Vanadium Oxide Interfacial Layer in Perovskite Solar Cells for High Temperature Operational Stability of Unencapsulated Devices in Air

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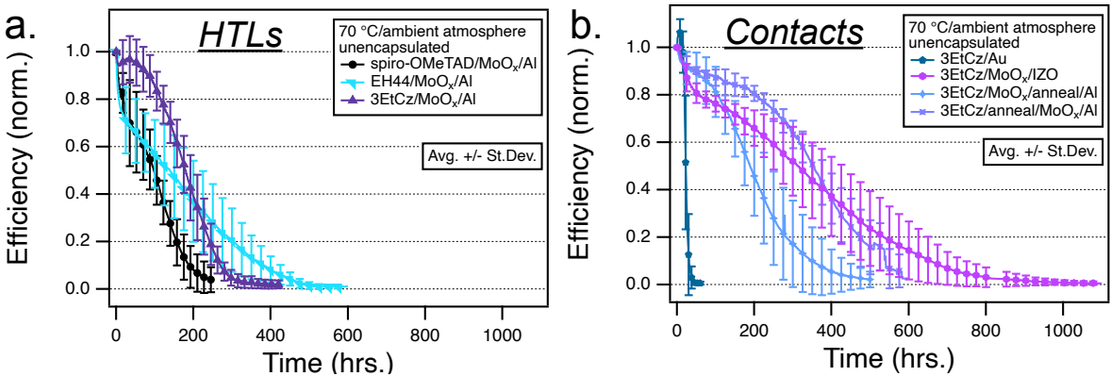
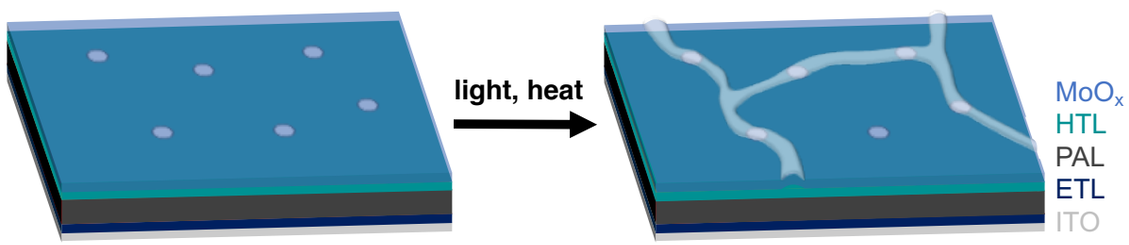
Goals Uncover Degradation Pathway to Improve Operational Durability at Elevated Temperatures



Our most stable device architectures fail when degraded at 70 °C, and the PCE losses correlate with J_{sc} losses.

The device PCE over time for unencapsulated devices with various HTLs and top contacts.
Architecture: ITO/SnO_2/$(FA_{0.79}MA_{0.16}Cs_{0.05})_{0.97}Pb(I_{0.84}Br_{0.16})_{2.97}$/HTL/Metal Oxide/Contact
Aging Conditions: 70 °C under constant illumination, constant load (510 ohms), JV scan every 30 minutes, and exposed to laboratory atmosphere (30-50% RH)

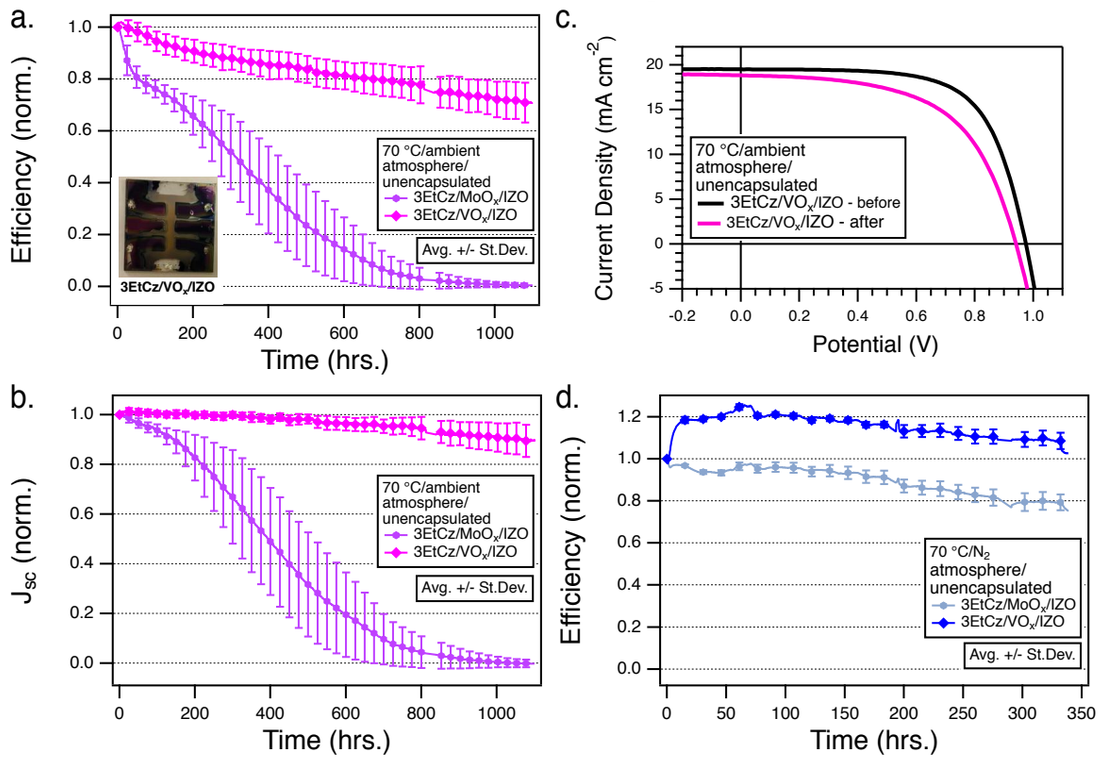
Degradation Pathway The HTL/MoO_x Interface is Morphologically Unstable at Elevated Temperatures



The HTL/MoO_x interface is unstable at high temperatures. During device operation, this leads to wrinkling and delamination, which is consistent with observed J_{sc} losses.

We tested many hypotheses to elucidate the origin of the interface instability, such as interfacial chemistry. We conclude that nanoscopic pores on the organic HTL act as nucleation sites for MoO_x to buckle.

A Solution & Conclusion Replace MoO_x with VO_x



- ***When MoO_x is replaced with VO_x, a metal oxide that is more morphologically robust on top of the organic HTL, operational stability is dramatically improved.***
- ***Unencapsulated devices with a VO_x interlayer aged for 1100 hours under constant illumination and load in ambient atmosphere (30-50% RH) maintain 71% initial PCE on average when measured at 70 °C.***
- ***Assessing interface stability under multiple conditions matters!***

(a) PCE and (b) J_{sc} over time for unencapsulated devices with 3EtCz-based HTL and various contacts tested at an elevated temperature of 70 °C under constant illumination, constant load, JV scan every 30 minutes, and exposed to ambient atmosphere. Inset panel a: photograph of aged device with 3EtCz/VO_x/IZO.(c) Champion current density-voltage scans of an unencapsulated device with 3EtCz/VO_x before and after 1100 hours of aging in ambient atmosphere and measured at room temperature under nitrogen. (d) PCE over time for unencapsulated devices with 3EtCz-based HTL and various contacts tested at an elevated temperature of 70 °C under constant illumination, constant load, JV scan every 30 minutes, and exposed to nitrogen atmosphere.