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Total number of authors:
12

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Vajner, D. A., Holewa, P., Sakanas, A., Gür, U. M., Mrowinski, P., Huck, A., Yvind, K., Gregersen, N., Musial, A., Syperek, M., Semenova, E., & Heindel, T. (2023). *On-demand Generation of Indistinguishable Photons in the Telecom C-Band*. Abstract from 22nd International Conference on Electron Dynamics in semiconductors, Optoelectronics and Nanostructures, Münster , North Rhine-Westphalia, Germany.

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On-demand Generation of Indistinguishable Photons in the Telecom C-Band

Daniel A. Vajner¹, Paweł Holewa^{2,3,4}, Aurimas Sakanas³, Ugur M. Gür³, Paweł Mrowinski², Alexander Huck⁵, Kresten Yvind^{3,4}, Niels Gregersen³, Anna Musiał², Marcin Syperek², Elizaveta Semenova^{3,4} and Tobias Heindel¹

¹*Institute of Solid State Physics, Technische Universität Berlin, 10623 Berlin, Germany*

²*Department of Experimental Physics, Faculty of Fundamental Problems of Technology, Wrocław University of Science and Technology, Wyb. Wyspińskiego 27, 50-370 Wrocław, Poland*

³*DTU Electro, Department of Electrical and Photonics Engineering, Technical University of Denmark, Kongens Lyngby 2800, Denmark*

⁴*NanoPhoton-Center for Nanophotonics, Technical University of Denmark, 2800 Kongens Lyngby, Denmark*

⁵*Center for Macroscopic Quantum States (bigQ), Department of Physics, Technical University of Denmark, 2800 Kongens Lyngby, Denmark*

Semiconductor quantum dots (QDs) generate single and entangled photons for applications in quantum information and quantum communication [1]. While QDs emitting in the 780 nm to 950 nm spectral range feature close-to-ideal single-photon purities and indistinguishabilities [2], they are not the best choice for non-classical photon sources devoted to silica fiber networks, due to the high optical losses in this spectral range. In this case, QDs operating in the low-loss spectral window near 1550 nm (telecom C-band) are a highly interesting solution. For that, either InAs/InP [3,4] or InAs/GaAs [5] material platforms can be used for making QD emitters. The latter platform requires tailoring strain through a modified growth scheme to shift emission to the C-band. Many ground-breaking results concerning single and entangled photon sources have been demonstrated using the InAs/GaAs QDs [6]. However, during the last few years, InAs/InP QDs technology has reached notable progress, resulting in state-of-the-art QD-based devices delivering non-classical photons in the C-band [7].

In this work, we demonstrate the coherent on-demand generation of indistinguishable photons at telecom C-band wavelengths from single QD devices. The latter consist of InAs/InP QDs in mesa structures heterogeneously integrated on silicon [7]. Using pulsed two-photon resonant excitation (TPE) of the biexciton-exciton (XX-X) radiative cascade, we show for the first time, for this material system, pulsed Rabi rotations up to 4 π in the emission from the XX- and X-state as a function of the excitation pulse power. We observe high single-photon purity in terms of $g^{(2)}(0)$ values of 0.005(1) and 0.015(1) for the photons originating from the XX- and X-state respectively. Analyzing the radiative decay times, we find a 4-times faster decay of the biexciton compared to the exciton state, which would ultimately limit the maximum achievable photon indistinguishability to $\sim 80\%$ under TPE [8]. By performing Hong-Ou-Mandel-type two-photon interference experiments and comparing co- and cross-polarized coincidences in a realistic 4ns time window, we obtain photon-indistinguishabilities of $V_{4\text{ns}} = 35(1)\%$ for the XX photons. This represents a significant improvement of the best C-band photon-indistinguishability reported to date [5].

Our work thus constitutes an important step towards next generation of quantum networks using deployed optical fibers in combination with engineered silicon-integrated quantum light sources.

References:

- [1] Vajner, Daniel A. et al., *Advanced Quantum Technologies* 5.7 (2022): 2100116.
- [2] Schöll, Eva et al., *Nano Letters* 19.4 (2019): 2404-2410.
- [3] Benyoucef, Mohamed et al., *Applied Physics Letters* 103.16 (2013): 162101.
- [4] Dusanowski, Łukasz et al., *Applied Physics Letters* 105.2 (2014): 021909.
- [5] Nawrath, Christian et al., *Applied Physics Letters* 115.2 (2019): 023103.
- [6] Portalupi, Simone Luca et al., *Semiconductor Science and Technology* 34.5 (2019): 053001.
- [7] Holewa, Paweł et al., in preparation
- [8] Holewa, Paweł et al., *ACS Photonics* 9.7 (2022): 2273-2279.
- [9] Schöll, Eva et al., *Physical Review Letters* 125.23 (2020): 233605.