Understanding Effect of Ion Migration Through Correlating Chemical and Ionic Properties in Halide Perovskites

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Research Background

Perovskite Solar Cells (PSC) are considered to be the next–generation solar cell technology.

Key Advantages:

- Higher efficiency
- Lower cost • Flexibility
- Easy manufacturing

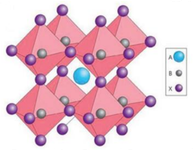


Fig 1: Halide Perovskite Crystal Structure (ABX_3)

Major Challenges: Inherently unstable & degrades faster due to ion migration with light, moisture & heat.

Ion Migration Process in PSC:

- The lattice structure is composed of ions that can move easily.
- In Methyl ammonium Lead Iodide, I^-, MA^+, Pb^{2+} ions migrate when aged under heat.

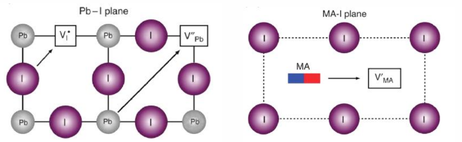


Fig 2: Ion migration in Methyl ammonium Lead Iodide

Glow Discharge Optical Emission Spectroscopy (GD-OES) for PSC

- Very fast technique
- Depth distribution of light to heavy elements
- Information about ion migration during film formation and cell operation
- Aging effect of solar cells

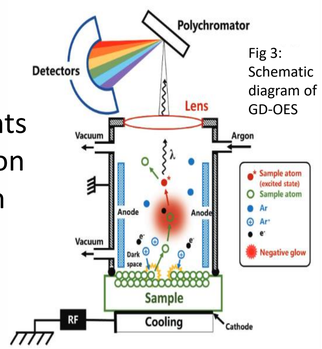


Fig 3: Schematic diagram of GD-OES

Research Objective

To observe and quantify ion migration in Methyl ammonium Lead Iodide (MAPI) Perovskite film by using Glow Discharge Optical Emission Spectroscopy (GD-OES) through elemental depth distribution of the film.

Methodology

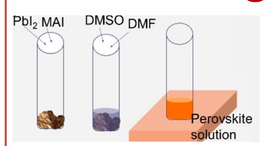
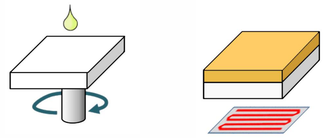
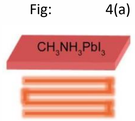


Fig: 4(a)

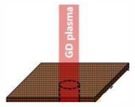


4(b)

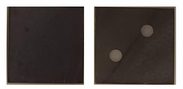
4(c)



4(d)



4(e)



4(f)

4(a): Perovskite Precursor Solution is made with Methyl Ammonium Iodide (MAI) and Lead Iodide (PbI_2) mixed in a solvent of 4:1 Dimethyl Formamide (DMF) and Dimethyl Sulfoxide (DMSO).

4(b): Precursor solution is spun on glass substrate at a speed of 4000 rpm for 30 seconds.

4(c): Annealed at 50 ◦C and then at 100 ◦C for 30 minutes.

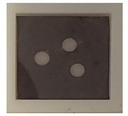
4(d): Aging test at 45°C, 65°C and 85°C for 0 hr, 48 hrs and 96 hrs (using glass slide on top).

4(e): Collected data from GD-OES to determine the movement of ions.

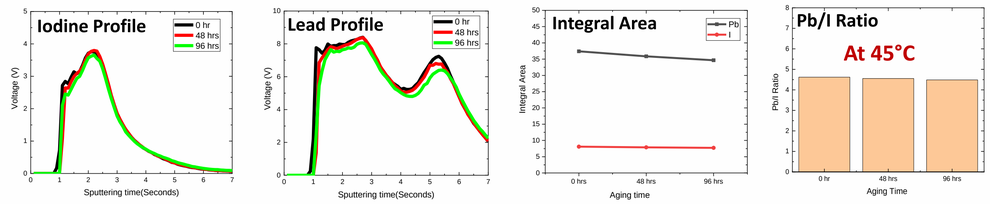
4(f): Images of sample before and after GD-OES.

Experiment Results

At 45°C

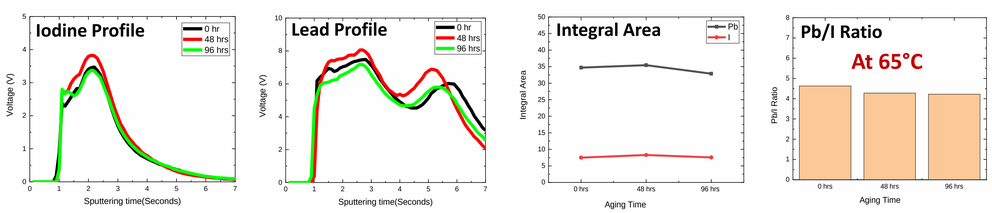


Sample Image(a)



At 65°C

Sample Image(b)



At 85°C

Sample Image(c)

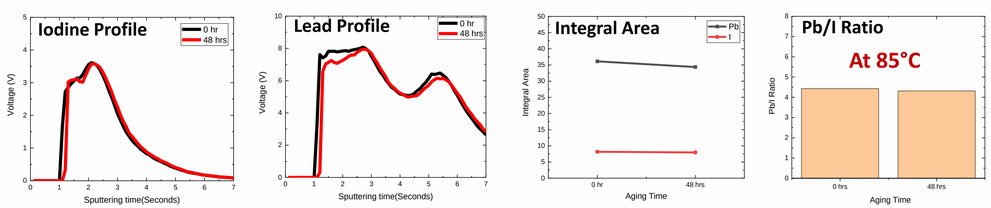


Figure 5: (from left to right) Image of the sample , Iodine profile, Lead profile , Integral area of Lead and Iodine and Lead/Iodine ratio (a) at 45° C (b) at 65° C and (c) at 85° C

Conclusion

GD-OES analysis shows that, at 45° C , 65 °C and 85° C, the composition of the Perovskite films are surprisingly quite stable. Pb/I ratio of the MAPI samples decreases with aging time.

Future Work

- Aging test at 85° C for 96 hours will be performed.
- Additional layers will be added (such as electrodes) to understand interface effects.
- Study of aging mechanism at higher temperature can help to identify the correlation between ionic movement and life span of the Perovskite Solar Cells.

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