Supporting Information

Strongly polarized quantum-dot-like light emitters embedded in GaAs/GaNAs core/shell nanowires

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I. Spatial distribution of the sharp lines monitored by μ-PL

In order to provide further evidence for the formation of QDs we monitored the spatial distribution of the sharp lines by measuring μ-PL spectra on different spots of the same GaAs/$GaN_{0.005}As_{0.995}$ NW. Figure S1 depicts μ-PL spectra measured at several positions (marked as Pos. 1 - 6) of the NW, which show that the spectral positions of the sharp lines is spot-dependent and changes along the wire. This is further evidence that the sharp lines originate from excitons strongly localized in certain regions of the wire acting as quantum dots.

II. Excitation power dependence

To further verify the suggestion that some of the monitored PL lines may stem from the self-assembled QDs, we have performed excitation power-dependent PL measurements on individual NWs. Typical spectra obtained under different excitation powers are shown in Figure S2, where the spectra have been normalized in intensity to the line denoted by A and are shifted vertically for clarity. The broad background due to the LE emission has been subtracted, in order not to mask the power dependence of the sharp lines. It was found that increasing excitation power (P) leads to an appearance of additional PL lines that show a superlinear dependence on P. This is demonstrated in the inset in Figure S2, taking as an example the excitation power dependences of the lines labelled as A, B and C in Figure S1.

Fitting the experimental data with the power function $I \propto P^{\beta}$ gives the values for the power factor β = 1, 1.5 and 2 for A-, B- and C-lines, respectively.

For excitons and exciton complexes bound to QDs, the power factor β is known to be determined by the origin of excitonic transitions. The single exciton (biexciton) is generally expected to have linear (quadratic) power dependence [1, 2]. For the trion, the values of β can vary between 1 and 1.5, depending on the capture mechanism of the spectator charge [3]. From figure S1, the value of β for the A-line is thus typical for the single exciton emission, whereas those for the B and C lines are characteristic for biexcitons and trions in QDs. These findings, therefore, support the hypothesis that some of the sharp lines may originate from excitons localized in QDs. The correlation energy of the exciton complexes varies depending on properties of the QDs. In GaAs QDs the correlation energy is reported to be of the order of several meV [2 - 4]. From Figure S2 it can be seen that the energy spacing between some of the sharp lines is within this energy range, which further supports the hypothesis. However, the definite values of the binding energies of biexction and trions cannot be determined from the present study due to the high spectral density of the detected lines.

III. Polarization of PL emission in the GaAs/GaNAs NWs with different N-compositions

Two samples, A and B, of GaAs/GaN_xAs_{1-x} NWs were grown, having nitrogen compositions of x=0.1 and x=0.5 % respectively. Figures S3 and S4 (a) show representative parts of photoluminescence spectra acquired from individual NWs from samples A and B, as a function of the polarization angle, θ. It can be seen that both samples A and B have the majority of lines polarized approximately orthogonal to the nanowire growth axis (111), while some lines show different polarizations. Figures S3 and S4 (b) show a magnification of two of the lines and figures (c) and (d) show the PL-peak intensity as a function of the polarization angle θ of those two lines. Varying the nitrogen content in this range does not significantly change the polarization properties of the sharp lines.

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[3] M. Abbarchi, C. Mastrandrea, T. Kuroda, T. Mano, A. Vinattieri, K. Sakoda, M. J. Gurioli, *Appl. Phys.* 2009*,* **106***,* 053504.

[4] K. Matsuda, T. Saiki, S. Nomura, M. Mihara, Y. Aoyagi, S. Nair, T. Takagahara, *Phys. Rev. Lett.* 2003, **91**, 177401.

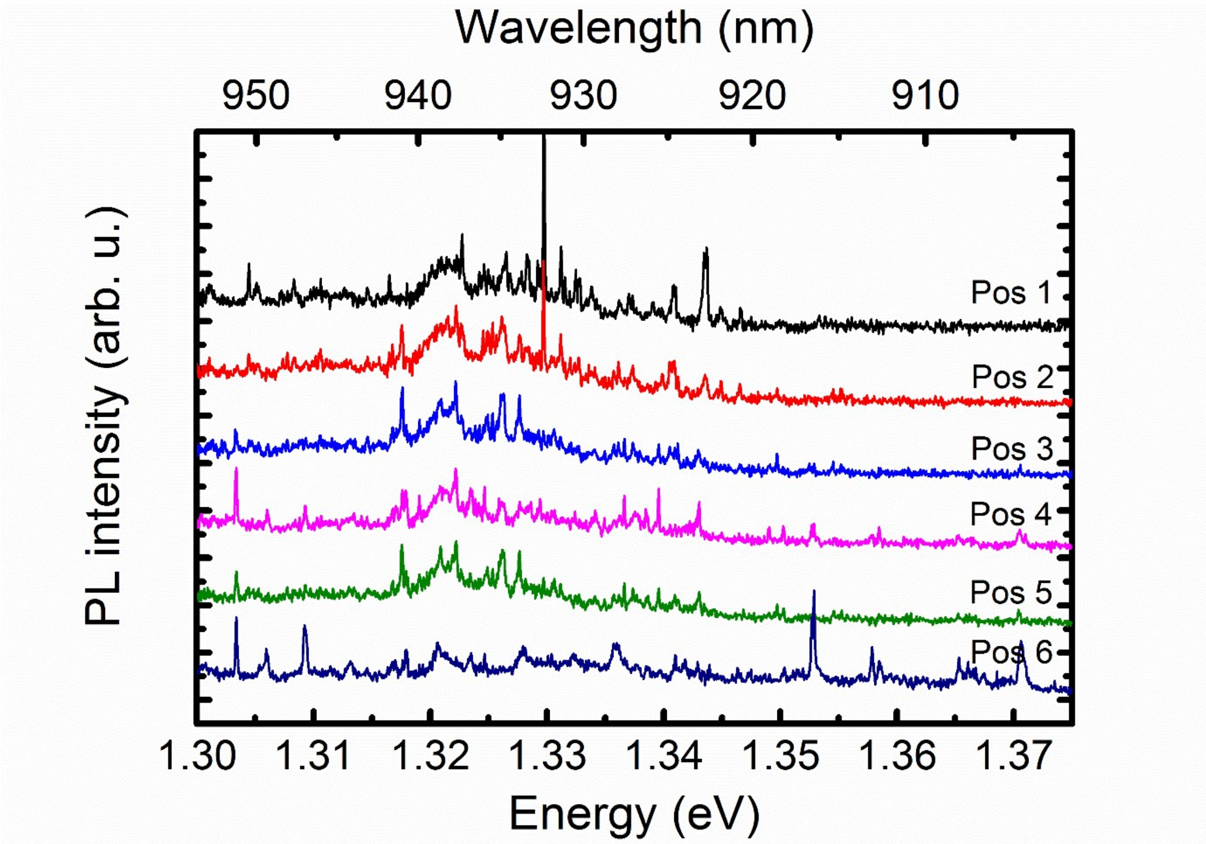

Figure S1. μ-PL spectra measure at 5K from one single GaAs/$GaN_{0.005}As_{0.995}$ NW. The spectra marked as Pos. 1, 2, 3, 4, 5, 6 were measured at different positions on the NW.

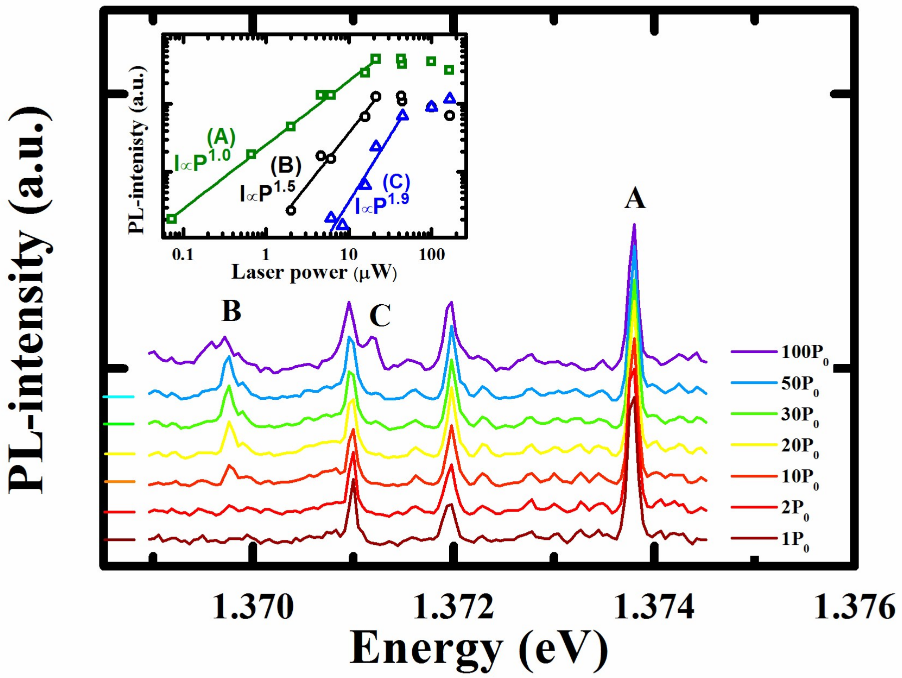

Figure S2. Excitation power dependent PL spectra displayed, as an example, within the 1.369-1.375 eV spectral range. The spectra are acquired from a single GaAs/$GaN_{0.005}As_{0.995}$ NW, and are normalized to the peak intensity of the line that is labeled as A in the figure. They are further shifted vertically for clarity as indicated by the horizontal lines on the left side of the figure. In the inset the symbols show power dependences of the peak intensities of the lines labeled as A, B and C in the spectra, and the solid lines show the best fits to the experimental data using the specified power factors.

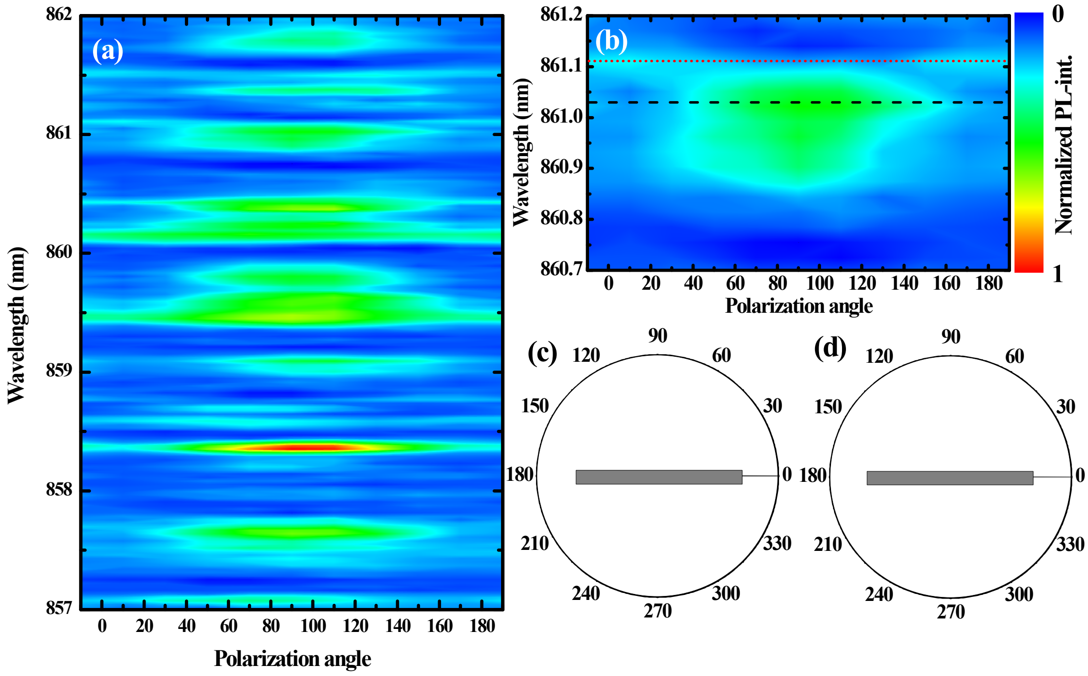

Figure S3. Polarizartion angle dependence of the emitted photoluminescence from one single $GaAs/GaN_{0.001}As_{0.999}$ NW. (a) A wide range of the PL spectrum, containing many sharp lines. (b) A part of the spectrum with two PL lines, which exhibit parallel (denoted by the dotted red line) and orthogonal (denoted by the dashed black line) polarization. The same lines are shown in angular plots in (c) and (d), where the NW direction is shown with the grey bar.

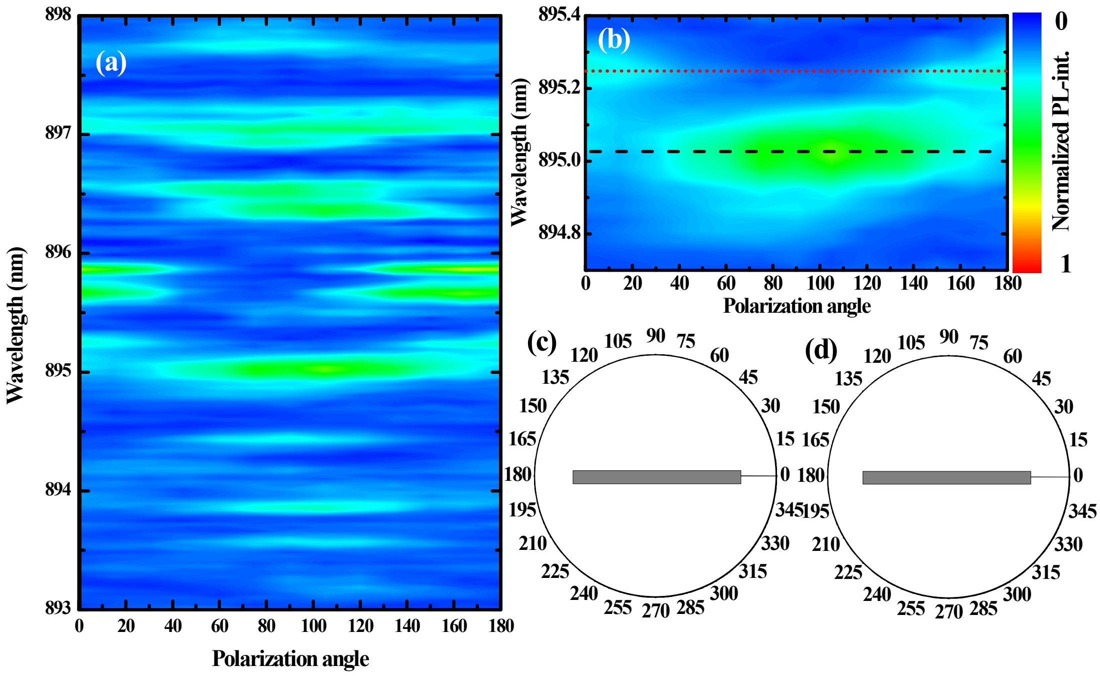

Figure S4. Polarizartion angle dependence of the emitted photoluminescence from one single GaAs/$GaN_{0.005}As_{0.995}$ NW. (a) A wide range of the PL spectrum, containing many sharp lines. (b) A part of the spectrum with two PL lines, which exhibit parallel (denoted by the dotted red line) and orthogonal (denoted by the dashed black line) polarization. The same lines are shown in angular plots in (c) and (d), where the NW direction is shown with the grey bar.