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Understanding the Role Thin Film Interfaces Play in Solar Cell Performance and Stability

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AIM: Improve stability of perovskite and Si solar cells through optimization of the metal oxide/thin film interfaces.

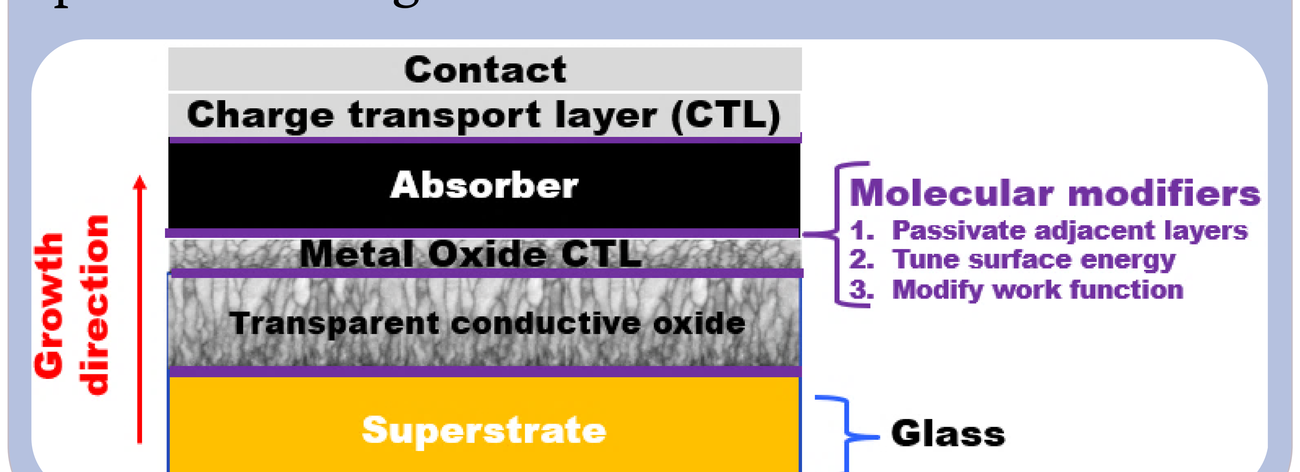
Film Studies and Device Performance

- Interfacial modification/structure affect:
  - Film uniformity
  - Crystallinity
  - Grain size
  - Defect density

Modifier	Stack Structure	V_{oc} [V]	J_{sc} [mA cm^{-2}]	PCE [%]
Bromobenzoic Acid (**Br-BA**) [2]	ITO/NiO_x/$MAPbI_3$/PCBM /bis-C_{60}/Ag	1.07	19.1	15.3
	ITO/NiO_x/**Br-BA** /$MAPbI_3$/PCBM/bis-C_{60}/Ag	1.11	21.7	18.4
(3-Aminopropyl) triethoxysilane (**APTES**) [3]	FTO/SnO_2/$MAPbI_3$ /Spiro-OMeTAD/Au	1.07	20.84	14.69
	FTO/SnO_2/**APTES**/ $MAPbI_3$ /Spiro-OMeTAD/Au	1.16	21.23	17.03
Naphthalene-imide Self-assembled Monolayer (**NMI**) [4]	ITO/ $Cs_{0.05}FA_{0.8}MA_{0.15}PbI_{2.5}Br_{0.5}$/ Spiro-OMeTAD/Au	1.00	18.3	11.5
	ITO/**NMI**/ $Cs_{0.05}FA_{0.8}MA_{0.15}PbI_{2.5}Br_{0.5}$/ Spiro-OMeTAD/Au	1.03	20.0	12.6

Approach

Deposition of $MAPbI_3$ on bare and silane-modified substrates to systematically investigate effects of TCO and interlayers on perovskite degradation.



a-Si:H/TCO Films

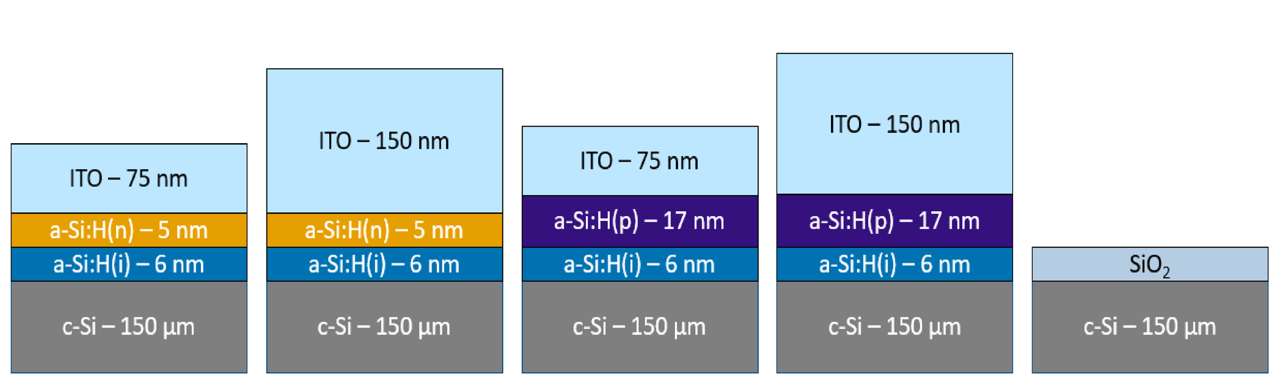
Silicon heterojunction PV among most efficient industrial-scale PV.

Goals:

- Decouple effects of encapsulation degradation from stack deterioration
- Rapid screening process for unencapsulated cells to probe fabrication variables

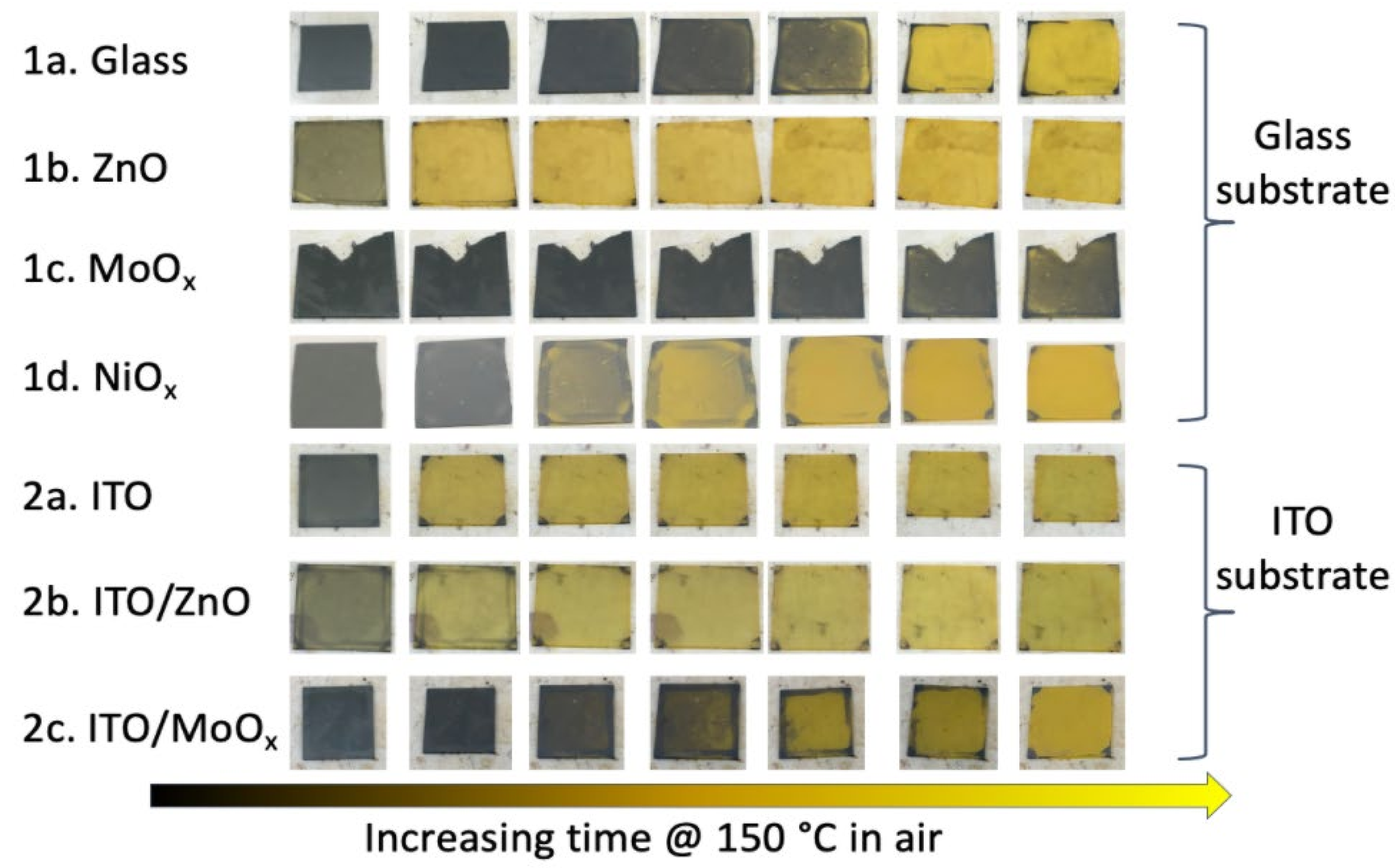
Focus on UV-induced degradation of film stacks:

- Step-wise aging study
- ToF-SIMS, XPS, spectroscopic ellipsometry
- Tracking hydrogen transport



Pb-Based Perovskite Films

- Emerging PV absorber – record devices over 20% efficient [1]
- Moisture and temperature sensitive
  - Complex effects of aging on multilayer systems



Results

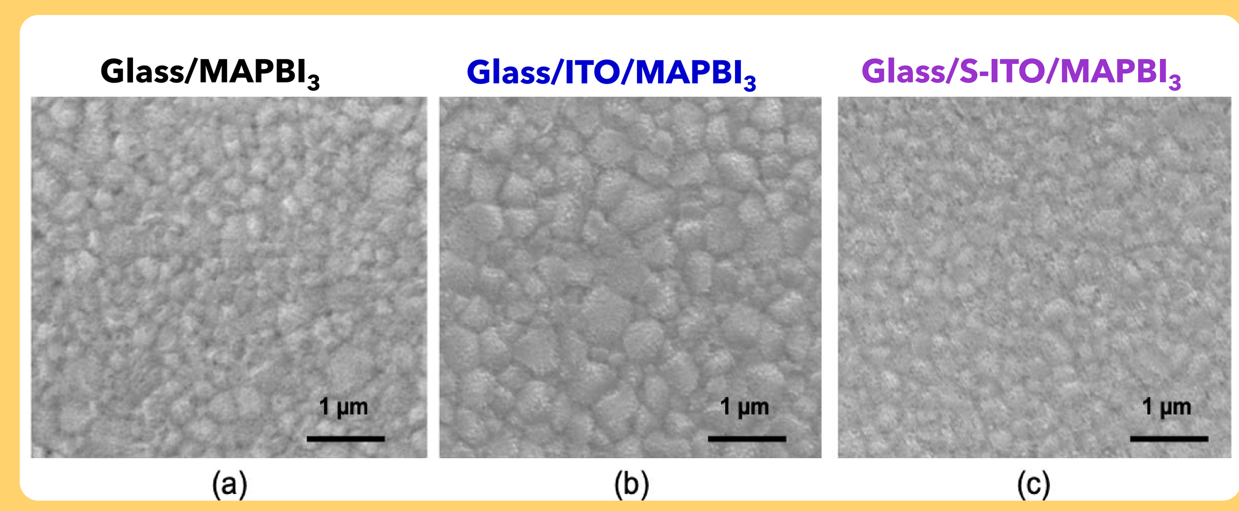
BPTMS passivates perovskite/TCO interface, affecting morphology and degradation profile.

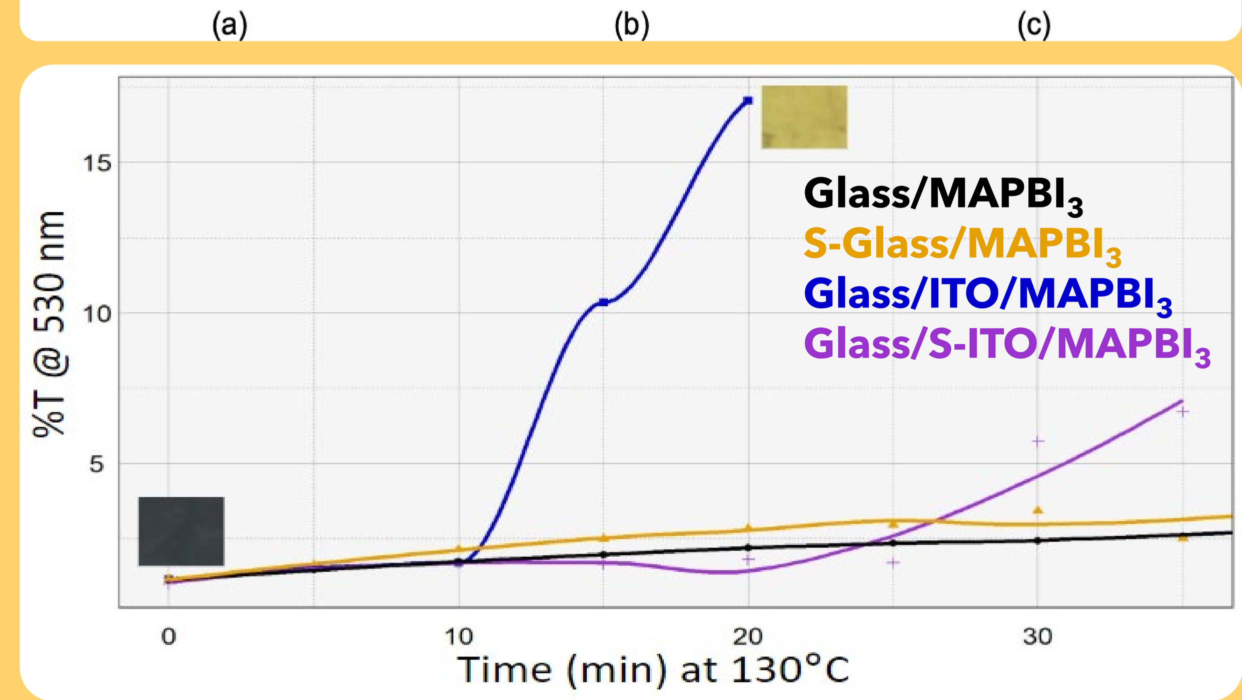
$MAPbI_3$ Grain Growth:

- BPTMS modification leads to smaller grains on ITO
- Grains on S-ITO comparable to those grown on glass

$MAPbI_3$ Degradation:

- BPTMS mitigates degradation on ITO compared to control
- Decouples effects of grain size from interfacial chemistry





Conclusions and Next Steps

Results highlight importance of film studies under device-relevant conditions.

- Organofunctional silanes can be used as molecular modifiers to passivate a TCO/perovskite interface
- Interfaces/interfacial modifiers have multifaceted effects on film morphology and lifetime

Future work:

- ToF-SIMS to track differences in atomic composition profiles through samples with and without silane layers

Contact

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