

***In situ* TEM characterization of a working perovskite solar cell**

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The development of a full understanding of local variations in the electrical performance of hybrid organic-inorganic perovskite solar cells is of critical importance, as both the current stability and the ability to scale up solar cell devices are highly dependent on film quality and homogeneity. *In situ* experiments in a transmission electron microscope (TEM) allow the local electrical properties of such solar cells to be probed at the nanoscale and correlated with their microstructure and chemical composition.

Here, we report for the first time *in situ* TEM measurements of an electrically biased perovskite solar cell in plan view geometry. Layer deposition onto the MEMS TEM support and transfer to the TEM were made without exposing the perovskite layer to air, in order to prevent degradation. The electrically biased solar cell (Fig. 1a) was characterized using several different electron microscope (EM) techniques (Figs. 1 b-f). We observed a strong correlation between an electron beam-induced current (EBIC) signal recorded in the TEM and a secondary electron signal recorded in a scanning EM (SEM). Cross-sectional X-ray maps and associated scanning TEM (STEM) images of the same device are shown in Figs. 1 g-i. This unique combination of techniques is expected to reveal correlations between the exceptional electrical and structural properties and local variations in chemical composition in such solar cells.

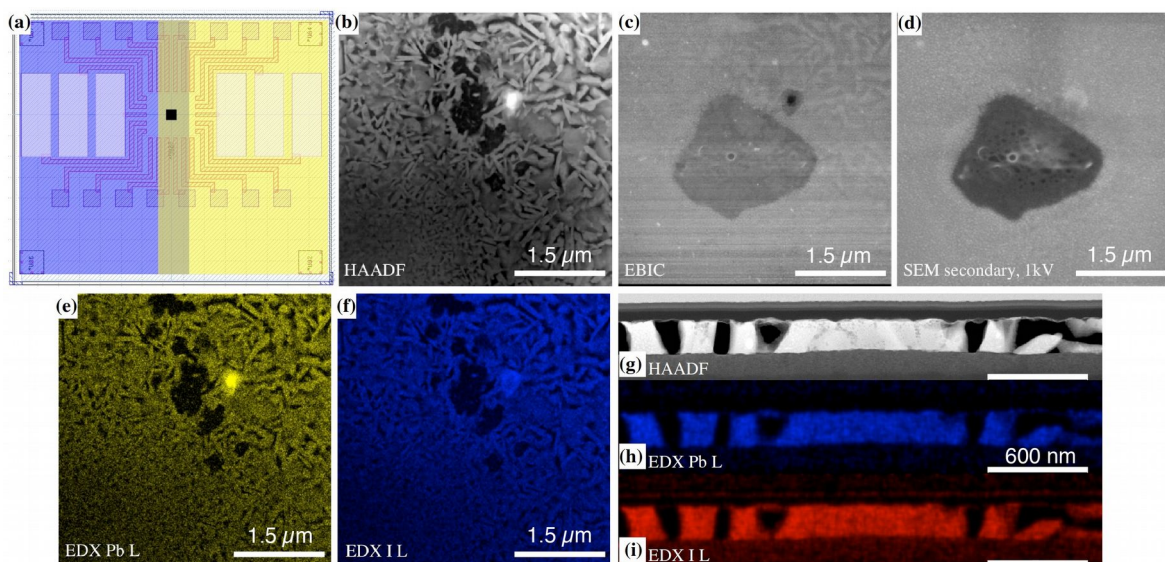


Figure 1: (a) Diagram of the solar cell deposited onto a custom-made MEMS TEM support. The blue rectangle shows the position of the bottom Al contact, PCBM, perovskite and PEDOT layers. The yellow rectangle shows the position of the Ag layer. The region where they overlap contains all of the layers, i.e., a perovskite solar cell. The black square is an electron transparent SiN_x window where EM observations were performed. (b-f) Images from the plan-view sample shown in (a) acquired using different imaging modes. (g-i) Cross-sectional STEM images and X-ray maps of the area shown in (b-f).