Single photon light-emitting diodes based on III-nitrides for quantum technologies

Quantum technologies like modern cryptography, quantum computing and quantum memories will surely have a great impact on our everyday life in the near future. The promise of unprecedented computing speed offered by quantum computers imposes at the same a need to improve the encryption methods. Numerous research groups are involved in using quantum mechanics to work out new concepts and architectures to implement quantum communication in devices.

The goal of this project is to develop one of the key components needed for quantum technologies: single photon light sources (e.g. for quantum key distribution protocol in telecommunication networks). An ideal single-photon source (SPS) for these applications should strictly provide on-demand generation of only one photon at ultrashort temporal intervals, with predefined and deterministic optical linear polarization, at temperatures relevant to on-chip environments. For the purpose of quantum computation these single photons should also be indistinguishable in their optical properties.

Among different solutions to fabricate SPSs, semiconductor quantum dots (QDs) have attracted considerable attention in the recent years thanks to their outstanding potential as a material for high-speed and integrated solid-state SPSs. A significant advantage of nitride QDs is related to their high-temperature operation, in contrast to other material systems.

In this Project we will fabricate and investigate monolithic electrically driven nitride single photon light emitting diodes (SP-LEDs) grown by plasma assisted molecular beam epitaxy (PAMBE). We will test SP-LED composed of a micro-LED with a nanowire (NW) containing a QD positioned on-top of the LED. The single photon emission be achieved by optical pumping of a QD by the light generated by the LED. We propose scalable process, where we place in deterministic way single QD inside one device. It is performed via selective area growth of GaN NW on Ti mask, previously used for growth of ordered NWs.

Our experience in epitaxial techniques and in advanced processing, supported with profound understanding of the physics behind, will be the key asset to reach this goal.

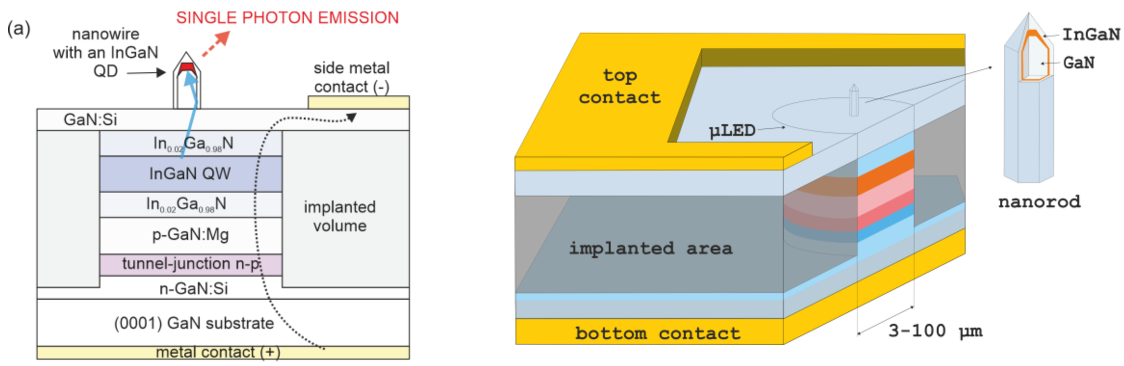

Figure 1. *QD pumped by tunnel junction µLED. Current path through LED is indicated by dotted line. Blue arrow shows the pumping light from µLED, red arrow – single photon emission from QW located on the apex of NW.*