Supplementary material

15% enhancement of the photocurrent at the maximum power point of thin film solar cell

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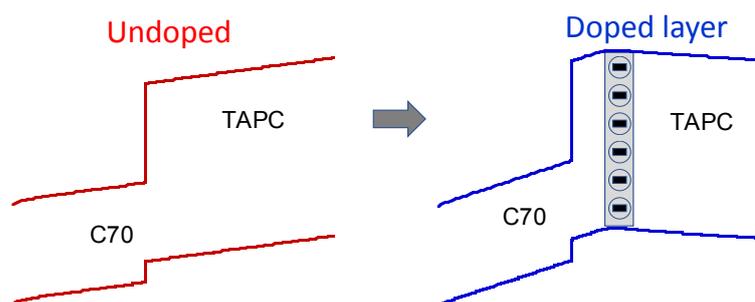
Device Structure

Figure S1. The energy band diagram of the C70:TAPC junction for the undoped (left) and d-doped (right) device. The diagram of the d-doped device illustrates also the sheet-charge introduced by the dopants which cause the significant change in the energy level slope.
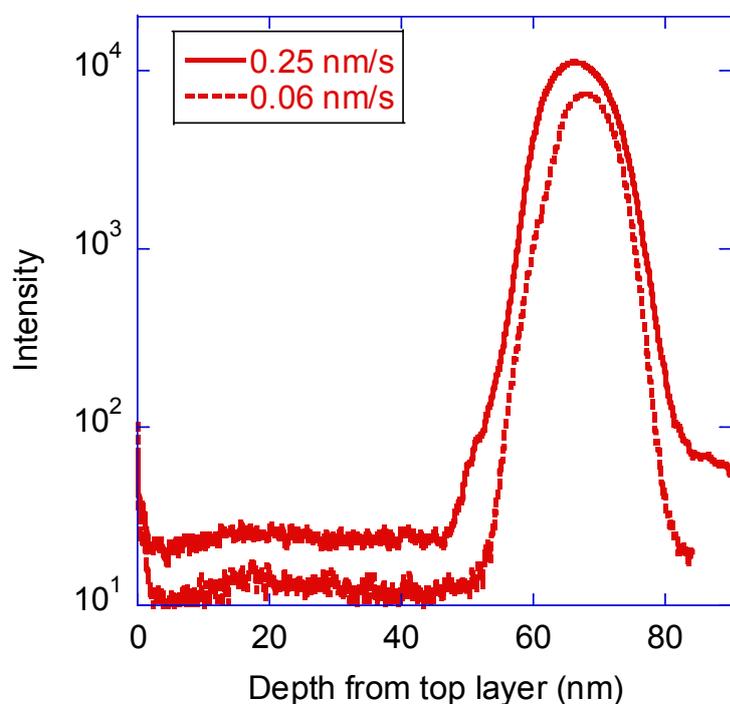

Figure S2. TOF-SIMS analysis of the Fluorine atom marking the position of the $C_{60}F_{48}$. The full line is the measurement presented in the main text. The dashed line is a measurement taken a week later and at a slower etch rate. Note that slowing the etch improves the resolution and that no broadening was observed.
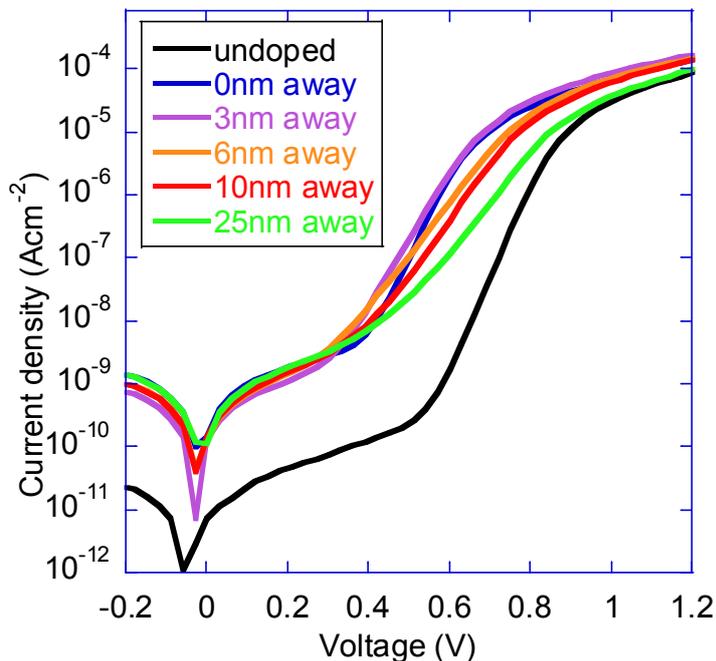
Experimental Results

Figure S3. Current density as a function of bias for 6 devices. Undoped and 5 δ-doped with the doping distance to the junction being nominally 0, 3, 6, 10, 25 nm. Measurement was done under dark conditions.
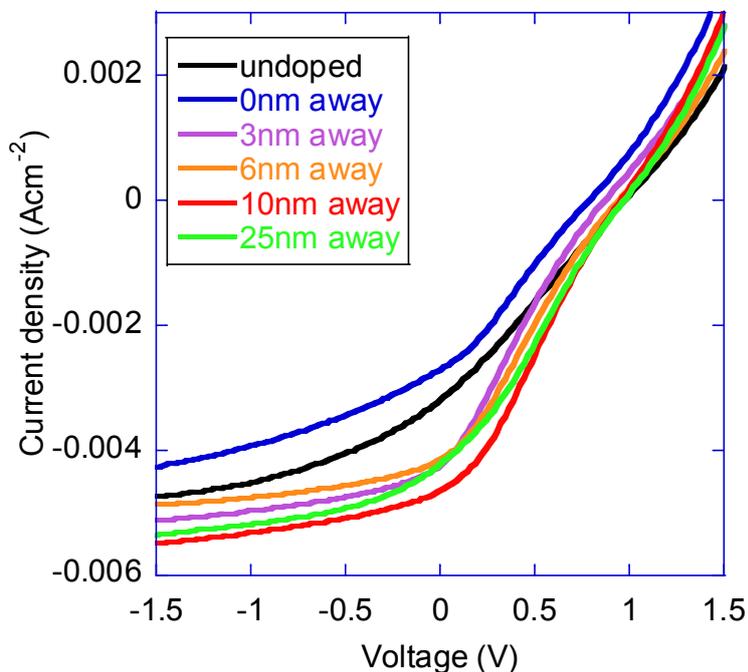

Figure S4. Current density as a function of bias for 6 devices. Undoped and 5 δ-doped with the doping distance to the junction being nominally 0, 3, 6, 10, 25 nm. Measurement was done under one Sun illumination.

The curve in Figure S3 and Figure S4 supplement those in the main text and show that only when the δ-doping is nominally 10nm away it is fully separated from the junction. This is in agreement with Figure 2a that showed that a nominally 10nm away could be only about 4nm away in practice.
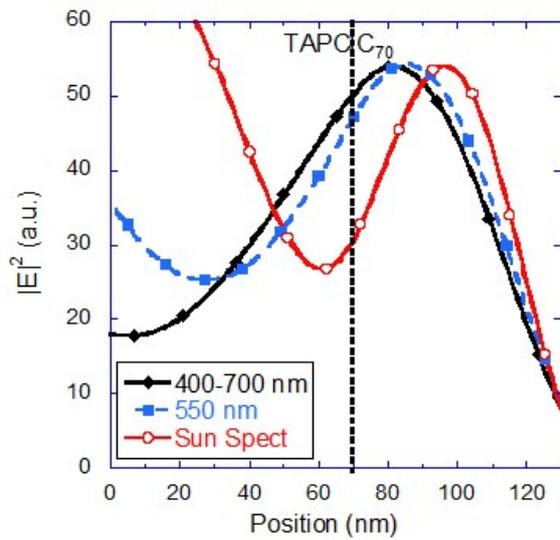
Simulation Results

Figure S5. Field intensity distribution in the TAPC and C70 layers. Black line is for wavelength integration across 400-700nm, The red line is for the same range but with the spectrum weighed by the sun spectrum, and the blue line is for single wavelength (550nm). The red curve was normalised to have the peak in the C_{70} of equal height to the other curves. The calculations were done for the various device structures yielding indistinguishable results.
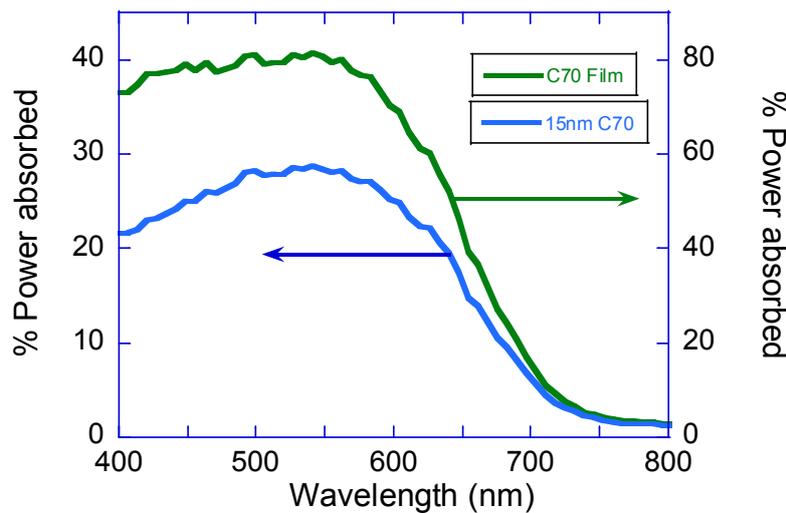

Figure S6. Calculated percent absorption as a function of wavelength. The blue line is using on the 15nm close to the junction (as in main text). The green line is when summing over the entire C_{70} film. Note that using more of the C_{70} film flattens the response toward short wavelength. This reminds the effect found for going from undoped to doped device (Figure 5).
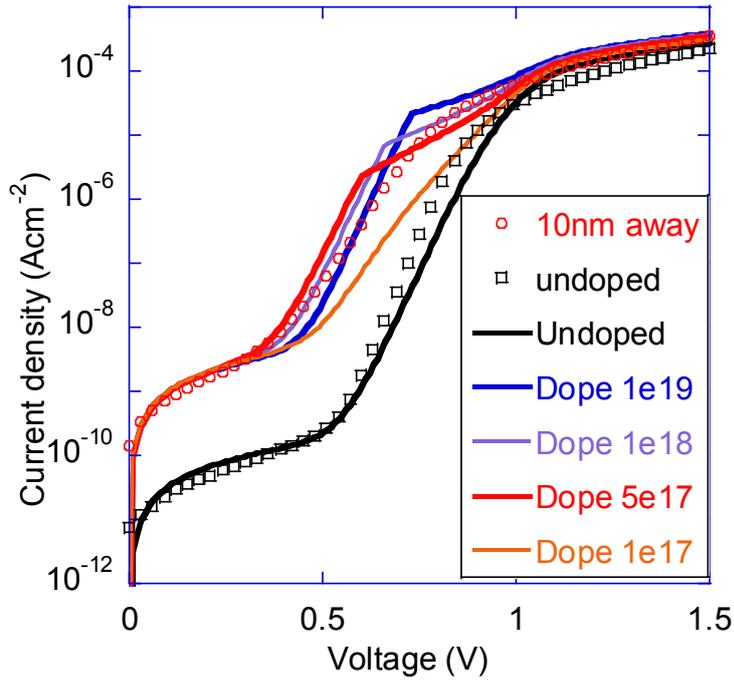
Figure S7. Measured and simulated dark current density as a function of voltage for undoped and 10nm away doped device. For the doped device the effect of varying the dopant density was explored. Above 5x10^{17}cm^{-3} no significant difference was observed.
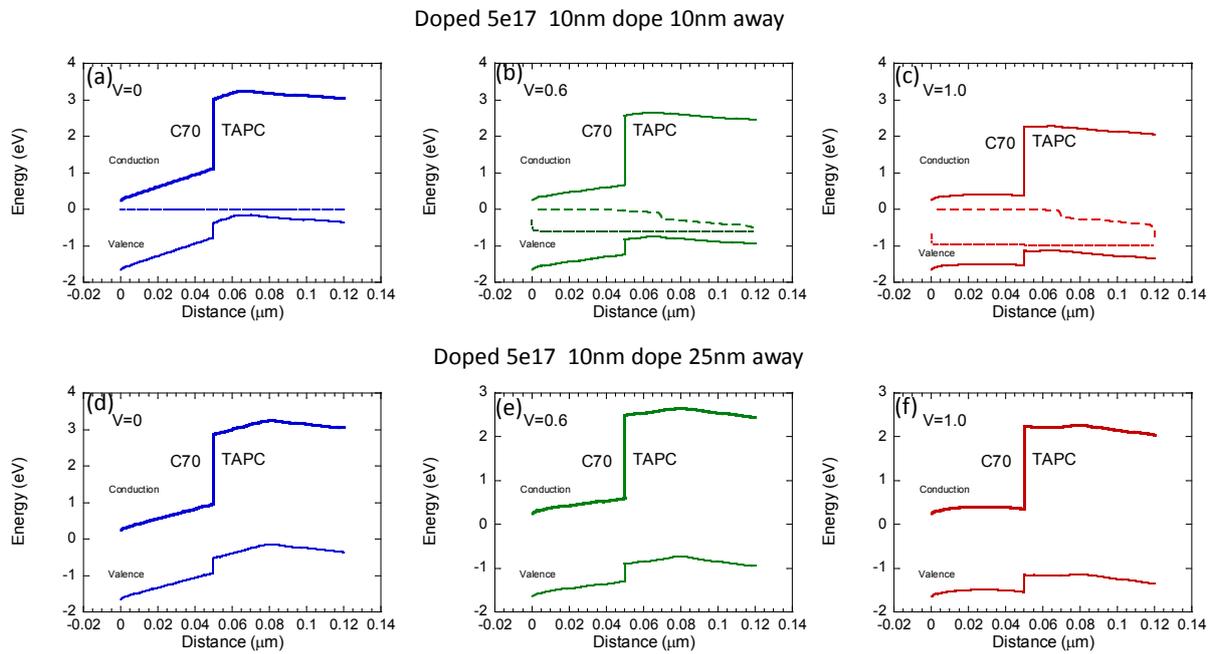

Figure S8. Energy level diagram as a function of voltage for devices with 10nm (top) and 25nm (bottom) separation from the junction. For the top figures the electron and hole quasi-Fermi levels are drawn as well.