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

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+, Pb2+ ions migrate when aged under heat.

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

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

Methodology
4(a): Perovskite Precursor Solution is made with Methyl Ammonium Iodide (MAI) and Lead iodide (PbI2) 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
- Iodine Profile
- Lead Profile
- Integral Area
- Pb/I Ratio

At 65°C
- Iodine Profile
- Lead Profile
- Integral Area
- Pb/I Ratio

At 85°C
- Iodine Profile
- Lead Profile
- Integral Area
- Pb/I Ratio

Figure 1: (from left to right) Image of the sample, iodine profile, lead profile, integral area of iodine and lead 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 MAI 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 ion movement and life span of the Perovskite Solar Cells.

References:

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