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

Supplementary Information

Temperature dependent behavior of lead sulfide quantum dot solar cells and films.

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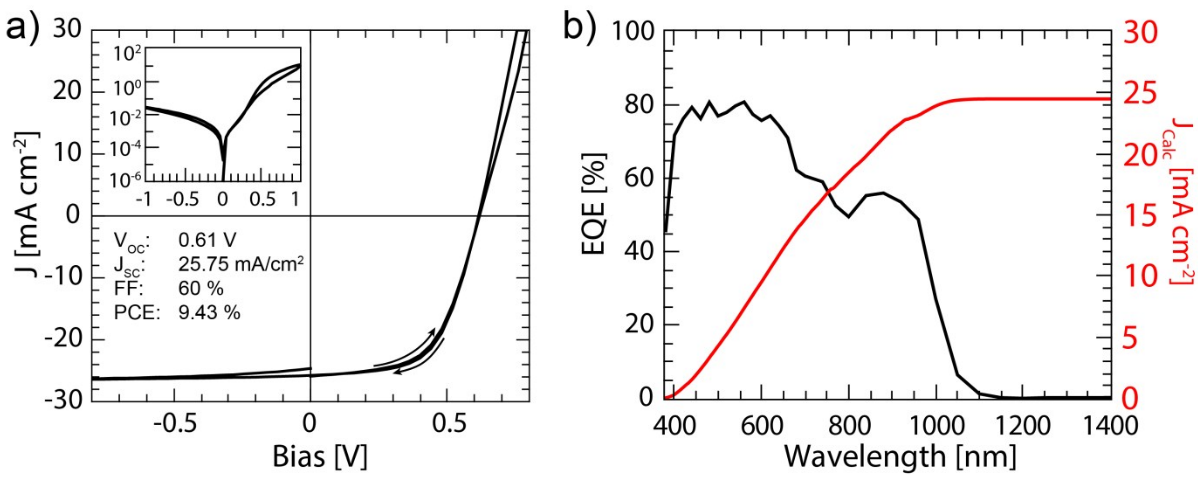

Figure S1. a) JV curve of the champion PN-junction solar cell solar cell under 1 Sun intensity at 25 °C in forward and reverse sweep. The dark current is shown in the inset. b) EQE spectrum of the same device (black dots) and the current calculated from integrating the product of the EQE spectrum and AM1.5G solar irradiation (red line).

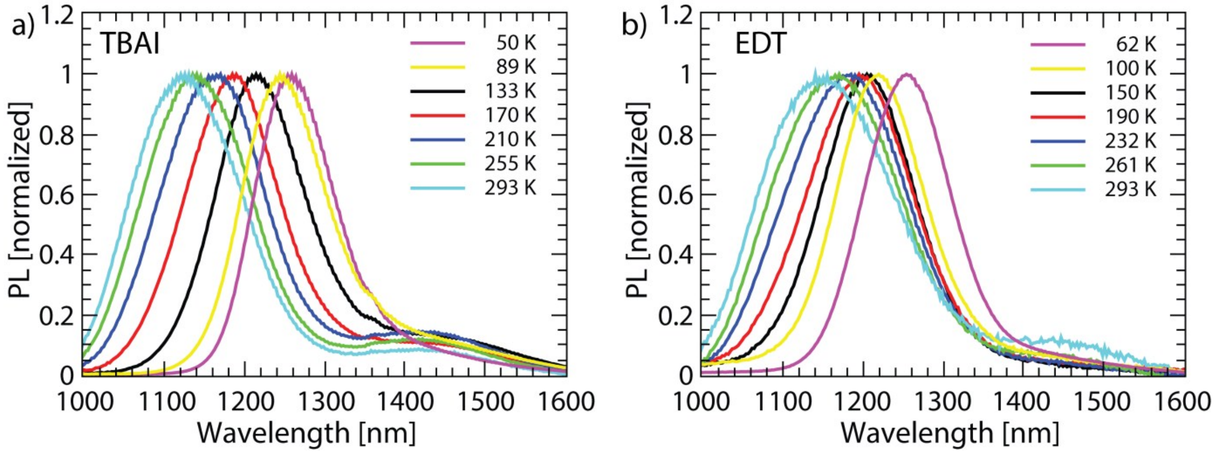

Figure S2. Photoluminescence excited at 400 nm of a) TBAI and b) EDT capped PbS QDs at various temperatures.

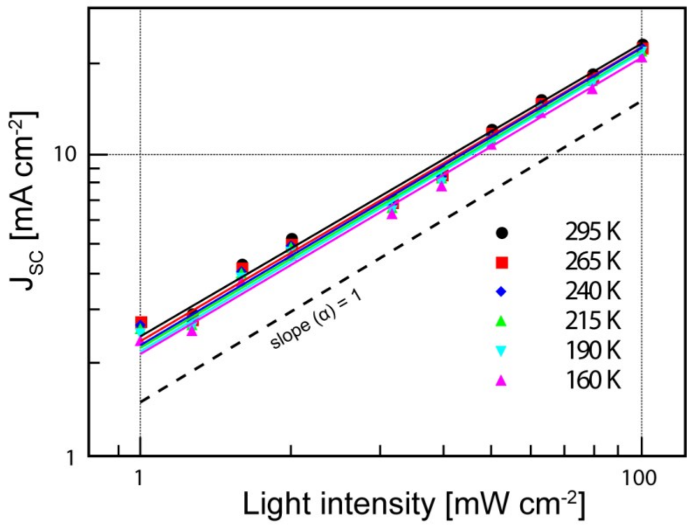

Figure S3. Light intensity dependence of the short circuit current at various temperatures. Markers indicate the data points, while the solid lines are fitted with the equation $J_{SC} = cI^{\alpha}$, where *I* is the illumination intensity and *c* and α are fitting parameters. The dashed line indicates the slope of a perfectly linear current-intensity behavior.

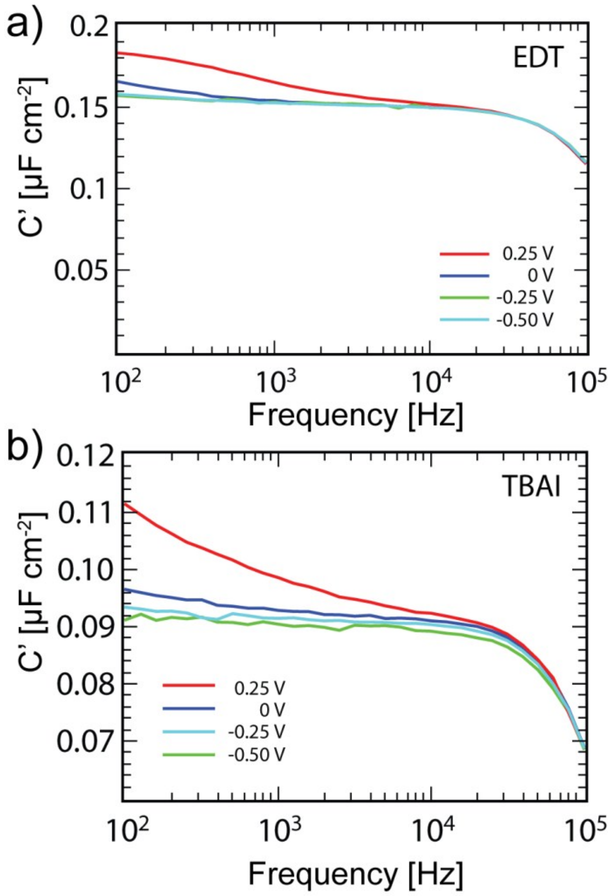

Figure S4. Capacitance measurements for EDT devices a) and TBAI devices b) with structure ITO/PEDOT:PSS/PbS/LiF/Al for various biases at room temperature. Below 0 V the capacitance does not change significantly in the range 10^3-10^4 Hz, indicating that the device is fully depleted.

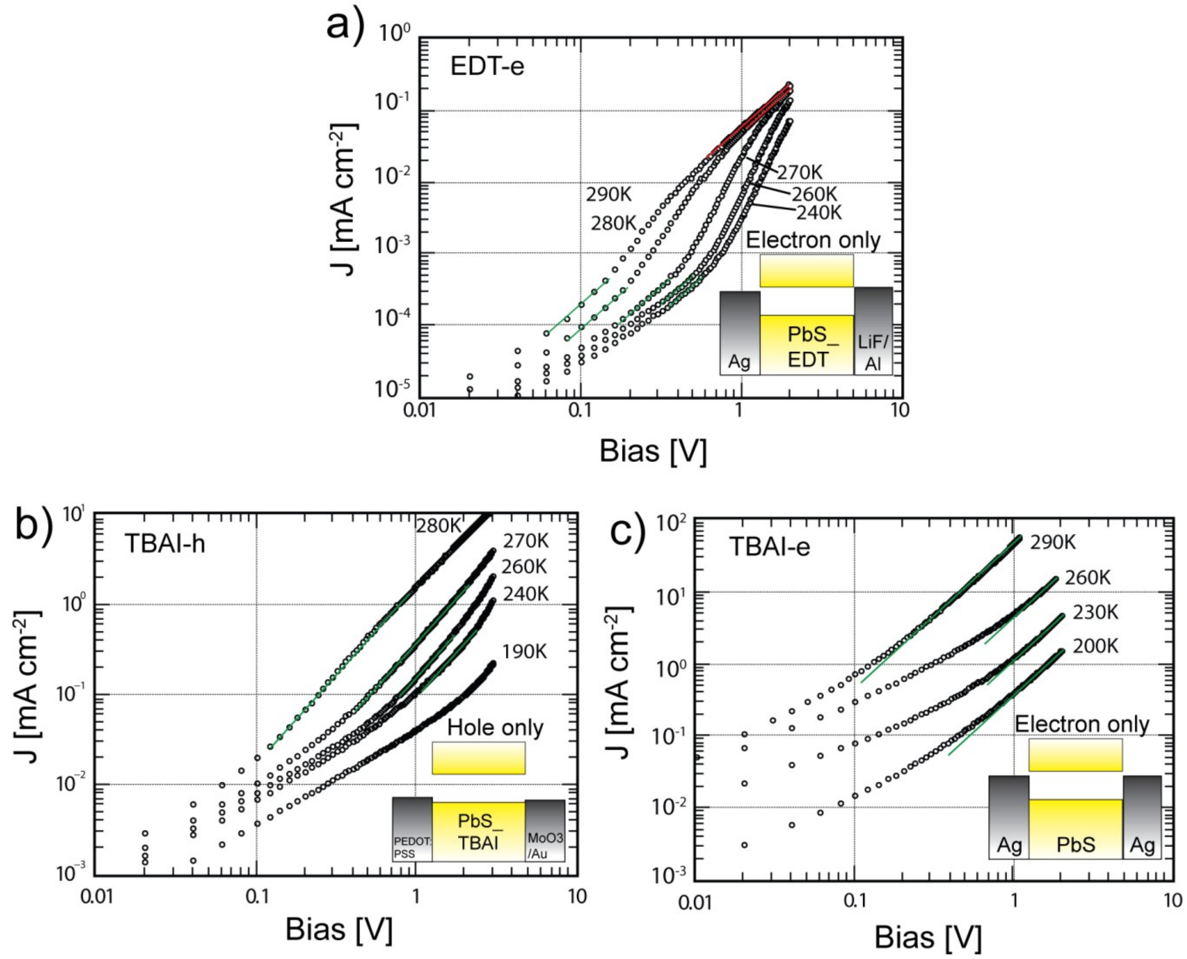

Figure S5 JV curves from single charge carrier devices at various temperatures, the device structure is shown in the insets. The green solid lines indicated the regions that were fitted with Equation 6 (trap-filling region). Red solid lines were fitted with Equation 7 (Mott-Gurney region). a) Electron only device with EDT capped PbS; b) Hole only device with TBAI capped PbS; c) Electron only device with TBAI capped PbS.

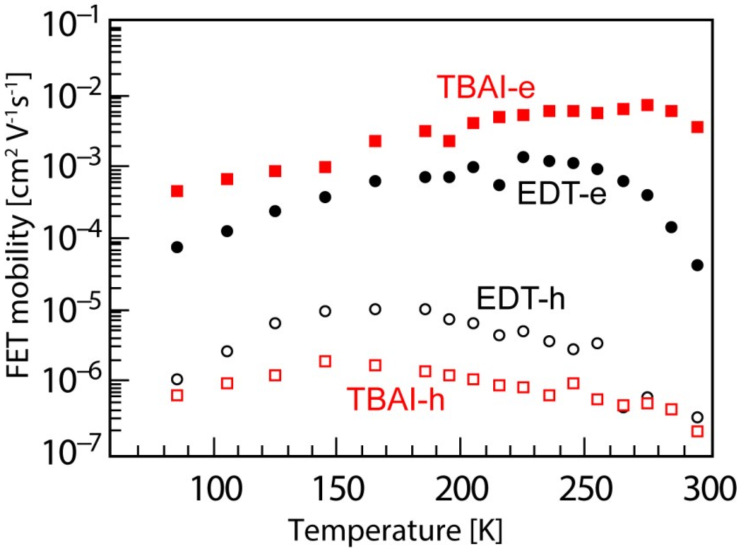

Figure S6 Temperature dependent mobility of PbS films capped with EDT (black dots) and TBAI (red squares) obtained from FET measurements under vacuum. Electrons are indicated by filled markers. Holes are indicated by empty markers.

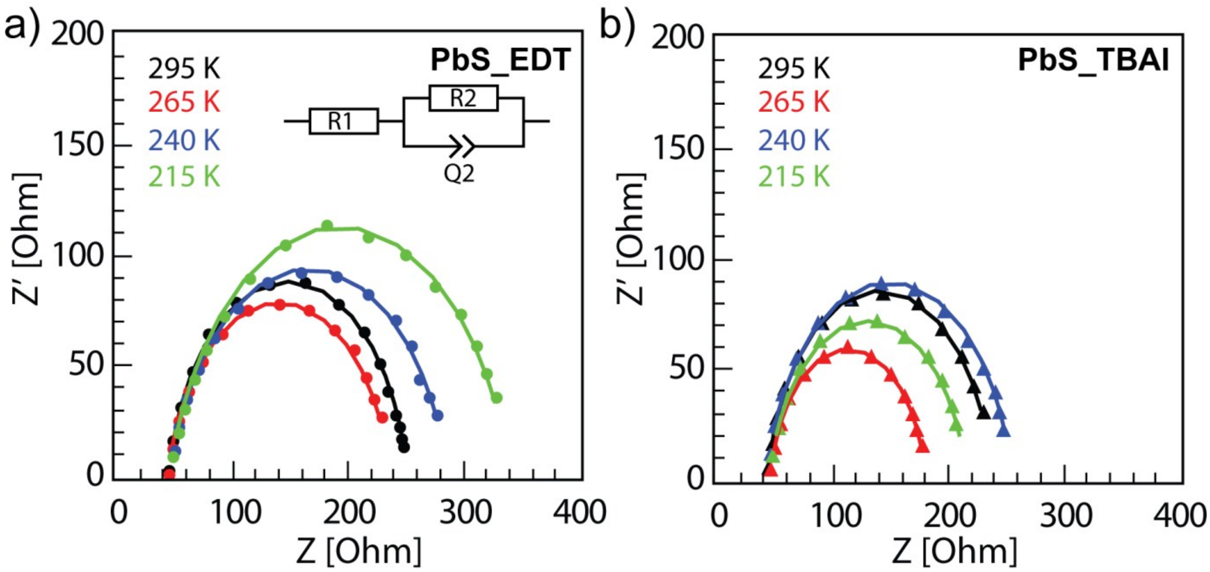

Figure S7 Temperature dependent Nyquist plots under 1 Sun illumination at open circuit voltage. The devices in this measurement have the structure ITO/PEDOT:PSS/PbS/ZnO/Al, where the PbS QDs are capped with a) EDT and b) TBAI. The Nyquist plots are fitted (solid lines) with the inset model. The capacitance is calculated from the constant phase element using $C = Q_2(2\pi f_{peak})^{a-1}$ where Q_2 is the constant phase element,[1] R_2 is the recombination resistance and a indicates how close Q_2 is to an ideal capacitor (1 is ideal), f_{peak} is the frequency at which the imaginary component of the impedance is maximized.

[1]: C.H. Hsu, F. Mansfield, *Corrosion* **2001**, 57, 747.

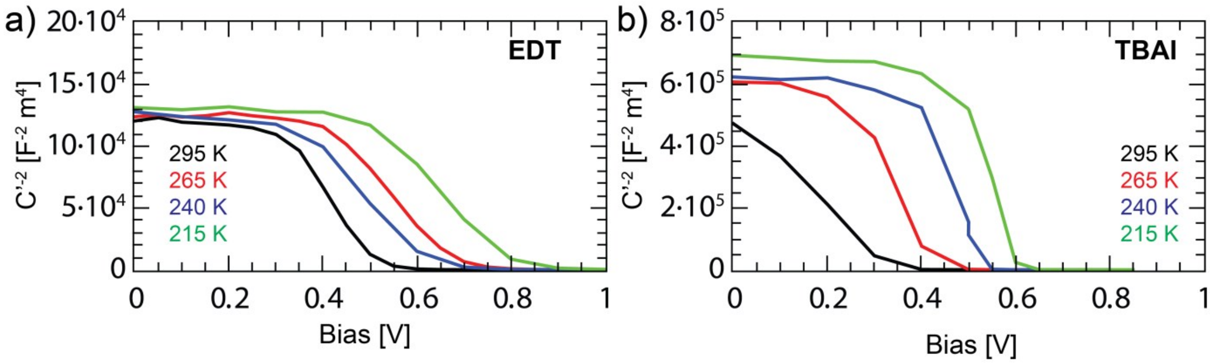

Figure S8 Mott-Schottky plots for EDT (a) and TBAI (b) capped PbS films. The capacitance is measured with a 10 mV AC perturbation with frequency 4.6 kHz superimposed on the forward bias.