Supplementary Information

"On-chip time resolved detection of quantum dot emission using integrated superconducting single photon detectors"

G. Reithmaier†, S. Lichtmannecker†, T. Reichert†, P. Hasch†, K. Müller†, M. Bichler†, R. Gross‡ and J. J. Finley†

†Walter Schottky Institut, Physik Department and Center of Nanotechnology and Nanomaterials, Technische Universität München, 85748 Garching, Germany
‡Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften and Physik-Department, Technische Universität München, 85748 Garching, Germany

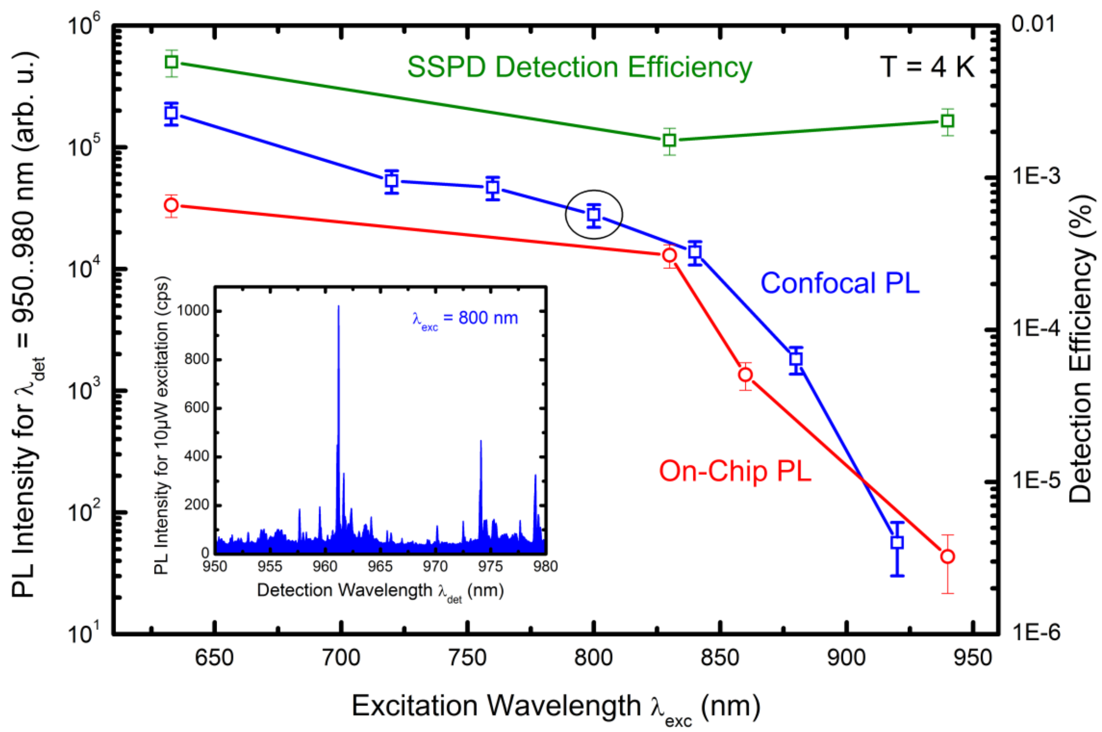

Figure S1: Comparison of the integrated on-chip (red curve) and confocal (blue curve) PL emission intensities and the measured SSPD detection efficiency

Figure S1 shows a comparison of the integrated on-chip (red curve) and confocal (blue curve) PL emission intensities and the measured SSPD detection efficiency. The data plotted on the figure was obtained using the methods described below:

- Confocal PL: Spectra were recorded at 16 different positions along the axis of the waveguide for each excitation wavelength. The integrated intensity over the wavelength interval from 950 - 980 nm was then plotted as a function of the excitation wavelength, representative of the photoluminescence yield from the optically pumped quantum dots within the laser focal volume. The inset shows a typical spectrum for an excitation wavelength of 800 nm.
- On-Chip PL: The maximum count rate with the background subtracted for the data presented in figure 2b is plotted as a function of the

excitation wavelength. Compared to the data presented in figure 2b an additional datapoint at 860 nm was recorded.

- The top-illumination detection efficiency of a similar SSPD having the same geometry is plotted on the rightmost y-axis. The detection efficiency was determined using the method reported in Reithmaier et al, arXiv:1212.2038 (2012).

➢ A ~ 3 - 4 orders of magnitude reduction of the integrated PL intensity is observed in both confocal (blue curve) and on-chip (red curve) detection geometries as the excitation wavelength is tuned > 814 nm, close to the GaAs bandgap (blue and red curve). In contrast, the SSPD detection efficiency reduces only weakly (~ 2.5 x) for wavelengths up to 940nm (green curve). Since the propagation losses of the multimode waveguide are very insensitive to wavelength, these observations unambiguously prove that the on-chip detected events arise from quantum dot emission, a conclusion that is further supported by the time resolved measurements presented in figure 3.

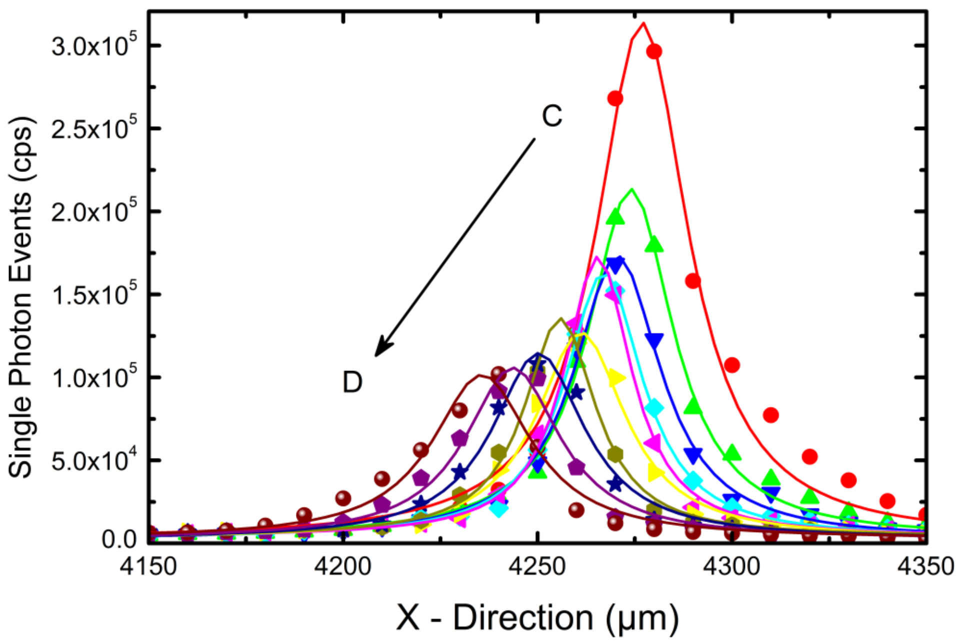

Figure S2: Estimation of the propagation losses along the waveguide bend for the path at the center of the waveguide from C to D (trajectory shown in figure 2a).

Figure S2 shows the detected single photon events as the laser spot is scanned along the x-direction in slices at different positions along the waveguide bend (C to D in figure 2a). Gaussian peak profiles were fitted to each of the curve, to obtain the amplitudes plotted in Figure S3 along the trajectory C-D.

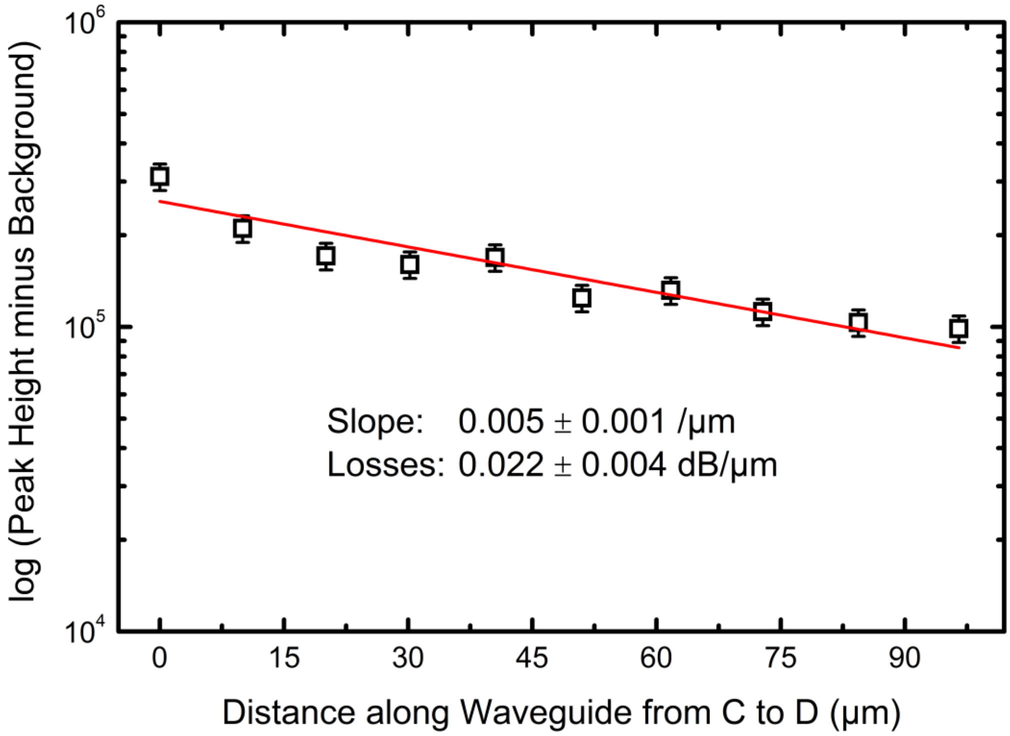

Figure S3: Amplitude of the detected light intensity, as shown in figure S2, plotted as a function of the distance along the waveguide bend.

The amplitude determined along the trajectory C-D shown in figure 2a is plotted on a semi-log scale in figure S3. A single exponential decay is found to represent the amplitude variation, from which we measure the losses along the waeguide bend to be 0.022 ± 0.004 dB/µm. A similar analysis was performed along the directory D-E in figure 2a, revealing losses of 0.0048 ± 0.0004 dB/µm.