Hybrid Electroluminescence Device Generating On-Demand Single Photons in Room Temperature

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Solid-state single photon emitters (SPEs) are nowadays one of the most promising platforms for providing a commercially viable devices that could be utilized in the technologies based on the quantum properties of light, e.g. quantum information storage, communications and sensing. So far the III-V group-based quantum dots (QDs) are the only system that has proved capable o supporting commercial-grade SPEs. Although these types of nanostructures can display nearly deterministic and highly efficient generation of photons of near-unity indistinguishability at the same time their implementation on a larger scale would require solutions that are, among others, cost- and production time-effective, reliable and reproducible. These issues are particularly obstructive for the platform, which depends on the manual selection of stochastically-produced SPE structures and also requires cryogenic temperatures and external laser excitation for its operation. In that context the recent advancements in the studies of SPEs in layered semiconductor materials, e.g. transistion metal dichalcogenides and hexagonal boron nitride offer a promising new path towards a low-cost alternative to QDs[1]. Furthermore, due to their ease of manufacture these materials can be simply integrated into stand-alone single-photon emitting devices like in the newly reported top-to-bottom excitation approach[2].

In this work we present prototype devices consisting of GaN-based 420 nm laser diodes passivated with highly reflective coating, which are used for exciting single-photon emitters in hBN nanocrystals deposited on top of the laser facets as presented in the Fig. 1. In the light emitted from these structures, that operate in room temperature, we observe narrow emission lines in the visible wavelength range of 600-800 nm. The single photon character of this signal is confirmed by the $g^{(2)}$ autocorrelation measurements which yield a zero-time-delay value of 19% satisfying the single-photon condition of $g^{(2)}(0) < 50\%$. Furthermore, in order to to test the viability of our approach for the on-demand generation of single photons, we use pulsed electrical driving of the laser diode to generate light pulses with short temporal width below 2 ns. This timescale is sufficiently short for the case of the chosen system of hBN emitters characterised by the lifetimes in the approximate range of 4-10 ns, which exceeds the duration of the laser pulses. This pulsed operation is then employed for the excitation of the deposited hBN, where, again, autocorrelation measurements are perfomed on the signal of an exemplary narrow emission line yielding the $g^{(2)}(0) = 37\%$ and confirming the on-demand generation of single photons in room conditions.

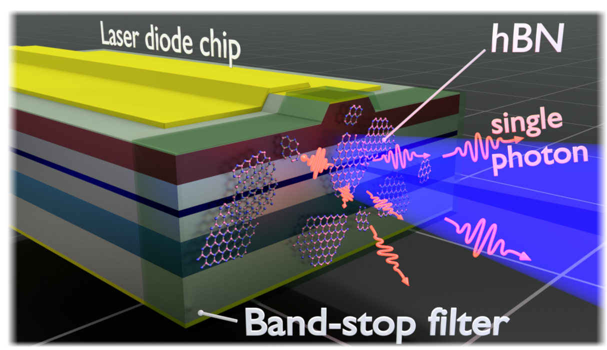

Fig. 1. Visualisation of the hybrid single photon emitter device

Presented compact, room-temperature-operating device that emits on-demand single photons from a low-cost material may be even further optimized to increase its scalability on an industrial level, for example by employing the already existing solutions to hBN deposition or by the implementation of 3D-printed microlenses [3].

References

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