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Exploring Halide Perovskite Structural Tunability to Design Materials for Dynamic Photovoltaic Windows

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Introduction

The structural tunability of halide perovskites offer exciting potential for their use as photovoltaic materials and semiconductors in diverse applications. We investigate 2-D Ruddlesden-Popper (RP) halide perovskite structural stability with the intercalation of methylamine (MA) gas

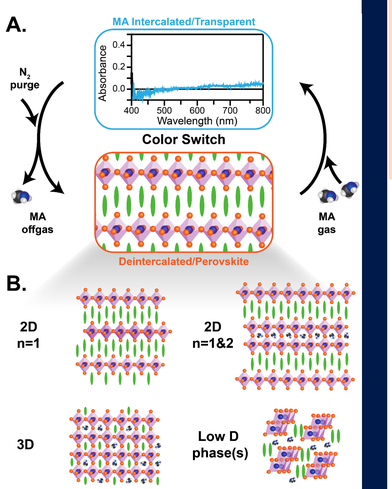

Figure 1. A) methylamine intercalation and deintercalation, structure of 2D halide perovskites. **B)** structural variations as a result of incomplete deintercalation.

Switchable Windows

- Photo-thermal heating can lead to switchable $MAPbI_3$ solar cells in the presence of MA gas
- Switchable PV circumvents the fundamental efficiency-transparency tradeoff of PV windows
- Morphological changes lead to degradation

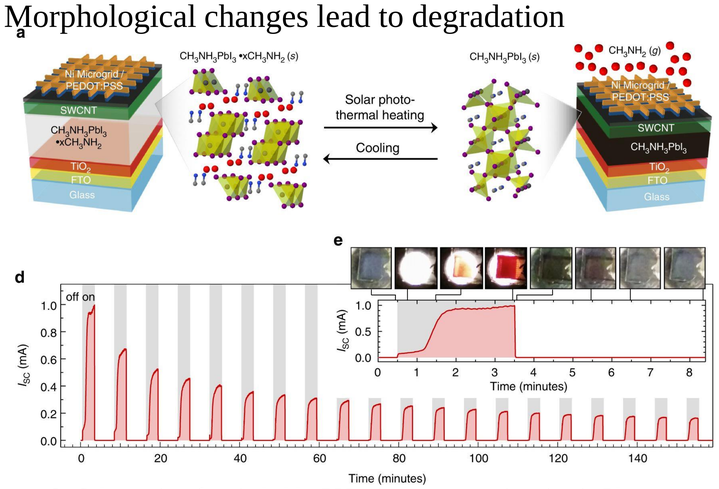

Figure 2. Schematic of switchable PV window operation (top). Photocurrent of devices with time for 20 switches (bottom). From Reference 1.

Goal: Evaluate stability as a consequence of lattice strain between organic spacers and lead halide perovskite sheets

Experiment

- Expose 2-D RP perovskite films to MA vapor to form intercalation compound
- Remove from MA to restore perovskite
- Change A-site in 2D perovskites to vary the lattice strain between the layers and observe the impact on stability.

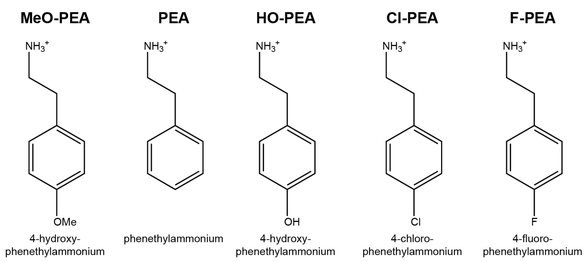

Figure 3. R-PEA organic spacer molecules used for varying lattice strain in 2-D halide perovskites

Key Findings:

- 2D RP perovskites show varying MA retention with varying A-site cations
- R-PEA molecules with R species that cause more lattice strain show improved reversibility when switched

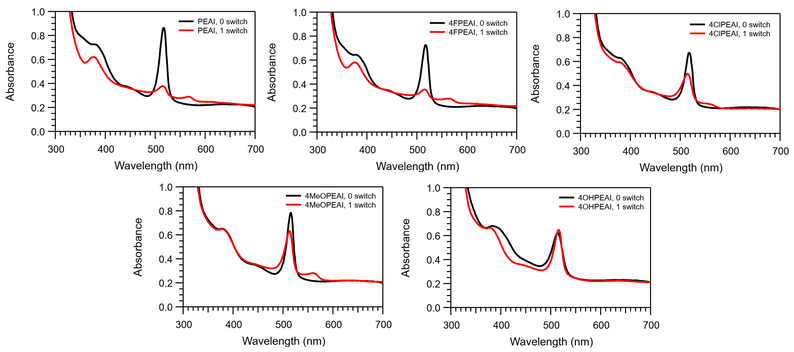

Figure 4. UV-vis traces of 2-D perovskites. From upper left to bottom right: 0 & 1 switch for PEA; 0 & 1 switch for F-PEA; 0 & 1 switch for Cl-PEA; 0 & 1 switch for MeO-PEA; 0 & 1 switch for HO-PEA.

Improved Stability

- Stability gains realized for 2-D materials with more lattice strain between layers an wider bandgap
- Correlation between IM force strength and reversibility

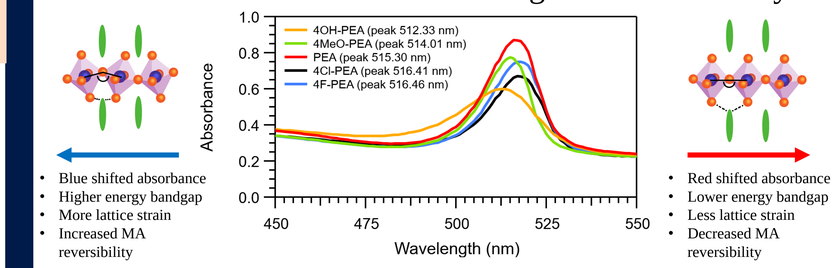

Figure 5. UV-vis trace of 2-D perovskites with various R-PEA spacers and the effect on bandgap and lattice strain

Conclusions

- 2-D RP perovskites show varying MA retention upon MA gas exposure
- Tuning A-site can increase MA intercalation and deintercalation reversibility
- Work continues to investigate the electrochemical relationship between the organic and perovskite layer
- Future work to design better A-site for perovskites for development of switchable PV

References

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Acknowledgements

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