Hybrid Perovskites for Photovoltaics

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Introduction

As the world transitions towards renewable sources of energy, the need for an affordable yet efficient source is ever increasing to meet the demands of global energy consumption. Hybrid organometallic perovskites have generated tremendous interest over the past 20 years for their photoactive capabilities which have the potential to truly be a disruptive technology owing to their high performance and low cost of production. Perovskites are a relatively new technology in the solar energy field and their meteoric rise in efficiency has been unprecedented compared to other competing technologies. The relatively simple synthesis and the ability to be manufactured through inkjet printing or spin coating makes them a viable economic candidate for mass production and integration into the grid. However, issues surrounding device lifetime stabilities and environmental toxicity remain major obstacles to overcome before they can become a fully integrated technology.

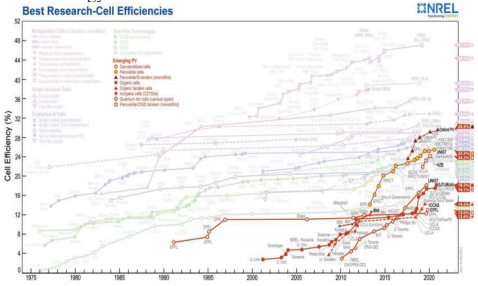

Figure 1. Chart plotting evolution of various cell technologies' efficiencies through time[1].

Hybrid Perovskites

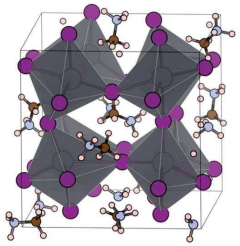

Figure 2. Crystalline structure of $MAPbI_3$ perovskite[2].

Hybrid perovskites are 3D ionic crystalline structures with the generic stoichiometry ABX_3, where A is an organic cation (most often methylammonium, MA^+, or formamidinium, FA^+), B is a transition metal cation (typically Pb^{2+} or Sn^{2+}), and X is a halogen anion (typically Cl^-, Br^-, or I^-). In Figure 2, the MA^+ cation ($CH_3NH_3^+$) is shown between PbI_6 octahedra. In this study, both $MAPbI_3$ and $(Cs_{0.05}MA_{0.16}FA_{0.79})Pb(Br_{0.10}I_{0.90})_3$ (triple cation) were studied.

$MAPbI_3$ Synthesis

Figure 3. Synthesis scheme for $MAPbI_3$[3].

Variables

- Quench
- Deposition type
- Volume deposited
- Spin coater rpm
- Humidity
- Substrate treatment
- Degradation in ambient (O_2)

Results and Discussion

$MAPbI_3$ | Triple Cation

Substrate Adhesion

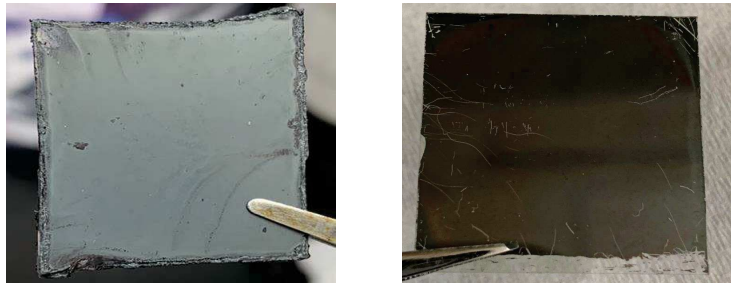

Figure 4. Images of two films. Left: deposition ~15 mins after UV/Ozone etching. Right: deposition immediately after UV/Ozone etching.

Phase Composition

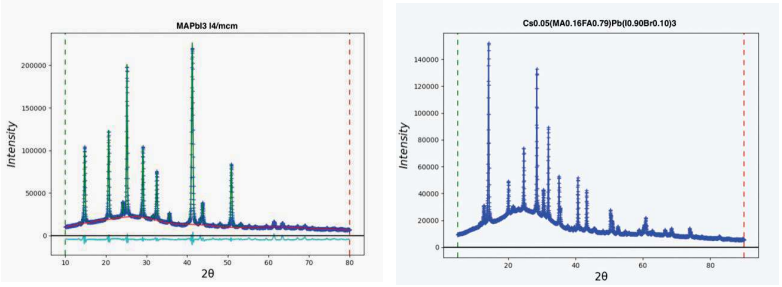

Figure 5. X-ray diffraction (XRD) patterns of perovskite films. Left: BSU. Right: NREL.

Optical Microscopy

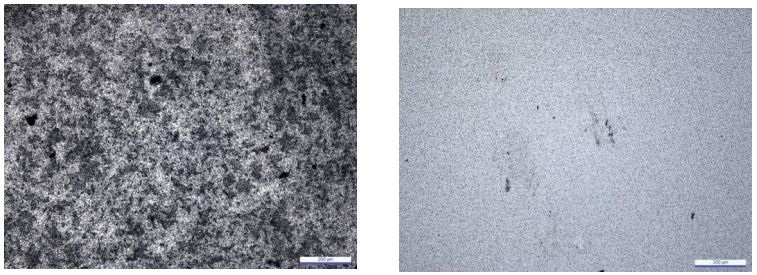

Figure 6. Optical microscopy images of perovskite films. Left: BSU. Right: NREL.

Profilometer

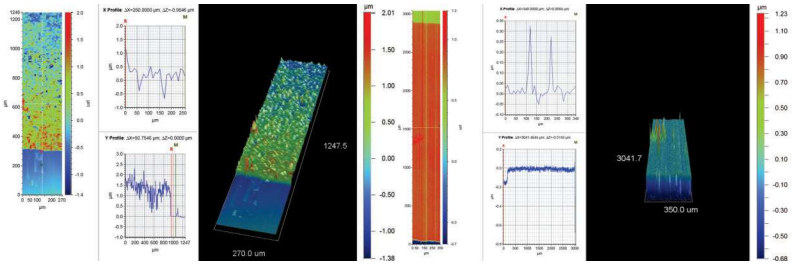

Figure 7. Profilometer data for perovskite films. Left: BSU. Right: NREL.

Future Work

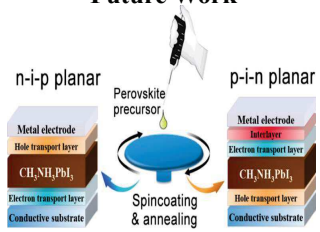

Figure 8. Visual of $MAPbI_3$ device stack structures[4].

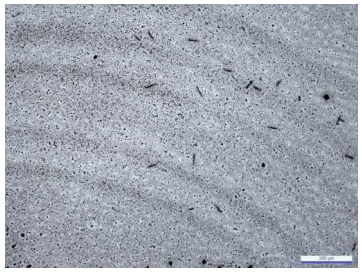

Figure 9. Optical microscopy image of triple cation thin film synthesized at BSU.

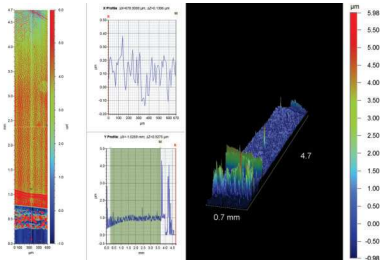

Figure 10. Profilometer data of triple-cation thin film synthesized at BSU.

This project has consisted of fine-tuning the deposition of the perovskite precursor thus far. The primary perovskites that have been investigated and synthesized through this work have been $MAPbI_3$ and $(Cs_{0.05}MA_{0.16}FA_{0.79})Pb(Br_{0.10}I_{0.90})_3$. Further characterization using scanning electron microscopy, UV-vis spectroscopy, x-ray diffraction, Raman spectroscopy, and Fourier Transform infrared spectroscopy will be carried out in-house and provide useful data for overall device architecture, obtaining band gap information from absorbance signatures and determining crystal structure and phase compositions. Once thin film synthetic methodology and accompanying substrate treatment and deposition are yielding homogeneous and pinhole-free thin films, the next step will be the fabrication of devices for photovoltaic applications.

Acknowledgments and References

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