Supporting Information

Charge carrier mobility of the organic photovoltaic materials PTB7 and $PC_{71}BM$ and its influence on device performance

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Figure S1 shows the hole mobility of PTB7:$PC_{71}BM$ as a function of temperature. The hole mobility (μ) depends almost exponentially on the temperature (T) as shown by the red fitting line. A simple equation of $\mu = a \times e^{(T/b)}$ revealed a fit parameter of $a = 2.75 \times 10^{-9}$ cm^2/Vs and b = 29.2 K. This relation was used to convert the temperature to the hole mobility

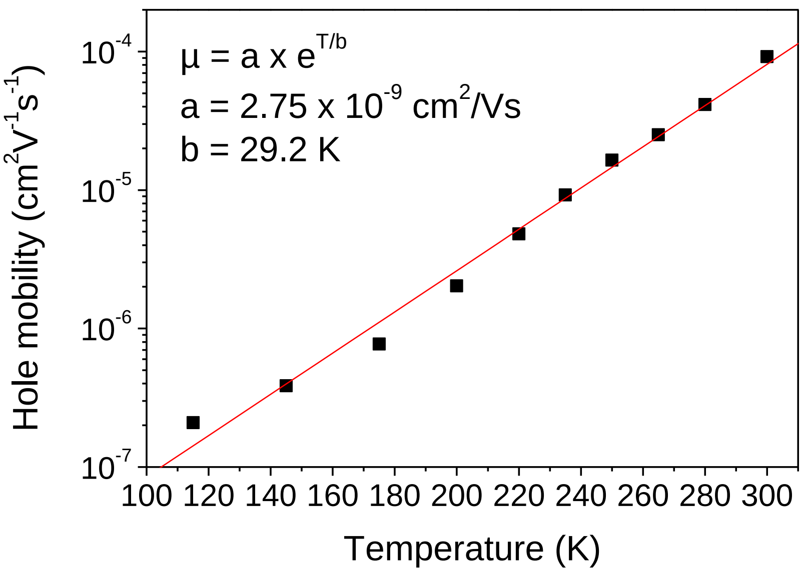

***Figure S1:* Hole mobility of PTB7:PC71BM vs. temperature on a semi-log scale.**

Figure S2 shows the open circuit voltage, extracted charge and the integral of the short circuit current for the turn-on behavior of PTB7:$PC_{71}BM$ solar cells. (This measurement was done on a separate device batch with similar performance.) The extracted charge was measured using a microsecond switch and the method described in the literature [1]. At 77 K the extracted charge reaches saturation at a much longer time scale compared to at room temperature. The steady state value at 77 K is 2.5 times higher than at 295 K.

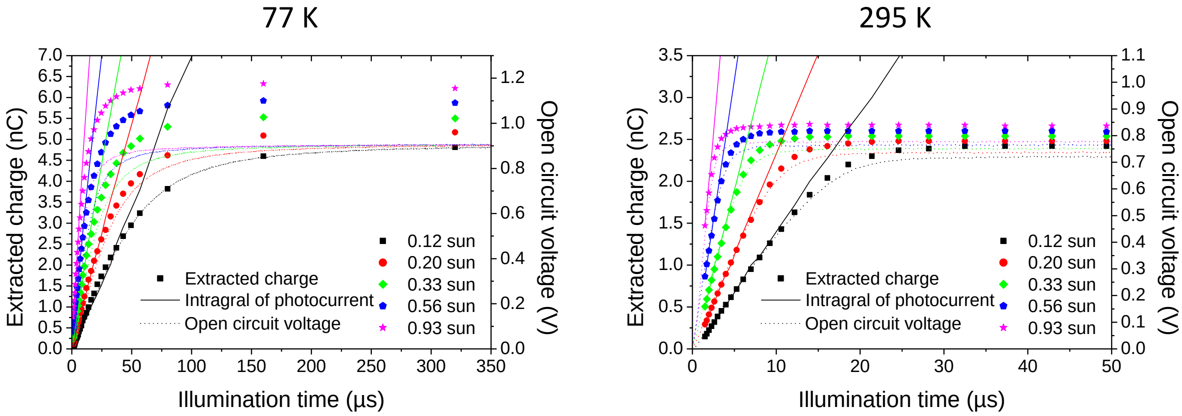

***Figure S2:** Extracted charge and open circuit voltage vs. illumination time. Increasing light intensity from 0.12 (black) sun to 0.93 sun (magenta)*

Figure S3 presents the series resistance of the devices obtained by the slope at high voltage (1.5 V), at the open circuit voltage and from a method based on two JV-curves with different intensity. The method using two JV-curves, which is recommended by the standard for testing solar cells (IEC 60891) [2], agrees well with the slope at V_{OC}. All curves show an increase of the series resistance with reducing hole mobility. The series resistance obtained from the two-curve method is approximately proportional to $\mu^{-1/4}$ (grey line).

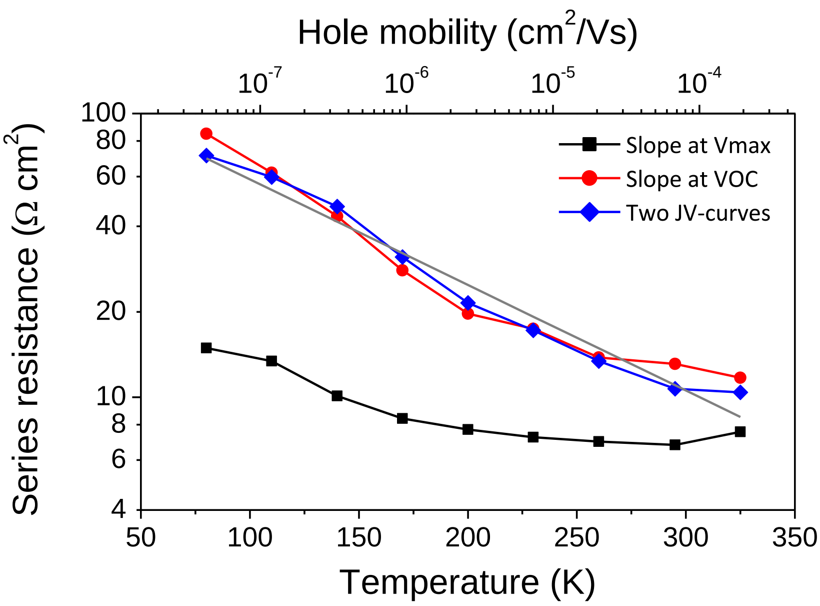

***Figure S3:** Series resistance of PTB7:PC71BM solar cells as a function of temperature and hole mobility.*

The fill factor is strongly influenced by the intensity of illumination as shown in **Figure S4**. At 77 K the fill factor increases from 33 % to 66 % when the light intensity is reduced from 1 sun to 0.01 sun, these values are comparable to the literature [3]. Increased light intensity leads to a higher density of charge carriers and higher bimolecular and trap-assisted recombination rates, giving rise to a decay of the fill factor.

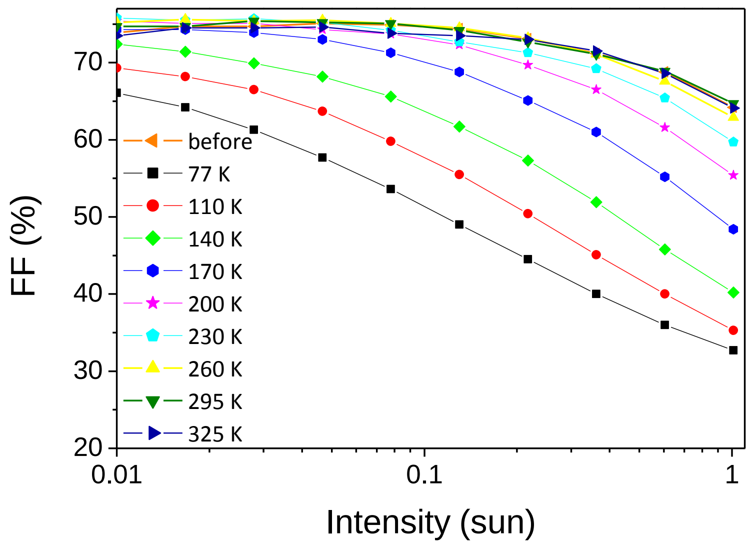

Figure S4: Fill factor as a function of light intensity for varying temperature.

Figure S5 shows the collapsed JV-curves of PTB7:PC$_{71}$BM solar cells of varying light intensity from 0.01 sun to 1.01 sun. The curves were normalized at -0.5 V. The spread at short circuit was attributed to trap-assisted recombination and the spread at open circuit to bimolecular recombination [4,5]. Cooling from 325 K to 77 K shows an increase of trap-assisted recombination.

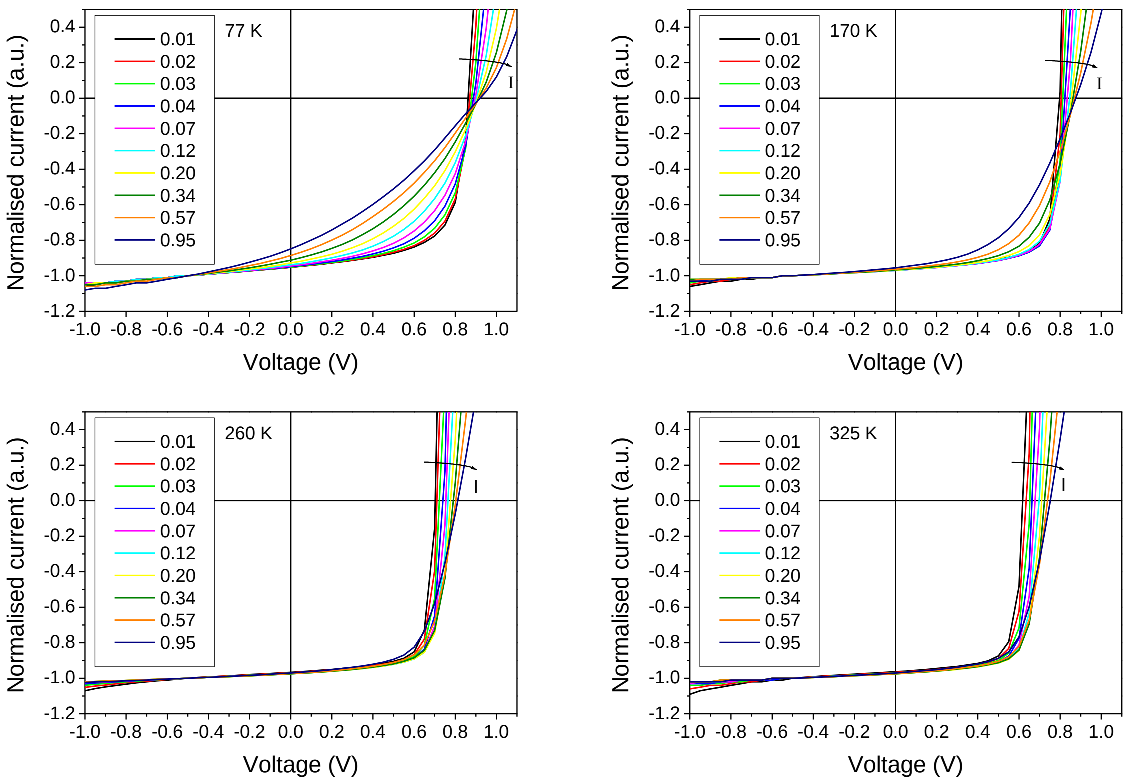

Figure S5: Collapsed JV-curves normalized at -0.5 V for different temperatures.

Figure S6 shows the fit parameters of the exponent of J_{SC} vs. intensity and the slope of V_{OC} vs. intensity. In the region between 200 K and 325 K the mobility has not much influence on the trap-assisted and bimolecular recombination. From 200 K to 77 K bimolecular recombination increases slightly, whereas trap-assisted recombination increases strongly.

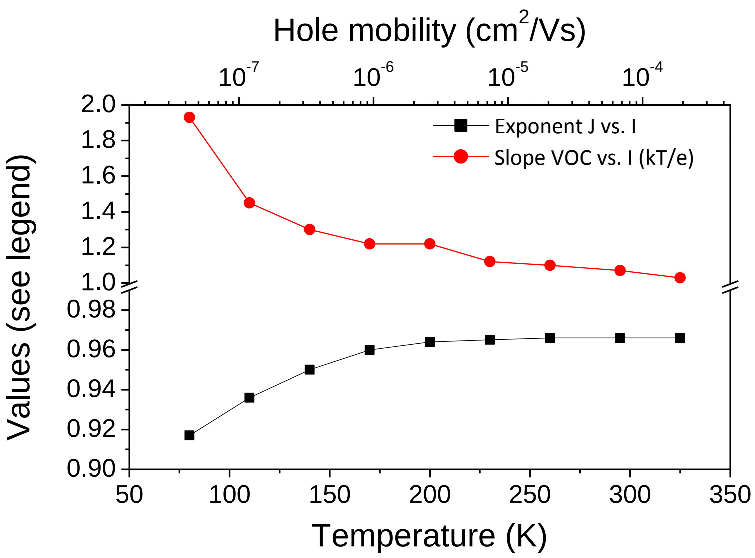

Figure S6: Fit values of the exponent of JSC vs. intensity and the slope of VOC vs. intensity as a function of temperature and mobility

References:

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