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

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## COLLEGE

# to Design Materials for **Dynamic Photovoltaic Windows**

# **Exploring Halide Perovskite Tunability** Josephine L. Surel, James R. Mandeville, Elizabeth V. Cutlip, Jeffrey A. Christians

### 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 intercalation with the 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.

Α.	MA Intercalated/Transparent	
N <sub>2</sub> purge		600 700 800 ength (nm)
	Color Switch	
$\Lambda$	0.0.0.0	0.0.0
MA		
offgas		
_	Deintercalated	l/Perovskite
B.		
2D n=1		2D n=1&2
3D		Low D phase(s)

## Switchable Windows

- Photo-thermal heating can lead to switchable MAPbI $_3$ solar cells in the presence of MA gas
- Switchable PV circumvents the fundamental efficiencytransparency tradeoff of PV windows
- Morphological changes lead to degradation

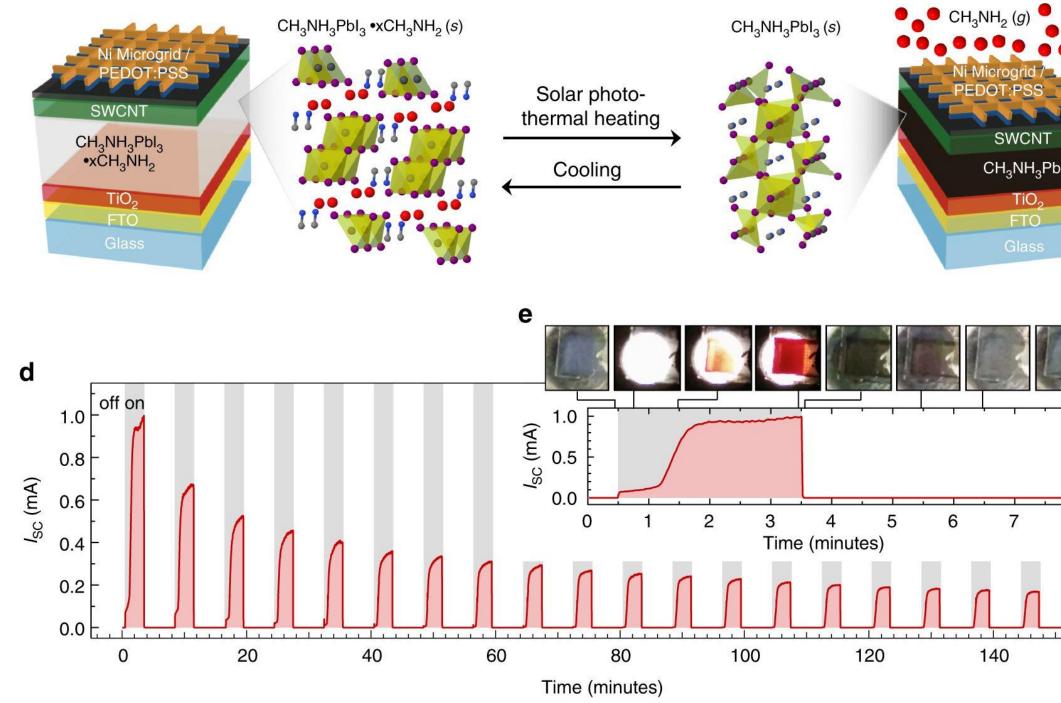
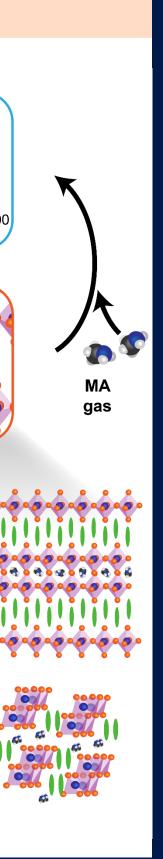


Figure 2. Schematic of switchable PV window operation (top). Photocurrent of devices with time for 20 switches (bottom). From Reference 1.

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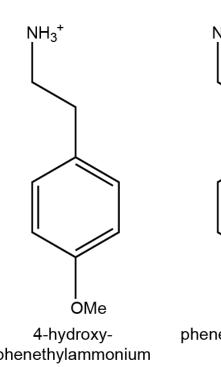


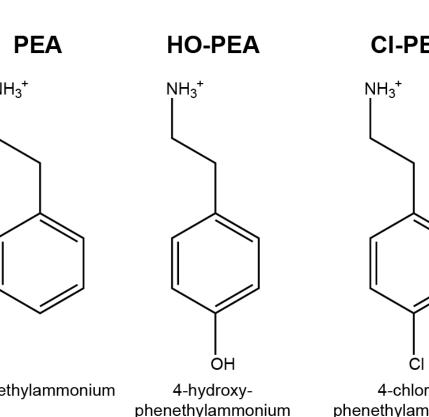
## Goal: Evaluate stability consequence of lattice strain between organic spacers and lead halide perovskite sheets

#### 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. **MeO-PEA**

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

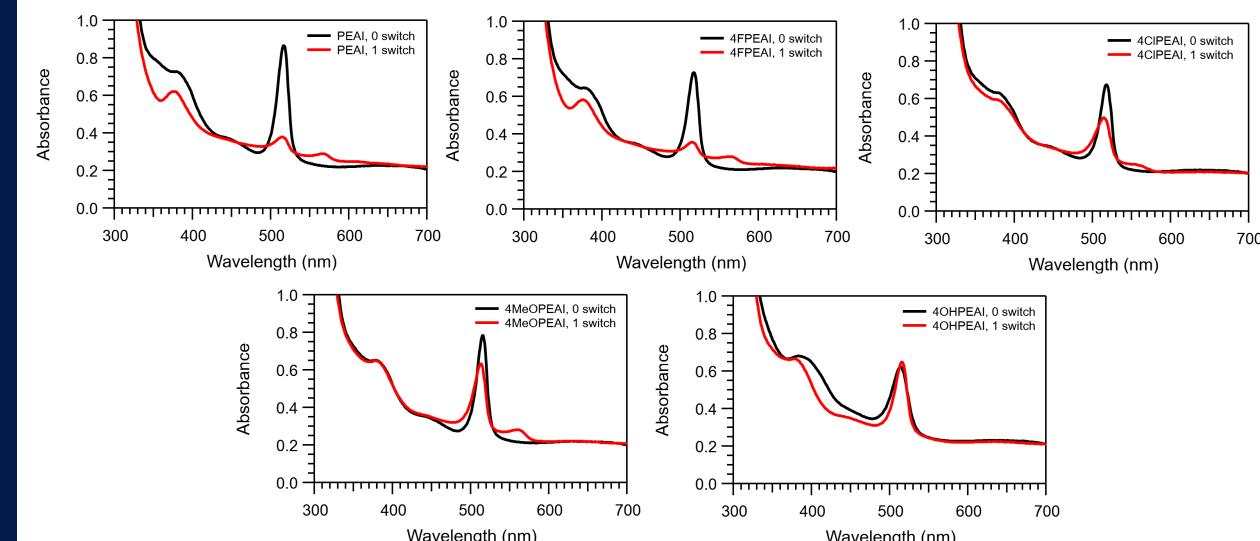
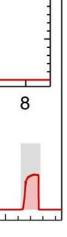
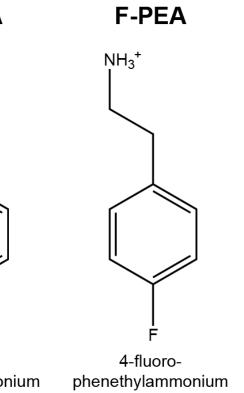


Figure 4. UV-vis traces of 2-D perovskites. From upper left to bottom right: 0 & switch for PEA; 0 & 1 switch for F-PEA; 0 & 1 switch for Cl-PEA; 0 & 1 switch for MeO-PEA; 0 & 1 switch for HO-PEA.



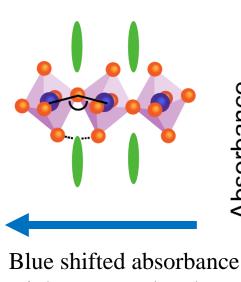
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#### **Improved Stability**

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



- Higher energy bandgap
- More lattice strain
- Increased MA reversibility

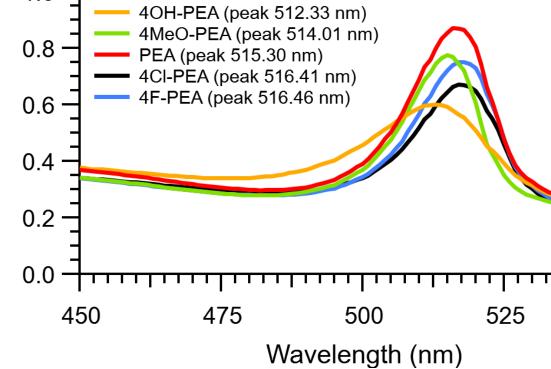


Figure 5. UV-vis trace of 2-D perovskites with various R-PEA spacers and the effect on bandgap and lattice strain

## 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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