.
- The Cs0.2FA0.8PbI3 samples (Figures 3&4) are similar to that of the graphs from Figures 1&2, with the exception of the Cs0.2FA0.8PbI3 samples naturally containing more layers in the crystalline structure.
- The samples aged in 65°C temperature contain more smaller peaks because the samples degraded at a higher temperature. Likewise, the samples aged longer contain more smaller peaks.

Conclusion

- The perovskite's exposure to heat degrades its crystalline structure—as the ions in the structure migrate rapidly and causes a decrease in absorption. The increase in temperature and the prolongation of time in the heat contributes to the increase of degradation in the crystalline structure.
- Future research may be done to fabricate and alter the composition of perovskites using additives to better its endurance against extreme heat. Research may also be done to characterize perovksites that contain additives to reveal any new features that may contribute to the resistance of heat.

References

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