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## Supplementary information

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# Organic bipolar transistors

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# Supplementary Information

## Organic bipolar transistors

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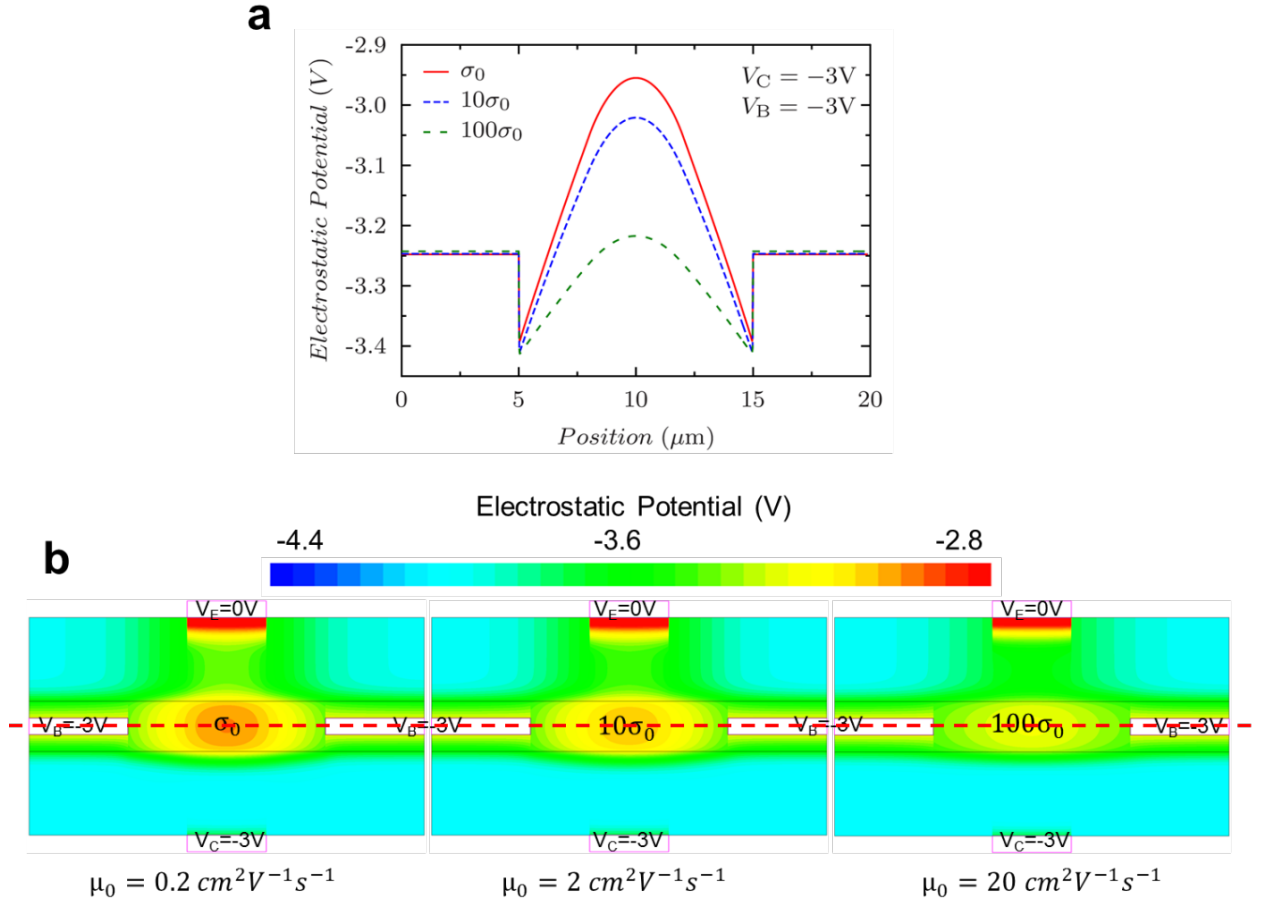
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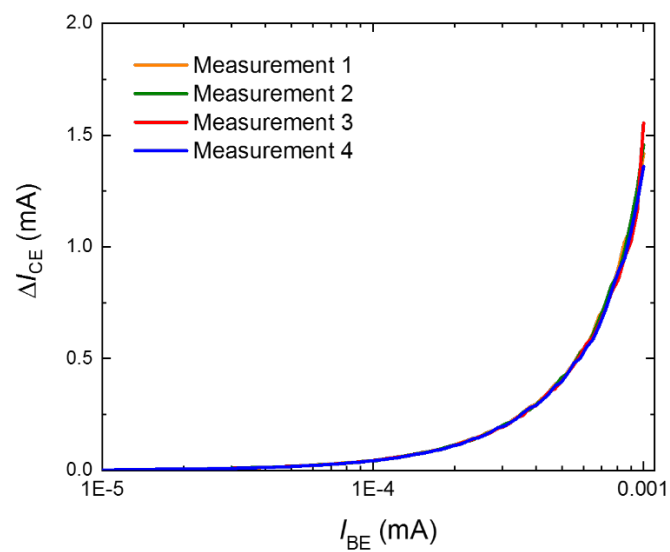
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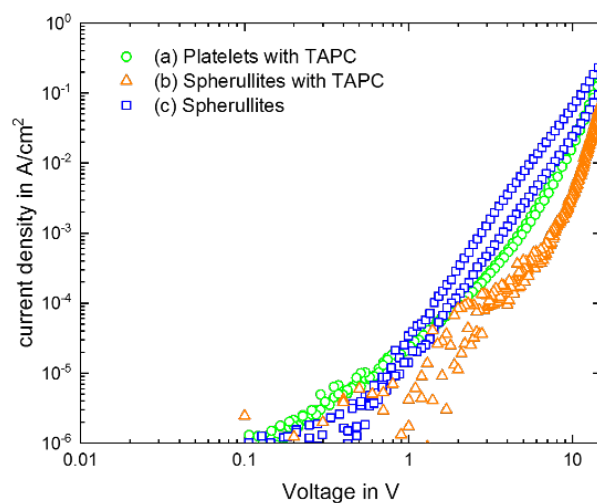


**Fig. S1.** (a) Electrostatic potential profile through the cutline (the dash-line indicated in red in Fig. S1b) with different base layer conductivity,  $\sigma_0 = qn\mu_0$  based on the calibrated simulator to the experimental data (b) The corresponding TCAD simulation of the electrostatic potential distribution in the OBJT devices with varying base layer conductivity  $\sigma_0$  through mobility  $\mu_0$ .

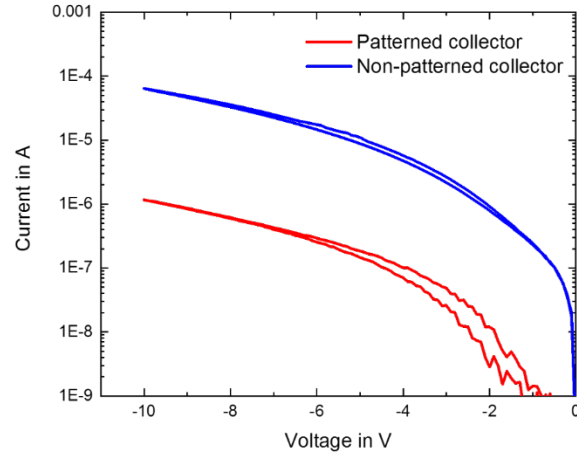
The electrostatic potential profiles and distributions (Fig. S1) show the impact of conductivity on the potential comparing that at the base electrode metal, with that in the organic semiconductor. Please note that we set the color map (blue is associated to -4.4V, and red for -2.8V) to see the potential distribution in the interested region (base-OSC-layer) in a more visible way. A difference between the applied  $V_B = -3 \text{ V}$  and the indicated potential (-3.25V) in the base electrode is caused by the fermi level of the base material. The conductivity  $\sigma_0 = qn\mu_0$  of the base OSC layer has been changed by considering different mobility  $\mu_0$  (see the legend) for the minority carrier “hole” in the layer. The conductivity controls and tunes the potential shape, penetration, and influence into the base-OSC-layer (see Fig. S1a). Therefore, the base control over the channel and accordingly the emitter-collector leakage current can be significantly controlled and suppressed by the conductivity. However, it is not just the conductivity, but also the applied biases, device dimensions/design and in particular the spacer between the base and emitter electrodes need to be optimized. Future work will focus on additional investigations and a more advanced optimization of the fabricated devices.



**Fig. S2.** Repeated OBJT amplification measurements for Fig. 1g experiments.



**Fig. S3.** *I/V* characteristics of undoped rubrene films in spherulitic (with and without 5 nm TAPC) and platelet (with 5 nm TAPC) phases: Stack consists of 30 nm of undoped seed and 370 nm of undoped bulk film between Au-electrodes (active area of 100  $\mu\text{m} \times 100 \mu\text{m}$ ). Note that in particular the spherulite samples show a certain hysteresis.



**Fig. S4.** Reverse current of the base-collector diodes of the OBJT devices (20 nm base thickness) with and without the structuring of the collector electrode.

**Table S1.** TCAD Simulation: Parameters and Units used for OBJT TCAD Simulation

| Quantity                                                      | Parameter Values and Units                     |
|---------------------------------------------------------------|------------------------------------------------|
| Device Width                                                  | 1 $\mu\text{m}$                                |
| Emitter/Collector Electrode Thickness                         | 30 nm                                          |
| p_OSC Thickness                                               | 100 nm                                         |
| n_OSC Thickness                                               | 30 nm                                          |
| Base Electrode Thickness                                      | 10 nm                                          |
| p-doping                                                      | $8\text{e}17 \text{ cm}^{-3}$                  |
| n-doping                                                      | $1\text{e}16 \text{ cm}^{-3}$                  |
| Low field Mobility (hole) $\mu_{0-hole}$                      | $2 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ |
| Low field Mobility (electron) $\mu_{0-elec}$                  | $3 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ |
| Temperature                                                   | 300 K                                          |
|                                                               |                                                |
| Base Lengths $L_B$ (Fig. 2d)                                  | 25, 10, 1, 0 $\mu\text{m}$                     |
| Distance between Adjacent Base-Electrodes $L_{BB}$ (Fig. 2d)  | 50 $\mu\text{m}$                               |
| Emitter and Collector Lengths (Fig. 2d)                       | 100, 70, 52, 50 $\mu\text{m}$                  |
|                                                               |                                                |
| Base Length $L_B$ (Fig. 2e)                                   | 0 $\mu\text{m}$                                |
| Distance between Adjacent Base-Electrodes $L_{BB}$ (Fig. 2e)  | 100 $\mu\text{m}$                              |
| Emitter Lengths (Fig. 2e)                                     | 100, 98, 96, 90 $\mu\text{m}$                  |
| Collector Length (Fig. 2e)                                    | 100 $\mu\text{m}$                              |
| Offsets between Base and Emitter $L_{BE}$ (Fig. 2e)           | 0, -1, -2, -5 $\mu\text{m}$                    |
|                                                               |                                                |
| Base Length $L_B$ (Fig. 2f)                                   | 25 $\mu\text{m}$                               |
| Distances between Adjacent Base-Electrodes $L_{BB}$ (Fig. 2f) | 100, 50, 25, 5 $\mu\text{m}$                   |
| Emitter and Collector Lengths (Fig. 2f)                       | 150, 100, 75, 55 $\mu\text{m}$                 |