Impact of Selected Ionic Liquids on the Properties of Metal Halide Perovskites

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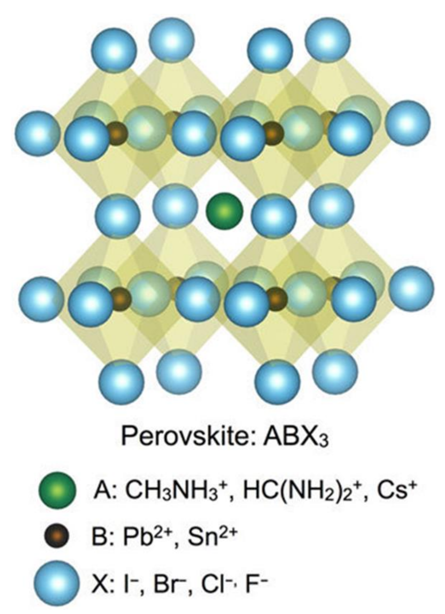
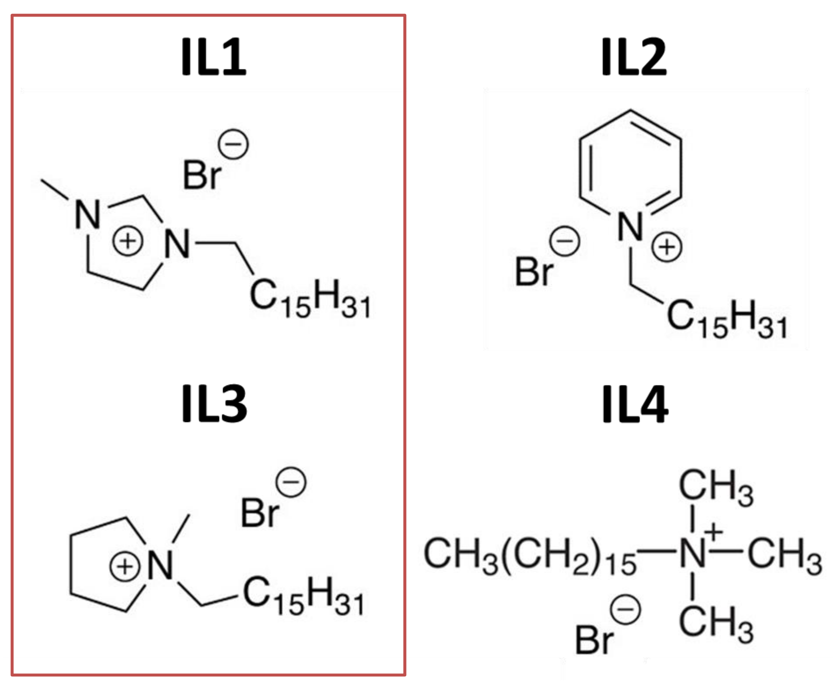
I. Introduction

Metal-halide perovskites are cubic crystalline materials that work as a semiconductor in both Light Emitting Diodes (LEDs) and solar cells. While they are easily fabricated, crystal size and number of defects are challenging to control. One approach to doing so is to use ionic liquids. Ionic liquids compounds made of ions in the liquid state due to a low melting temperature. They can be added to the perovskite precursor solution to slow down the crystallization process so that fewer defects are created. In this project, cetyl-ionic liquids are being investigated for their effects on perovskite structure and light emission. The four ionic liquids being investigated are [C16-mim]Br (referred to as "IL1"), [C16-py]Br ("IL2"), [C16-C1pyrr]Br ("IL3"), and CTAB ("IL4").



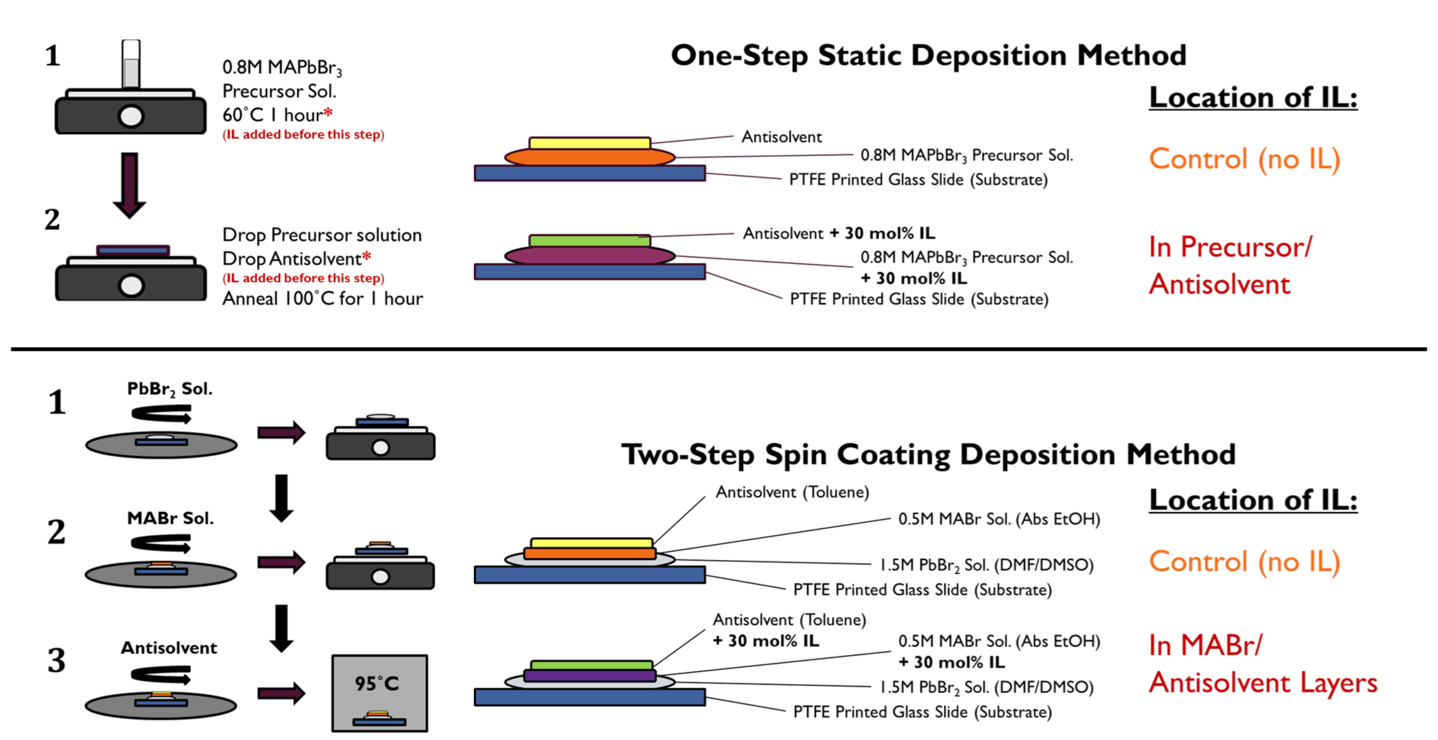


IL= Ionic Liquid
MA= Methylammonium

This presentation will focus on a variation of deposition methods of IL1 and IL3 due to preliminary results suggesting that they are more effective at increasing the photoluminescence of the perovskite films than IL2 and IL4. The goal of this project is to create new metal halide perovskites in the presence of selected ionic liquids and evaluate their structure and photophysical properties, with the long-term goal of creating new LEDs that are both stable and efficient.

II. Experimental

A- Deposition Methods +/- IL

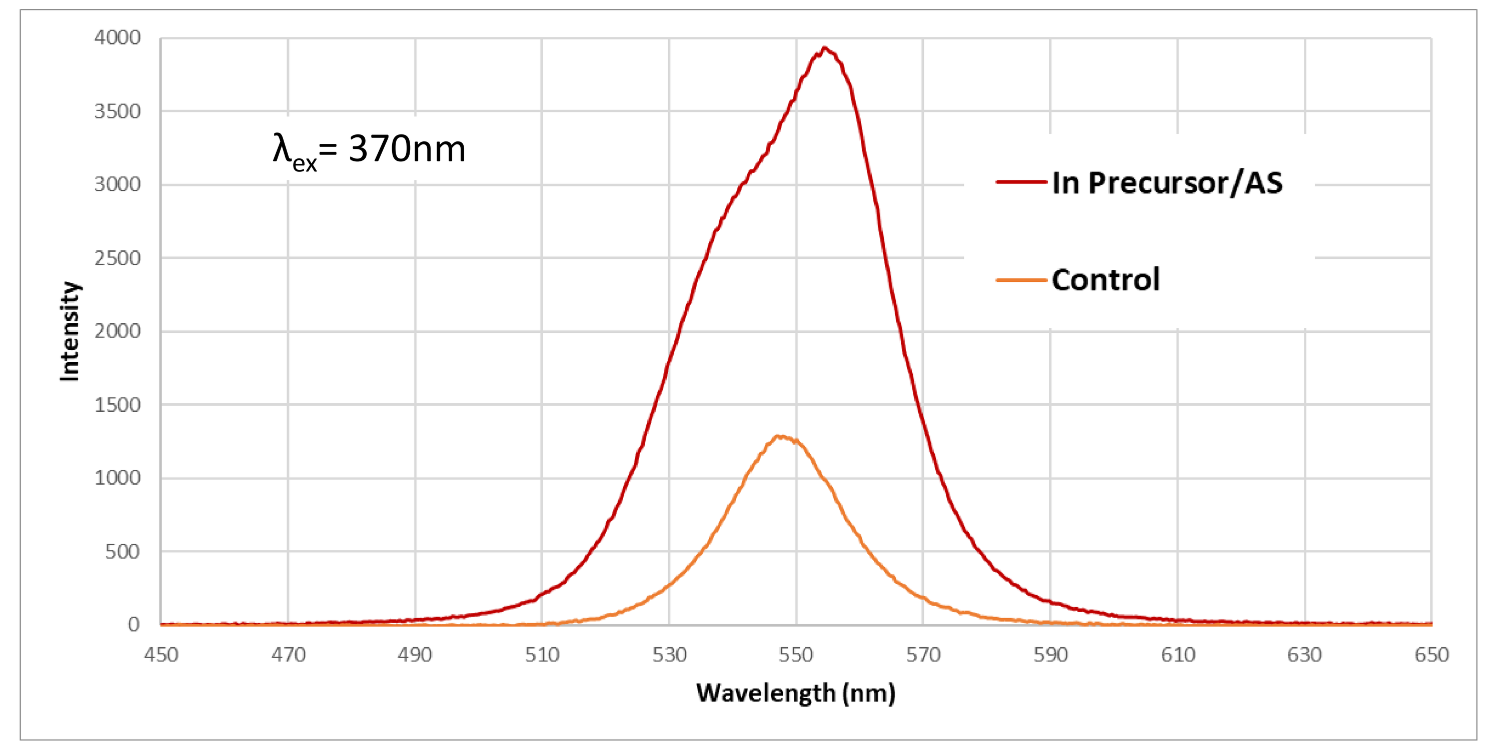


B- MAPbBr3 +/- IL on PTFE patterned glass slide

A- Static In Precursor/AS B- Spin Coat In MABr/AS

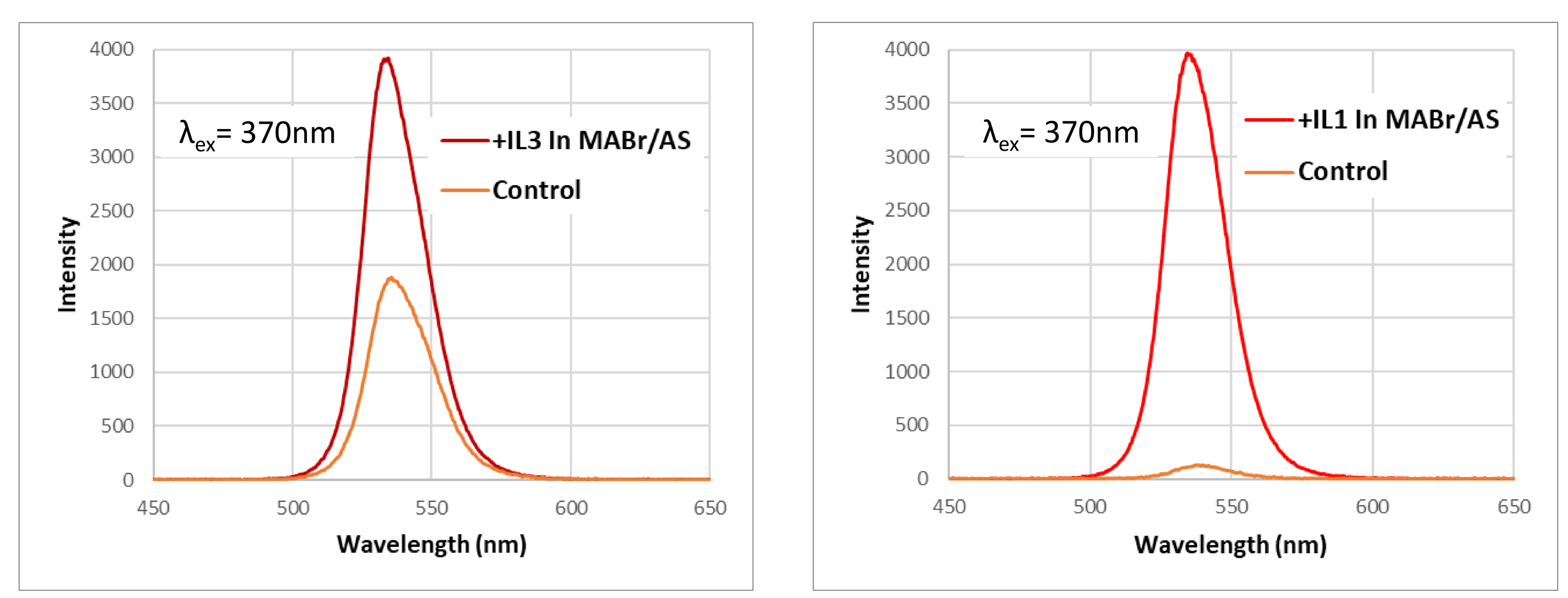
III. Results

Figure 1- Photoluminescence (PL) of $MAPbBr_3$ perovskites +/- IL3 [One Step Static Method]



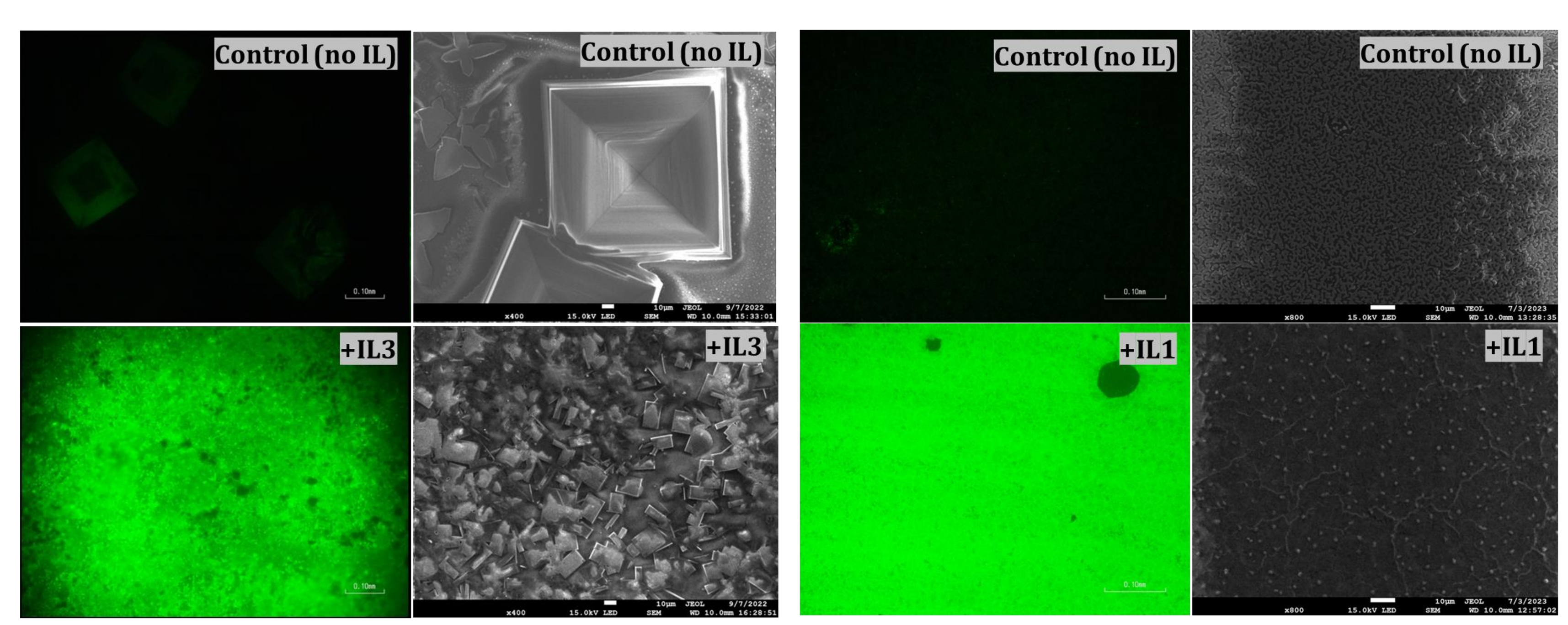
- $MAPbBr_3$ perovskites with IL3 in the precursor and antisolvent layers are more intense (PL) than the control $MAPbBr_3$ perovskites for the One Step Static deposition method.

Figure 2- PL of $MAPbBr_3$ perovskites +/- IL [Two Step Spin Coat Components]



- $MAPbBr_3$ perovskites with IL3/1 in the MABr and Antisolvent layers are more intense (PL) than the control $MAPbBr_3$ perovskites for the Two Step Spin Coating deposition method.

Figure 3- Fluorescent Microscopy and Scanning Electron Microscopy Images of $MAPbBr_3$ perovskites +/- IL [One Step Static and Two Step Spin Coat]



A- $MAPbBr_3$ +/- IL3 One Step Static Method Fluorescent (20x, 0.1mm) SEM (400x, 10μm)

B- $MAPbBr_3$ +/- IL1 Two Step Spin Coat Method Fluorescent (20x, 0.1mm) SEM (800x, 10μm)

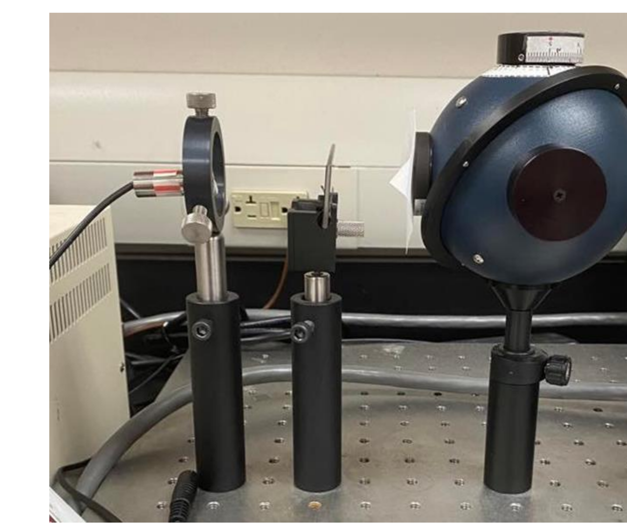
- The addition of IL and the deposition method affects the photoluminescence and morphology of $MAPbBr_3$ perovskites. The smaller macro-cube size and surface smoothness both correlate with an increase in the photoluminescence.

Figure 4- PL Quantum Efficiency (PLQE) Data of $MAPbBr_3$ +/- IL Static vs Spin Coat

Sample	PLQE (%)
Static In Precursor/AS	6.2
Static Control	Not detectable
Spin Coat In MABr/AS	33.0
Spin Coat Control	5.4

$$QE = \frac{A_{em}}{A_B - A_{ex}}$$

Deposition method → Ionic Liquid ↓	Static One-step	Spin Coat Two-Step
IL1 (imidazolium)	Lower PLQE 3%	Higher PLQE 60%
IL3 (pyrrolidinium)	Higher PLQE 6-9%	Lower PLQE 30%



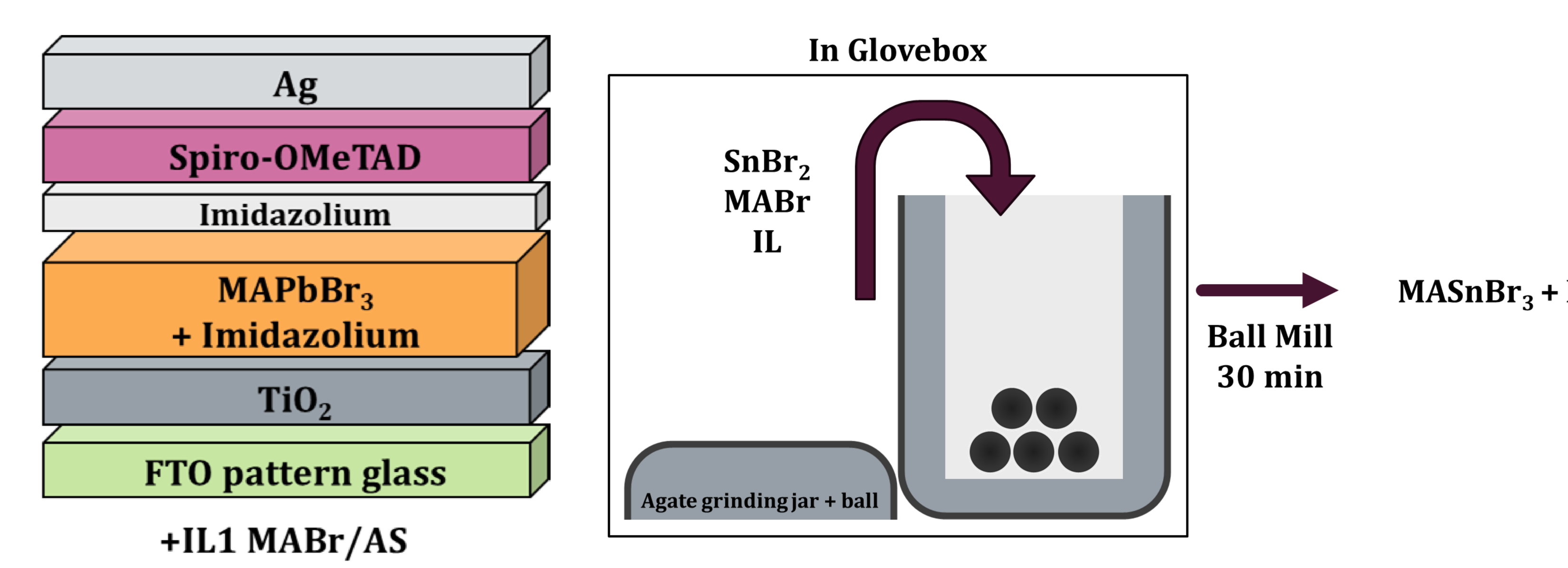
IV. Discussion

- $MAPbBr_3$ perovskites with IL3 in the precursor and antisolvent layers are more intense (PL) than the control $MAPbBr_3$ perovskites for the One Step Static deposition method.
- $MAPbBr_3$ perovskites with IL3/1 in the MABr and Antisolvent layers are more intense (PL) than the control $MAPbBr_3$ perovskites for the Two Step Spin Coating deposition method.
- The addition of IL and the deposition method affects the photoluminescence and morphology of $MAPbBr_3$ perovskites. The smaller macro-cube size and surface smoothness both correlate with an increase in the photoluminescence and PLQE.

V. Future Work

- Applying $MAPbBr_3$ + IL perovskites as an emitting layer in LEDs
- Expand into tin chemistry with $MASnBr_3$ + IL perovskites through mechanosynthesis

Figure 5- Schemes for LED with $MAPbBr_3$ + IL and $MASnBr_3$ mechanosynthesis



VI. References

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VII. Acknowledgments

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