Hybrid Integration of III-V Nanowires Embedded with Quantum Dots on SiN Photonic Integrated Circuits

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Solid-state emitters that generate on-demand single-photons play an integral part in many quantum information technologies. Semiconductor quantum dots (QDs), such as InAs quantum dots embedded in InP nanowires (NWQDs), are single-photon sources that can reliably be grown to operate at desired wavelengths [1, 2]. Integrated optics, which is the basis for building complex circuits using different optical components on chip, can provide a miniaturized, stable platform for single-photon generation and manipulation. As such, combining NWQD single-photon sources and silicon-based photonic integrated circuit is a promising technology for the fabrication of stable, scalable, low-loss quantum circuits for applications in future quantum networks.

Our approach for generating on-chip indistinguishable photons is based on the evanescent coupling [3, 4] of high performance single photon sources (NWQDs) [2] to SiN-based photonic integrated circuitry. Using a pick-and-placed method, the nanowire is taken from the growth substrate (Fig. 1a) and placed along a SiN waveguide (Fig. 1b) in the photonic circuit. The emitted light can then be easily coupled into the circuit. Nanometer-scale precision placement is achieved using nano-manipulator probes in a scanning electron microscope setup.

We have used this hybrid integration approach to demonstrate devices having high QD emission-waveguide coupling efficiency (>90%), high single-photon purity (>95%) (Fig. 1c (top)), and high two-photon interference visibilities (>90% under continuous wave excitation; 19.2% under pulsed excitation shown in Fig. 1c (bottom)) [5]. We are currently in the process of incorporating these NWQDs into more complex integrated photonic circuits (Fig. 1d) capable of generating, manipulate, and detecting single-photons on chip.

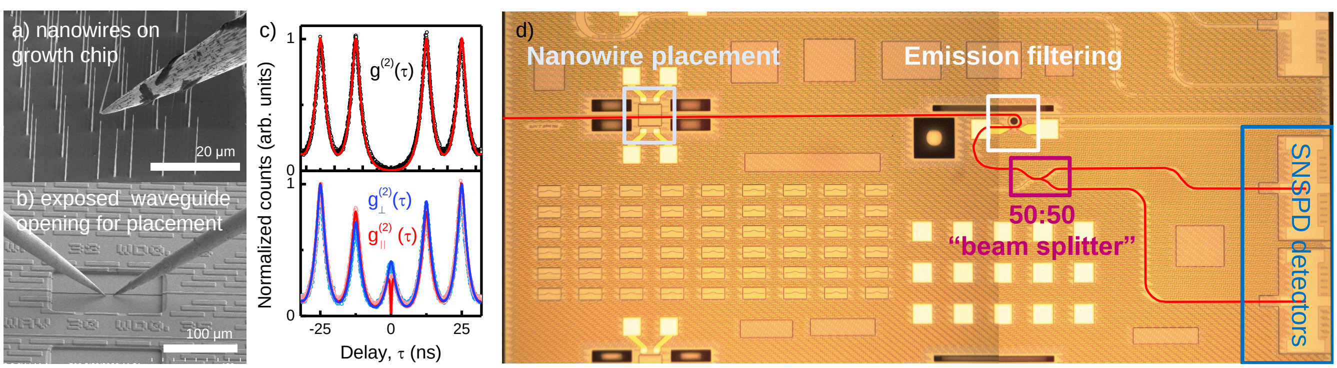

Fig. 1. **Pick-and-place method**: (a) a single nanowire is picked up by a probe tip and (b) transferred to a chip containing waveguides. (c) **Non-postselected** $g^{(2)}(\tau)$ **correlation measurements using quasi-resonant excitation** showing (top) the auto-correlation (single-photon purity >95%) and (bottom) the correlation measurements for co-(red) and cross (blue) polarization measurements. (d) **Hanbury Brown and Twiss experiment on-chip.** One emission line from the NWQD is filtered from the other peaks and pump laser using a ring resonator and sent to two SNSPD detectors via a 50:50 splitter for measuring coincidences.

References

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