Towards single-photon sources heterogeneously integrated on SiN

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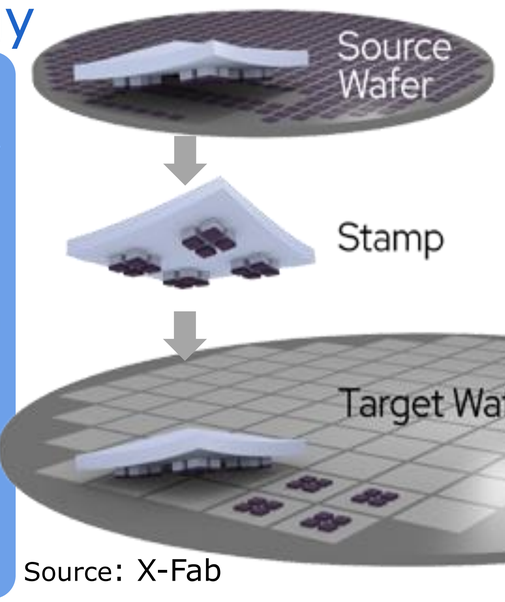
Rationale

- Very high performing single-photon sources have been realized in GaAs nanobeam waveguides[1].
- This platform suffers from propagation losses in the order of 10 dB/mm, hindering larger-scale photonic integrated circuits.
- Heterogeneous integration on SiN could overcome this bottleneck towards scalable quantum hardware.

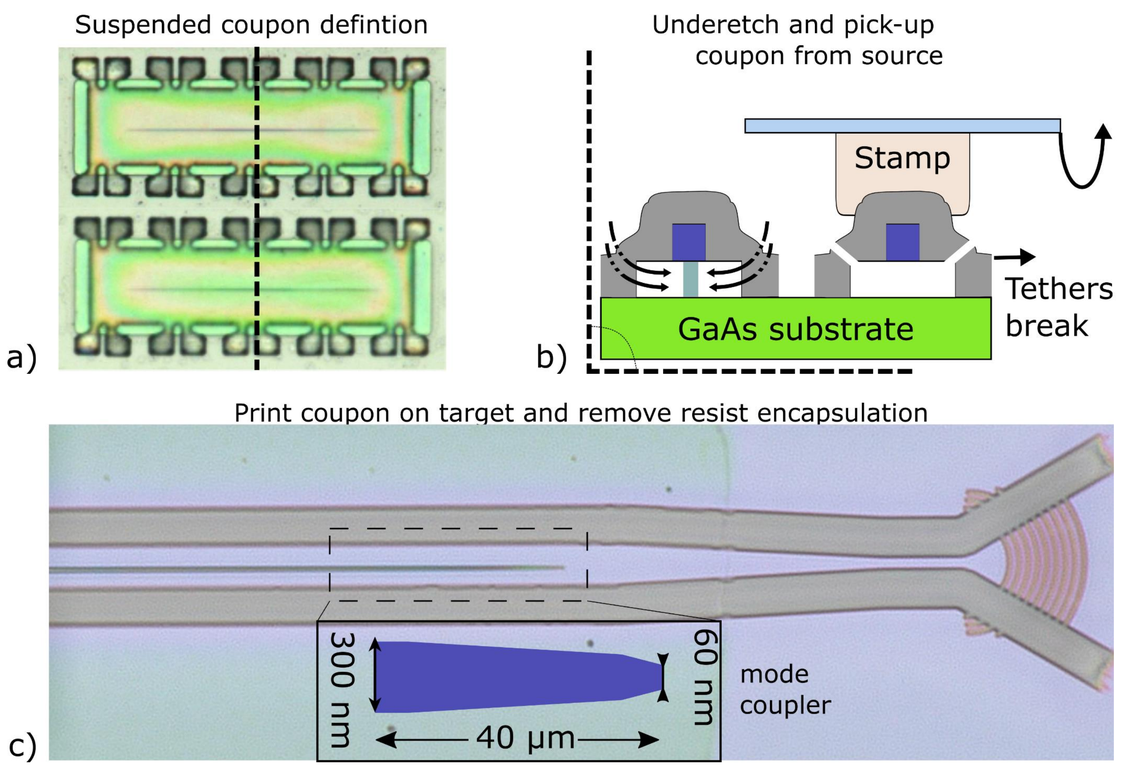
Micro-transfer printing technology

- Micro-transfer printing allows for III-V on SiN fabrication, compatible with commercial foundry photonic platforms.
- Devices from III-V source wafers are pick- and printed on top of a target wafer, possibly in high throughput.
- This scalable and versatile solution is a main research area of the PRG with most experience in printing III-V amplifiers and photodetectors[2].



Source: X-Fab

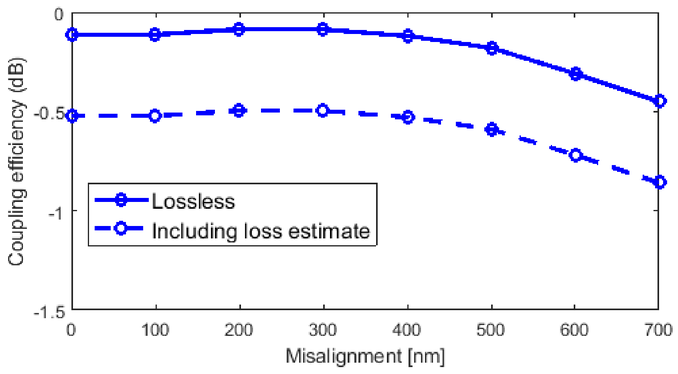
Heterogeneous integration of GaAs nanobeams



- A tapered GaAs nanobeam containing InAs quantum dots is printed on top of SiN resulting in 3 dB overall excess losses.
- The printing process for a standalone nanobeam posed new challenges to manage internal stresses in the ‘coupon’.
- Developed process:
  a) Encapsulation of the GaAs device in protective photoresist with tethers anchored to the substrate
  b) ‘Coupon’ underetching in HCl to suspend the devices
  c) Pick- and print on LPCVD SiN using BCB adhesive bonding layer

Mode coupling

- Printing with lateral accuracy < 750 nm (3σ)
- Piecewise linear mode coupler tolerant to misalignment, considering a tradeoff with propagation losses



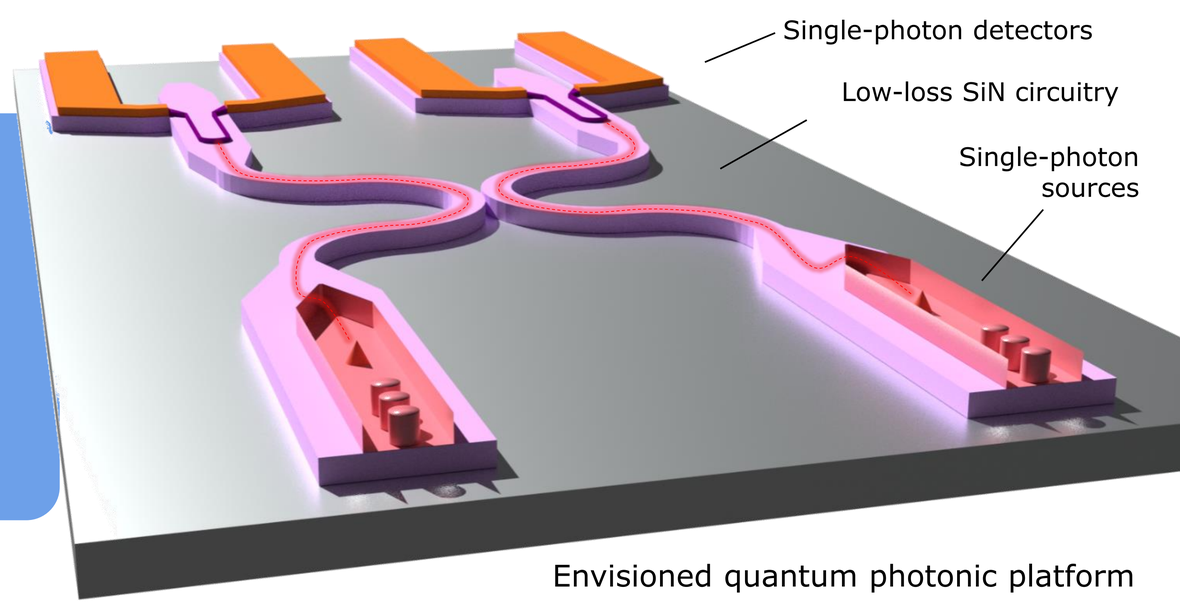
Conclusion

- GaAs nanobeam embedded with InAs quantum dots micro-transfer printed on top of low-loss SiN
- Efficient mode coupling resulting in 3dB overall losses

Future outlook

After studying the quantum dot emission, further steps are envisioned partly related to advances in the monolithic GaAs platform[1]:

- Vertical p-i-n junction to reduce charge noise
- Inline resonant excitation by means of dual-mode waveguides
- Co-integration of superconducting nanowire single-photon detectors to pave the way for larger-scale quantum information processing



Envisioned quantum photonic platform

References

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[2] J. Zhang et al., ”III-V-on-Si photonic integrated circuits realized using micro-transfer printing.” APL Photonics, 2019.
[3] L. A. Shiramin et al., ”Demonstration of a New Technique for the Transfer Printing of Graphene on Photonic Devices,” Conf, on Lasers and Electro-Optics (CLOE), 2017.

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