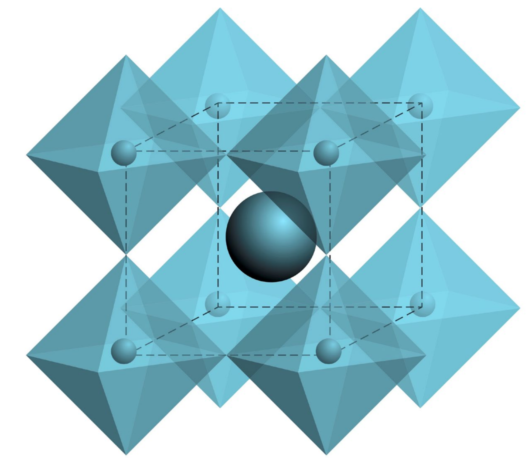
Energy Materials Lab

PI: Dr. Juan-Pablo Correa-Baena

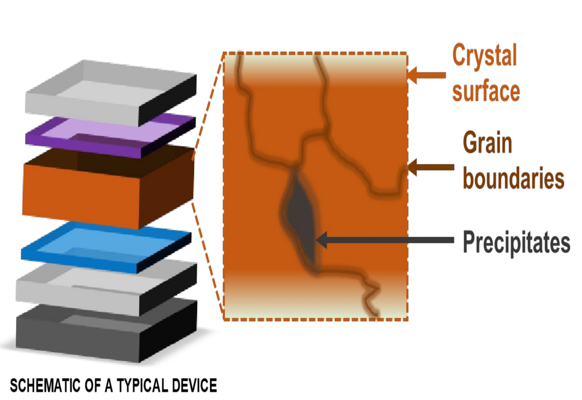


Dr. Juan-Pablo Correa-Baena

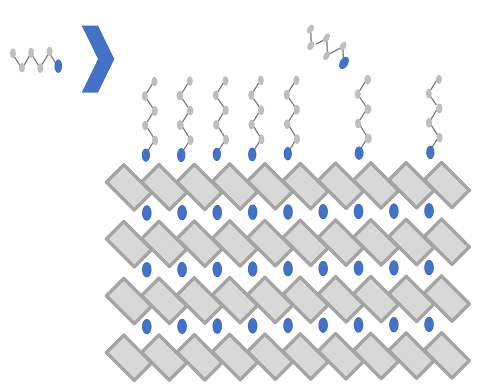
- Juan-Pablo Correa-Baena joined Georgia Tech in the Spring of 2019. His group focuses on the understanding and control of electronic dynamics at the nanoscale for low-cost semiconductors, such as halide perovskites and other materials.
- Juan-Pablo received his PhD from the University of Connecticut, where he studied metal oxide aerogels as porous conductive electrodes for dye-sensitized solar cells, funded by two National Science Foundation fellowships.
- His work as a postdoctoral fellow at the Ecole Polytechnique Fédérale de Lausanne focused on understanding of fundamental questions regarding band alignment at interfaces and their influence on performance in perovskite solar cells.
- His work at MIT shed light onto minority phase formation and elemental distribution in complex, multi-element halide perovskites, which determine the efficiency of the solar cells. His contributions have ultimately helped boost the efficiencies of perovskite solar cells above 25%.

Research Focus

Understand



Design



The role of interfaces and of 2D and 3D defects in low-cost semiconductors

- Advanced X-ray and neutron characterization

Device fabrication with monolayer control and large area uniformity

- Vapor deposition of perovskites and charge extraction layers

Physical Vapor Deposition

- Scalability remains an obstacle towards commercialization of perovskite solar cells (**PSCs**)
- PSCs are composed of many layers traditionally deposited via solution, which poses concerns over toxicity, low solubility of precursors, potential damage to underneath layers, and limited control on thickness
- Our research is focused on fabrication of PSCs by physical vapor deposition: thermal evaporation and atomic layer deposition (**ALD**)
- Thermal evaporation enables deposition on large area, and improved thickness control. Co-evaporation of perovskite precursors allows for control over the resulting stoichiometry
- ALD is a sequential, self-limiting process (**Fig.1**), that allows for angstrom-level thickness control of deposited layers with superior uniformity
- Our group devised a novel ALD process for PbI_2, cheaper and with reduced hazard with respect to existing techniques

Thermal Evaporation | **Atomic Layer Deposition (ALD)**

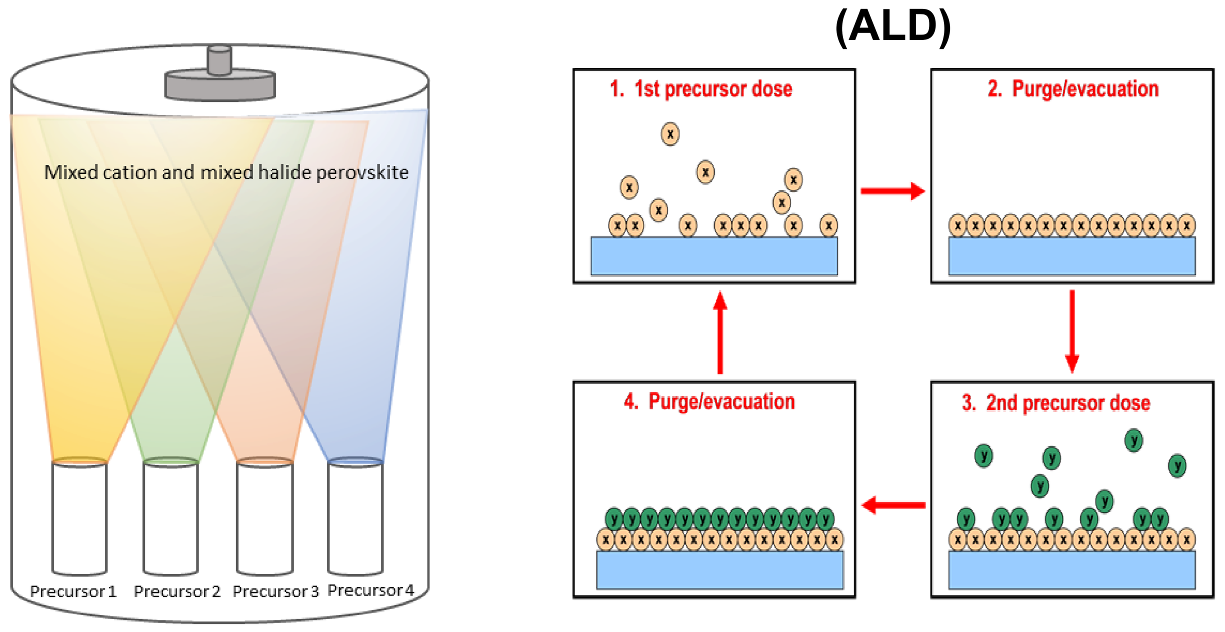


Figure 1. Co-evaporation of mixed cation and mixed halide perovskites (left). Schematics of an ALD deposition process (right)

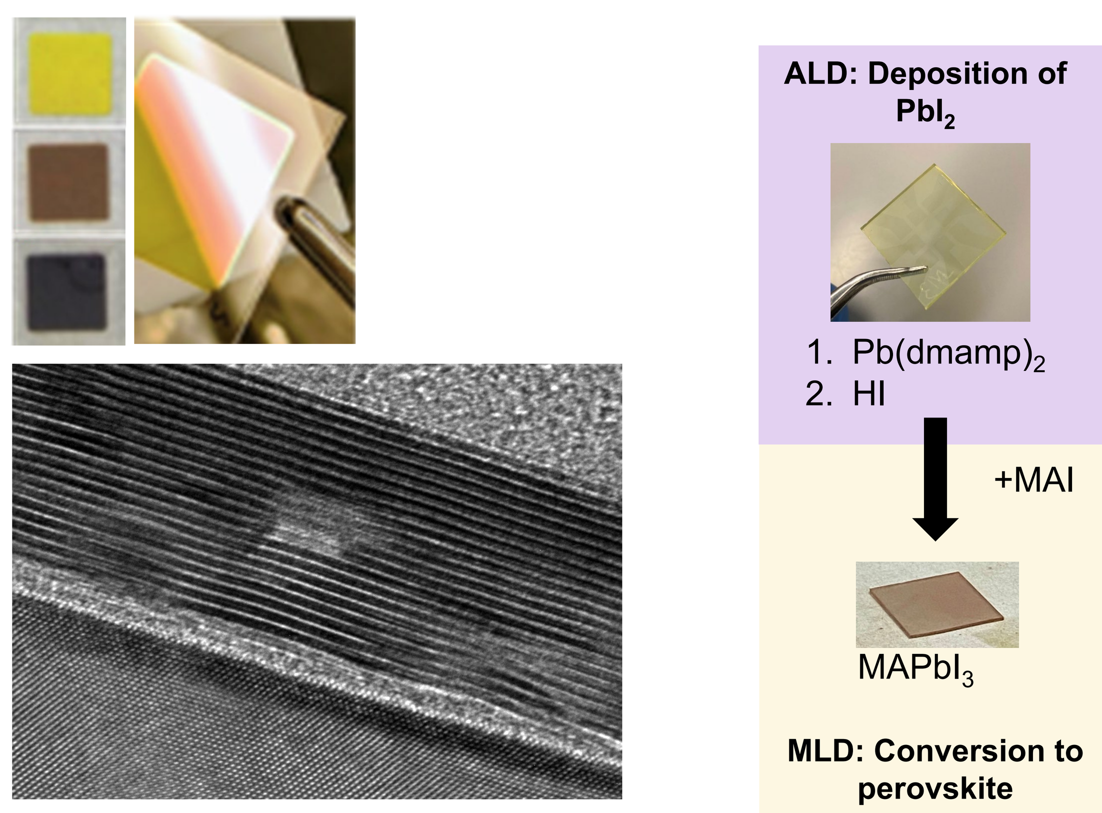


Figure 2. Thermally evaporated perovskite films (Top Left). Schematics of the ALD/MLD process for perovskite deposition (right). TEM image of PbI_2 films via ALD (bottom left)

Efficiency, Stability, Defects

- Poor environmental stability is another factor that hinders PSC commercialization
- Composition engineering has been a very successful approach to enhance both power conversion efficiency and long-term stability
- We control humidity, heat, and light to study the environmental stability of PSCs and its degradation mechanisms

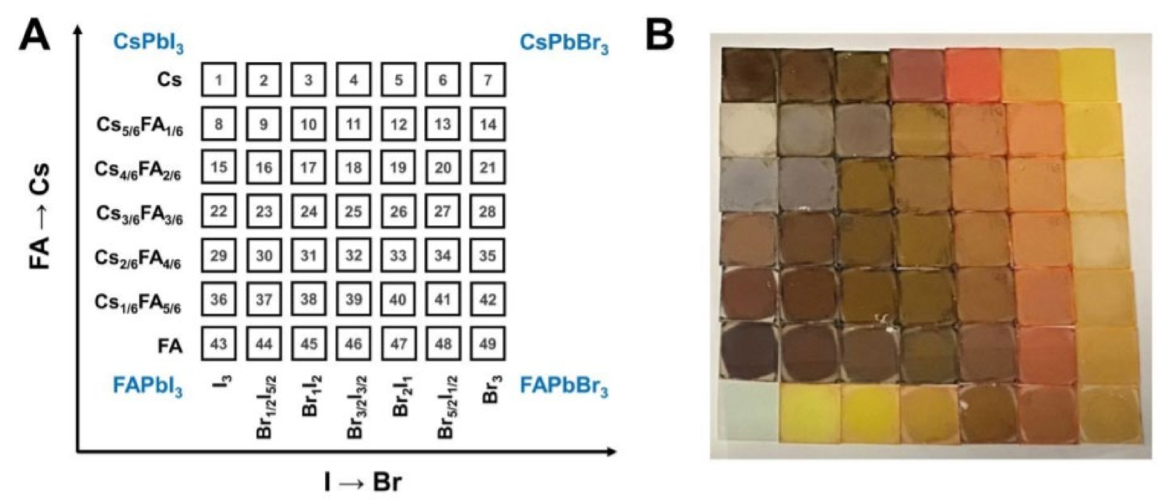


Figure 3. Matrix of $Cs_xFA_{1-x}PbI_yBr_{3-y}$ compositions

- PSCs stability is not only affected by the composition, but also by the presence of defects in the film
- Surfaces are extended defects by definition. As such, they can introduce trap states that lower the solar cell efficiency and lifetime
- We work on understanding the impact of interfaces on the stability and optoelectronic films, and we study methods to passivate defects at those interfaces.

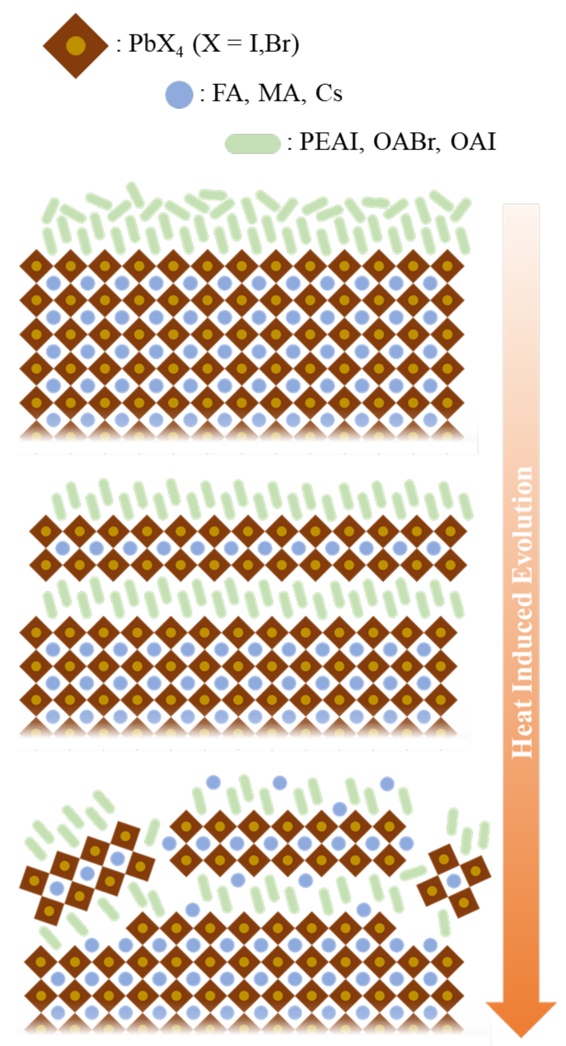
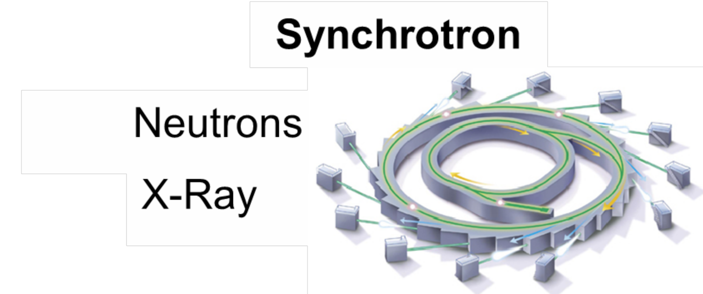


Figure 4. Thermal induced degradation of interfaces treated with bulky cations to passivate surface defects.

Advanced Characterization



TO CORRELATE

Physical Properties

- GIWAXS/GISAXS: Information on crystal structure of materials
- XRF: Elemental distribution
- Neutron Diffraction: Chemical State/Bonding

Performed *In-situ* to monitor changes due to environmental conditions

Electrical Properties

- XBIC: Distribution of currents
- JV and MPP: Efficiency and stability of PSCs

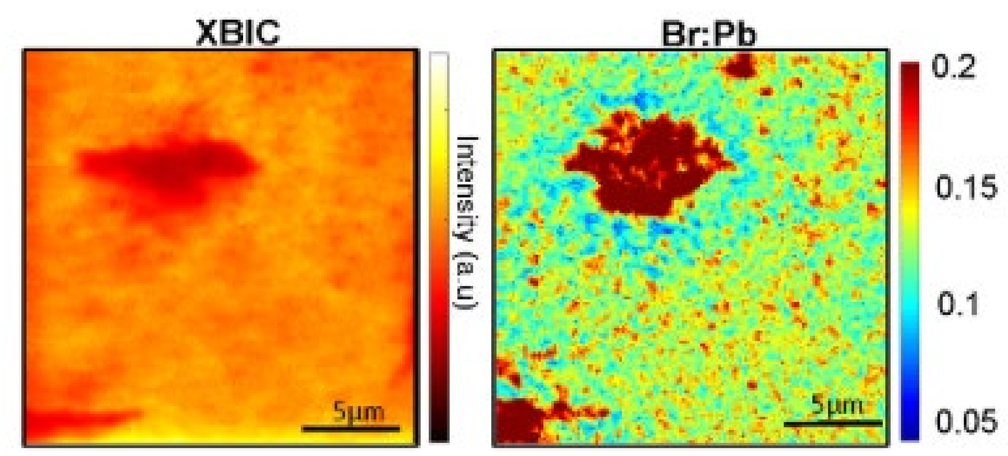
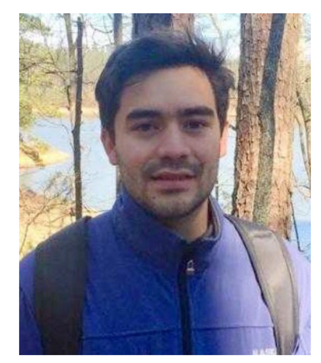


Figure 5. Correlating XBIC current map and XRF elemental distribution in a CsMAFA perovskite film

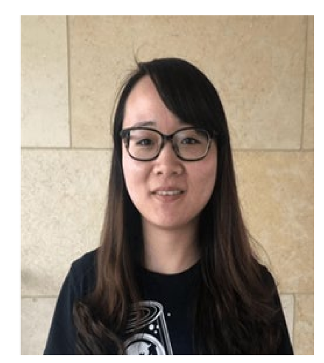
The group

Carlo Perini

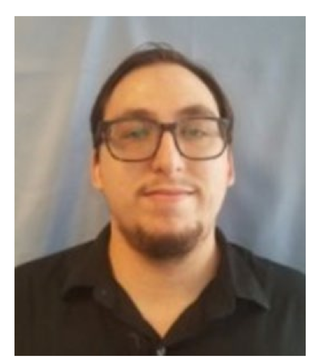
Juanita Hidalgo



Andrés Felipe Castro Méndez



Jingwei Yang



Jake Vagott

Diana LaFollette

Sanggyun Kim

Martin Gomez Dominguez