Joint CQSE and CASTS Seminar

2019
Feb. 22, Friday

TIME	Feb. 22, 2019, 14:30 ~ 15:30
TITLE	Single-photon Emission from an Acoustically-driven Lateral Light-emitting Diode
SPEAKER	Dr. Tzu-Kan Hsiao
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PLACE	Rm716, CCMS & New Physics Building, NTU

Abstract

Single-photon sources are essential building blocks in quantum photonic networks, where quantum-mechanical properties of photons are utilised to achieve quantum technologies such as quantum cryptography and quantum computing. Most conventional solid-state single-photon sources are based on single emitters such as self-assembled quantum dots, which are created at random locations and require spectral filtering. These issues hinder the integration of a single-photon source into a scaleable photonic quantum network for applications such as on-chip photonic quantum processors. In this work, using only regular lithography techniques on a conventional GaAs quantum well, we realise an electrically triggered single-photon source with a GHz repetition rate and without the need for spectral filtering. In this device, a single electron is carried in the potential minimum of a surface acoustic wave (SAW) and is transported to a region of holes to form an exciton. The exciton then decays and creates a single photon in a lifetime of $\sim 100\,\text{ps}$. This SAW-driven electroluminescence (EL) yields photon antibunching with the second-order correlation function $g^{(2)}(0) = 0.39 \pm 0.05$, which satisfies the common criterion for a single-photon source $g^{(2)}(0) < 0.5$. Furthermore, we estimate that if a photon detector receives a SAW-driven EL signal within one SAW period, this signal has a 79%–90% chance of being a single photon. This work shows that a single-photon source can be made by combining single-electron transport and a lateral n-i-p junction. This approach makes it possible to create multiple synchronised single-photon sources at chosen positions with photon energy determined by quantum-well thickness. Compared with conventional quantum-dot-based single-photon sources, this device may be more suitable for an on-chip integrated photonic quantum network. On the other hand, our technique may also be used to convert an electron-spin state into a photonic state (flying qubit) to achieve a more scalabe quantum computing network.

References

C. L. Foden, V. I. Talyanskii, G. J. Milburn, M. L. Leadbeater, and M. Pepper, *High-frequency acousto-electric single-photon source.* Physical Review A 62, 011803 (2000)

C. J. B. Ford, *Transporting and manipulating single electrons in surface-acoustic-wave minima.* Physica Status Solidi (B) Basic Research 254, 1600658 (2017)

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