Superconducting Nanowire Single-Photon Detector as a Key Element for Quantum Photonic Integrated Circuits

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Currently, many physical systems are studied for the realization of qubits including superconducting circuits, trapped ions and atoms, quantum dots, color centers in a solid and photons. Here after short introduction we focus on the last item in the list - photons. Due to the fact, that photons interact weakly with an optically transparent medium, do not interact with each other, have several degrees of freedom for encoding of quantum information as well as have a fast propagation speed, the photons are the best choice for creation a quantum networks. However, while the manipulation of individual photons did not cause any difficulties, the creation of two-, three- and more deterministic qubit gates require strong nonlinear interaction between photons. In this case, the advantages of the photons are transformed to their shortcomings and for a long time limited the use of photons as qubits.

Fortunately, Knill, Laflamme and Milburn (KLM) proposed the concept of linear optical quantum computing (LOQC), allowing you to create non-deterministic gates using photons, linear optical elements and detectors. Despite the fact that the implementation of the KLM-protocol is possible in free space, the need for a large number of optical components and their precise configuration requires the more complex solutions. Due to a number of advantages, such as scalability, small footprint, low weight, no need for optical alignment as well as a power consumption and CMOS-compatibility, quantum photonic integrated circuits (QPICs) can successfully solve this problem. The most popular material platforms for QPICs realization are silicon, gallium arsenide, and polycrystalline diamond. Each platform has its own advantages and disadvantages and is characterized by its degree of development. Nevertheless, all of these platforms have the fundamental blocks that require combining on-chip, such as single photon source, linear optical elements and single-photon detectors. In the presentation, I'm going to talk about operation principles, a history of development as well as the latest success of the most promising approach for QPICs realization, based on hybrid nanophotonic-superconductor devices. The realization of large scale QPICs, can produce a profound impact on science and technology, material engineering, as well as quantum information processing including quantum computing, simulation and metrology.