## Supporting Information

## Colloidal 2D PbSe Nanoplatelets with Efficient Emission Reaching the Telecom O-, E- and S-Band

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## Photoluminescence quantum yield (PLQY) measurements

Steady-state PL spectra were measured using an Edinburgh FLS 1000 UV-Vis-NIR photoluminescence spectrometer. The optical characterization of nanoplatelet dispersions was carried out using quartz cuvettes with a path length of 10 mm. The steady-state PL was collected by exciting the samples at 500 nm (optical density < 0.2 at the excitation wavelength) with a Xenon lamp and utilizing an InGaAs PMT detector. The PLQY was determined inside an integrating sphere, measuring the scattering in the visible range with a 980 PMT and the emission in the NIR with the InGaAs detector of both, a blank and the sample. The measured spectra were corrected for the difference in the detector sensitivities. The following formula was used for the determination of the PLQY<sup>S1</sup>:

$$PLQY = \frac{E_B - E_A}{S_A - S_B}k$$
(1)

$$k = \frac{Signal_{980 PMT}}{Signal_{InGaAs}}$$
(2)

With *E* the emission area (area under the curve), *S* the area of the scattering, i.e. the non-absorbed light at the excitation wavelength, k the ratio of the detector sensitivities, and the indices *A* and *B* marking the reference and the sample, respectively.



**Figure S1:** PL of PbSe NPLs shown in Figure 1b plotted against the wavelength and exhibiting increasing PL wavelengths with increasing lateral size of the NPLs.



**Figure S2**: Size histograms of the PbSe NPLs shown in the TEM images in Figure 1 of the main manuscript with the smallest NPLs exhibiting the smallest lateral size distribution.



**Figure S3:** a) Powder X-ray diffraction and b) TEM image of a PbSe NPL emitting at 1200 nm. The inset in b) shows the FFT of the TEM image in Figure S2b and underpins the cubic rock salt structure of the obtained PbSe NPLs. A distance of 3.1 Å corresponds to the (200) lattice.



**Figure S4**: HR-TEM images of PbSe NPLs emitting at 1280 nm and positioned upright on the TEM grid. All scalebars correspond to 10 nm. All latice plains show a distance of 3.1 Å, corresponding to the (200) lattice of cubic PbSe. From the HR-TEM images a NPL thickness of 0.8 nm  $\pm$  0.1 nm is deduced.



**Figure S5**: Absorbance of two different CdCl<sub>2</sub> treated PbSe NPLs and associated 2<sup>nd</sup> derivate for determining the maximum curvature associated with the excitonic absorption stated in the manuscript. The shoulder at 845 nm shown in a) might indicate a second NPL population with a smaller lateral size. The absorbance values were smoothed before calculating the 2<sup>nd</sup> derivate with a Lowess plot (absorbance is shown uncorrected).



**Figure S6**: Energy of the first excitonic transition in the PbSe NPL absorbance in comparison with the sizing curve of PbSe NCs (double logarithmic plot). The width and length of the PbSe NPLs are plotted and fitted separately with a hyperbolic fit and effective mass  $m^*$  values of  $0.053m_e$  and  $0.07m_e$  are obtained, respectively.



**Figure S7**: Absorbance of the PbSe NPLs used for transient absorption measurements shown in Figure 3. The slight absorption feature at 1200 nm originates from residual hexane from the synthesis, while the feature close to 1400 nm originates from the fused quartz cuvettes used for the transient absorption measurements which does not affect the transient absorption measurement data.<sup>S2</sup>



**Figure S8**: Color-coded 2D TA spectra of (a) pristine and (b) CdCl<sub>2</sub> treated PbSe NPLs photoexcited at 700 nm with transients discussed in the main text.



**Figure S9**: Spectral line cuts of pristine and CdCl<sub>2</sub> treated PbSe NPLs photoexcited at 700 nm. Transients of CdCl<sub>2</sub> treated PbSe NPLs exhibit a considerable bleach contribution close to their PL maximum of 1050 nm at 10 ps and 3.5 ns after photoexcitation, while pristine NPLs with a PL maximum at 985 nm exhibit a stronger decay after 3.5 ns.



**Figure S10**: Lateral size histograms of PbSe NPLs shown in Figure 4 before and after the CdCl<sub>2</sub> treatment with NPLs exhibiting a small size increase after the treatment.



**Figure S11:** a) PL and absorbance spectra of PbSe NPLs emitting at 990 nm (pristine) and 1045 nm (CdCl<sub>2</sub> treated). The PL is fitted with two Gaussians as discussed in the main text. b) Measured lifetimes at the maximum of the Gaussian Peak A and Peak B of the CdCl<sub>2</sub> treated PbSe NPLs in a), fitted biexponentially. The fitting parameters are shown in Table S1.

**Table S1**: Fitting parameters of the PL lifetime measurements shown in Figure S9b. The contribution of the shorter time constant to Peak B (trap related) is higher than to Peak A (bandgap related). Please note that at the maximum of Peak B, Peak A still has a major contribution (60 % at the maximum of Peak B, also apparent from Figure S9a and Figure 4 in the main manuscript.

Measured at	$ au_{1PL}$ (ns)	A <sub>1</sub> (%)	$ au_{\mathit{2PL}}$ (ns)	A <sub>2</sub> (%)
Peak A	168	25	1320	75
Peak B	168	40	1320	60



**Figure S12**: Emission spectra of PbSe NPLs exemplarily shown in Figure S9a, and their excitation spectra at the two emissive states A and B in good agreement with the absorbance of the samples.

PL Position 1.27 1.21 1.16 1.13 1.05 0.98 0.93 0.9									•
	PL Position	1.27	1.21	1.16	1.13	1.05	0.98	0.93	0.91

201

203

225

186

Table S2: CdCl<sub>2</sub> treated PbSe NPLs with associated PL position and FWHM

216

214

192

FWHM

(meV)

184

	Pristine PbSe NPLs	CdCl <sub>2</sub> treated PbSe NPLs
Pb	55.3 %	38.7 %
Se	44.7 %	33.2 %
Cd		10 %
Cl		18.1 %

Table S3: Table with the elemental ratio of Pb, Se, Cd and Cl determined by EDXS.

## References

(S1) Würth, C.; Geissler, D.; Behnke, T.; Kaiser, M.; Resch-Genger, U. Critical Review of The Determination of Photoluminescence Quantum Yields of Luminescent Reporters. *Anal. Bioanal. Chem.* **2015**, *407*, 59–78.

(S2) Gesuele, F.; Sfeir, M. Y.; Koh, W.-K.; Murray, C. B.; Heinz, T. F.; Wong, C. W. Ultrafast Supercontinuum Spectroscopy of Carrier Multiplication and Biexcitonic Effects in Excited States of PbS Quantum Dots. *Nano Lett.* **2012**, *12*, 2658–2664.