Electronic Supplementary Material (ESI) for Energy & Environmental Science.

How the Formation of Interfacial Charge Causes Hysteresis in Perovskite Solar Cells

Supporting Information

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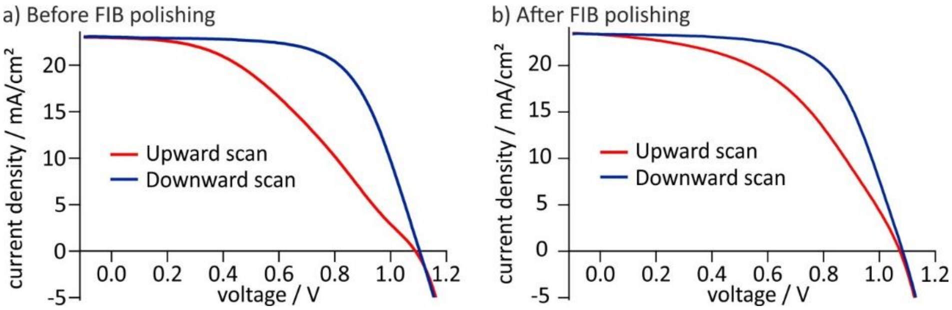
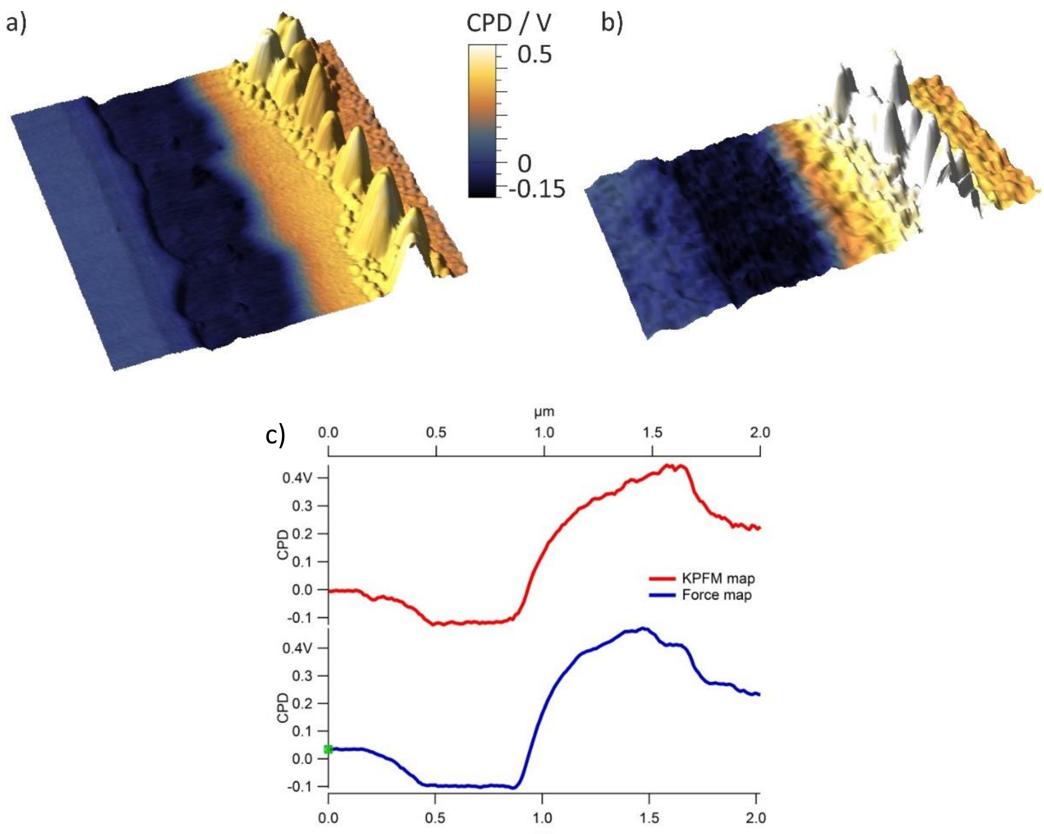
S1: Current-Voltage curves before and after the cross section preparation



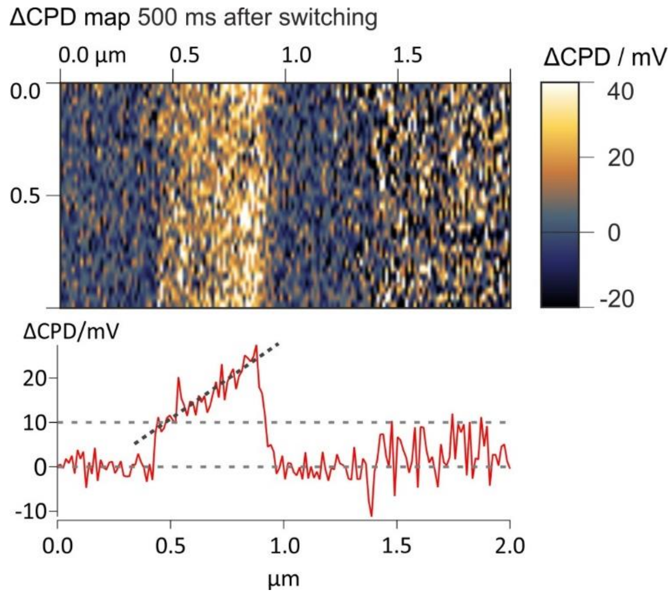
Supporting Figure 1: Current density vs voltage curves recorded at a rate of 130 mV/s before (a) and after (b) the FIB treatment. Maximum efficiencies were a) upward scan: 10%, downward scan: 16.4% and b) upward scan 12.2% and downward scan: 16.5%. Measurements were done under 1 sun, AM1.5 conditions with a mask of 0.16 cm² (a) and 0.08 cm² (b) aperture.

S2: Comparison KPFM-trKPFM



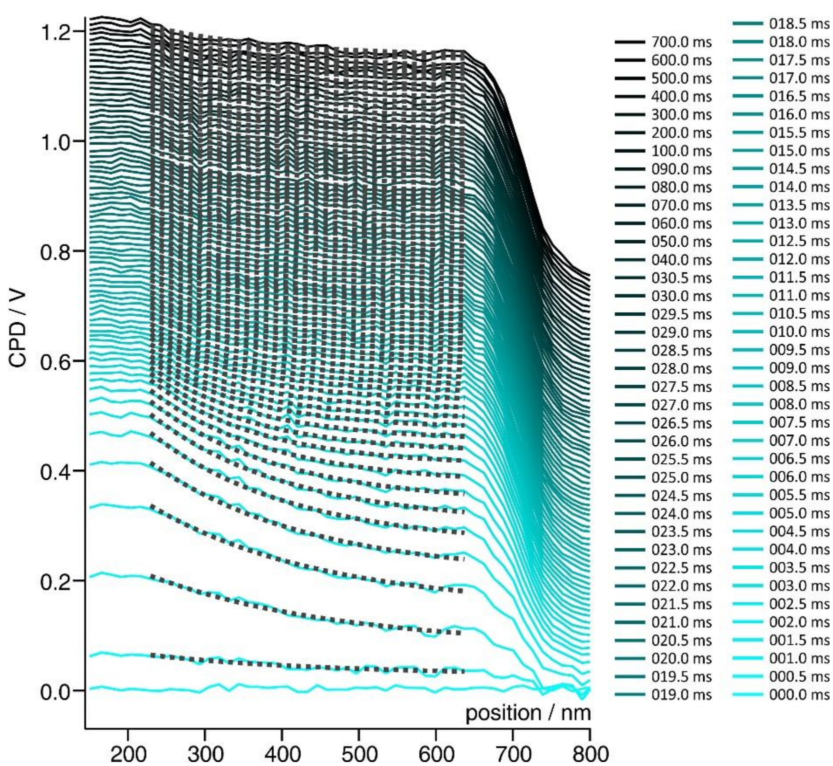
Supporting Figure 2: SFM topography/ CPD overlay for and a) conventional KPFM and b) tr-KPFM, recorded using the same tip on a different position on the cross section. c) Section graphs for conventional KPFM (red) and tr-KPFM (blue). Both methods reveal a field-free perovskite layer. The potential gradient on the FTO electrode could originate from a doping gradient in the tin oxide.

S3: Residual potential after voltage pulse

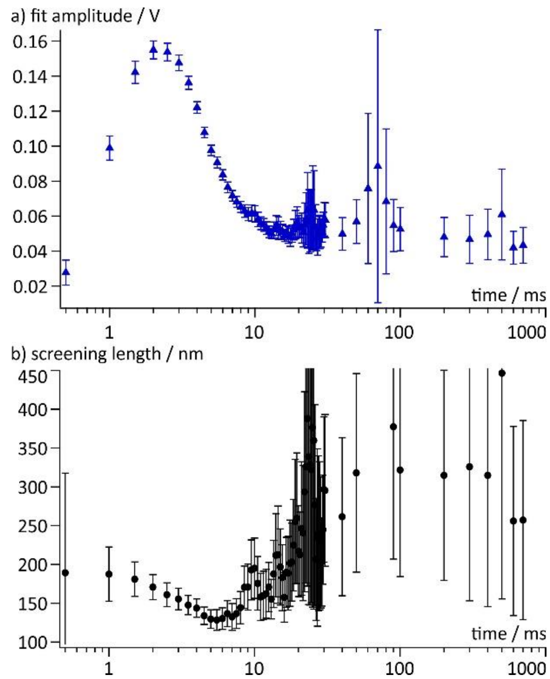


Supporting Figure 3: b) Residual potential offset of 10 mV 500 ms after switching. The potential inside the perovskite layer is still linear without any blurring in the space charge layer, further supporting the assumption of localized charges at the interfaces instead of diffuse charges in the perovskite layer.

S3: Exponential fits to potential profiles

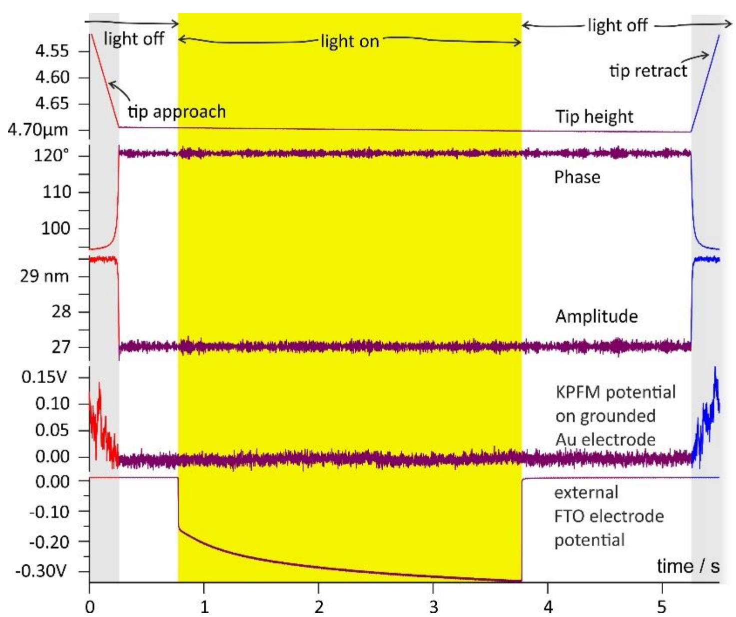


Supporting Figure 3: Potential profiles with exponential fits used for calculating the charge density in Figure 5 (profiles were vertically shifted for better visibility).

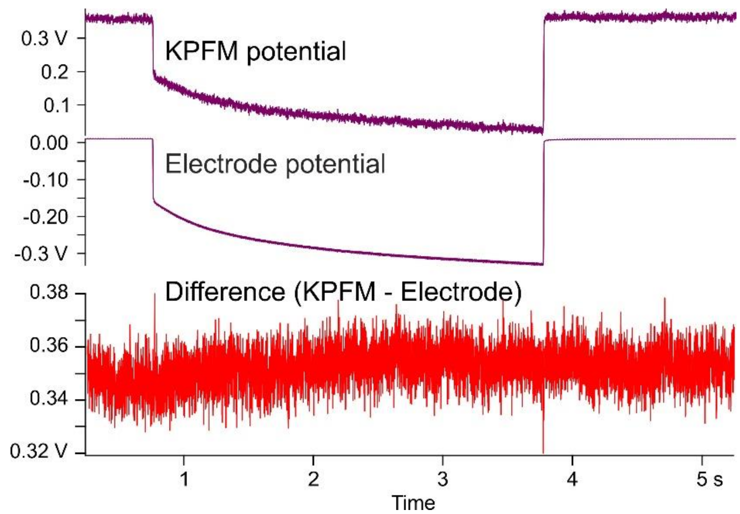


Supporting Figure 4: Screening amplitude and screening lengths from the fits in supporting Figure 3.

S4: Image reconstruction from tr-KPFM data



Supporting Figure 5: All SFM signals as function of time plus FTO electrode potential, measured through the SFM controller's analog input. After the tip is approached, the vertical position is kept constant by a height feedback that keeps the amplitude constant. Topography and phase images are reconstructed by calculating the average over the entire surface dwell. Tt-KPFM maps are generated by evaluating the KPFM CPD signal for each pixel at a given time.



Supporting Figure 6: comparison of the KPFM potential to the externally measured potential on the FTO electrode. The difference between the two traces only contains the static CPD and demonstrates the excellent temporal resolution and the quantitative nature of the KPFM signal.