Hybrid quantum photonic integrated circuits

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Photonic quantum information processing applications require a scalable approach to integrate large numbers of entangled photon-pairs light sources in complex on-chip quantum photonic circuits. Currently, the most promising bright on-demand sources are based on III/V semiconductor quantum dots. However, sophisticated photonic circuitry is mainly achieved in silicon photonics due to technological challenges in circuit fabrication in other platforms. Our approach takes the best of both worlds by developing a new hybrid on-chip nanofabrication method [1]. We demonstrate for the first time on-chip generation, spectral filtering, and routing of single-photons from selected and positioned single III/V semiconductor nanowire quantum emitters all deterministically integrated in a CMOS compatible silicon nitride photonic circuit [2]. Our approach paves the way for large-scale integration and excitation of multiple quantum emitters in the same photonic circuit as shown in the schematic of Fig.1 a. The circuit design (shown in the inset) allows for efficient in-plane excitation of the nanowire quantum dots. Fig.1 b to g show the emission spectrum of 6 independently and deterministically integrated nanowire quantum emitters operating on the same photonic chip. Our pick and place technique for integration of single quantum emitters on-chip eliminates the need for bulky tabletop components, opening up new possibilities for quantum photonic circuits with multiple on-chip single- and entangled photon sources.

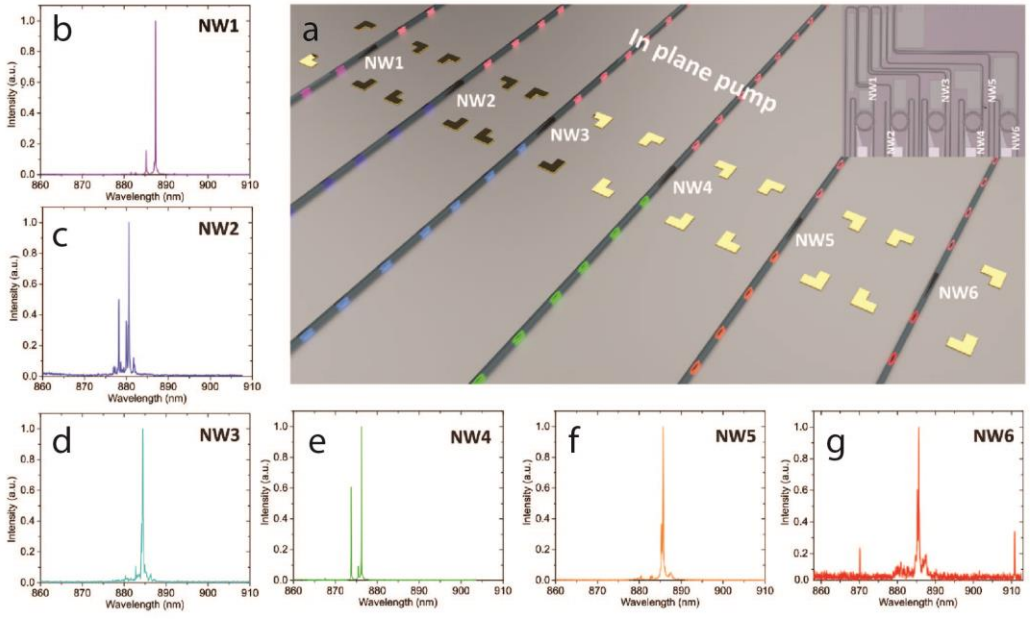

Figure 1: a) Schematic of multiple nanowire quantum dots integrated on the same photonic circuit chip. Inset shows the actual circuit design. (b-g) Spectra of the six nanowire quantum dots.

References

[1] I. Esmaeil Zadeh et al., "Deterministic integration of single photon sources in silicon based photonic circuits", Nano Letters **16(4)**, 2289-2294 (2016).

[2] A. W. Elshaari et al., "On-chip single photon filtering and multiplexing in hybrid quantum photonic circuits", Nat. Commun. **8**, 379 (2017).