Spatially resolved optical and electrical characterization of thin films formed by CdSe/CdS octapod-shaped nanocrystals

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Supporting information:

Figure S1. Absorption and emission of CdSe/CdS octapods: The absorption recorded from solution is shown in red. The absorption spectrum shown in blue and the emission (black data points) were recorded from an octapod film deposited on a glass substrate. In the emission experiment the sample was illuminated with a laser at 405 nm wavelength.
Figure S2. X-ray diffraction patterns recorded from an octapod film at different temperature. The broad peak that is visible at RT around 2-theta = 15° resulted from organic contaminations in the film and is not present in the spectrum recorded at 200°C. This confirms that annealing at 200°C removes most of the organic contaminants from the octapod film. For a detailed assignment of the other peaks please see Fig. 4f in ref. 16.

Figure S3. Electrode structures fabricated by optical lithography with 8 µm separation (a), and by EBL with 200 nm separation (b).
Figure S4. Dark current versus bias voltage at RT of octapod films on electrode devices with 200 nm (a) and 8 µm (b) electrode separation.

Figure S5: Confocal images of the electrode area of figure 6: (a) backscattered light of the laser beam at 515 nm recorded in the spectral range of 500-540 nm. (b) nanocrystal fluorescence of the octapod film excited with a laser beam at 405 nm and recorded in the spectral range of 575-655 nm.
Figure S6: Confocal microscope image (a) of an interdigitated electrode device region covered with a thin octapod film, and the photocurrent signal of the corresponding area at a bias -30 V (b). In the left electrode gap the scratch leads to a suppression of the photocurrent signal, and in the right gap the photocurrent signal is enhanced in the vicinity of small voids present in the film.

<table>
<thead>
<tr>
<th>Intensity (mW/cm²)</th>
<th>45</th>
<th>125</th>
<th>227</th>
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<tbody>
<tr>
<td>σ₀(S)</td>
<td>5.73e-7</td>
<td>1.56e-6</td>
<td>7.21e-6</td>
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<tr>
<td>T₀(K)</td>
<td>94.9</td>
<td>115.5</td>
<td>136.7</td>
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<tr>
<td>n</td>
<td>1.40</td>
<td>1.50</td>
<td>1.72</td>
</tr>
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Table 1. Fitting results of the temperature dependent photocurrent in the regime II for different light intensities with the equation $\sigma = \sigma_0 \exp \left( \frac{T}{T_0} \right)^n$.

Estimation of the tunnel barrier width dependence on the thermal expansion of the octapods:
The thermal expansion curve of CdS (taken from Springer Semiconductors Data Handbook) shows an almost linear expansion in the regime from 290-450K leading to an increase in lattice constant from 4.136 Å to 4.140 Å. This corresponds to a relative increase of 0.001 for ΔT=160K. Extrapolation of this linear behavior to T = 10 K can give an upper limit for the thermal expansion in the range from 10 – 220 K. We consider octapods with CdS arms with diameter and length of 10 and 40 nm, respectively. Since the tip-to-tip connection in a dense film is much more unlikely than the case of laterally connected arms we consider the arm diameter as the relevant length scale. Thus we calculate (220K/160K)*0.001*10 nm = 0.014 nm as the upper limit for thermal expansion of the tunnel barrier over the temperature range from 220 – 10 K.
Figure S7: Fitting of the photocurrent versus temperature with the model $\sigma_0 \exp \left( \frac{T}{T_0} \right)^n$ at bias voltages of 0.5V and 10V.