Large Scale Deterministic Creation of Single Photon Emitters in Silicon Nitride

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Background

Silicon Nitride (SiN) embedded single photon emitters (SPEs) were recently discovered at the interface between SiN and SiO2 after rapid thermal annealing (RTA).

Single Photon emitters are a key component in photon based Quantum Information Science and Technology (QIST). They create the Qubits.

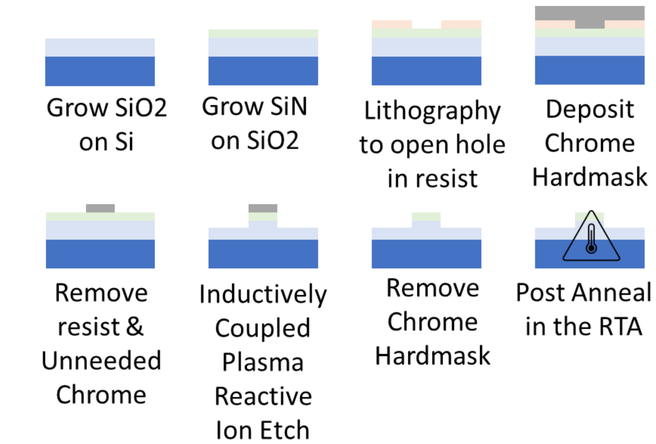
- SiN emitters can be directly integrated in SiN photonic circuitry.
- Observed SiN emitters are bright, stable, and linearly polarized.

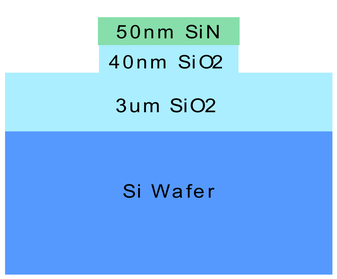
However, creation of these emitters is still stochastic which means:

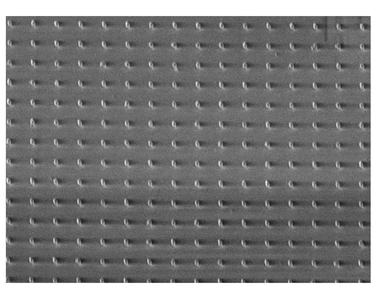
- Integration with SiN Photonic components is difficult since individual emitters need to be localized and aligned with extreme precision or done stochastically which has very low yield.

The method shown here demonstrates lithographically defined high yield and high precision placement of SiN SPEs!

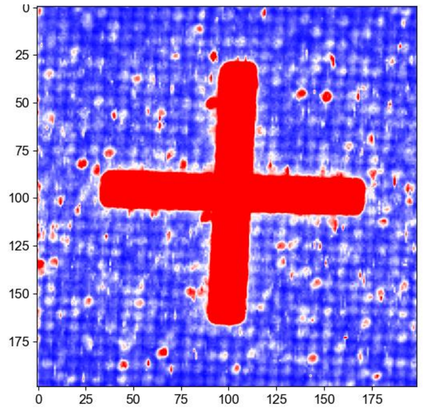
Deterministic Emitter Fabrication Process







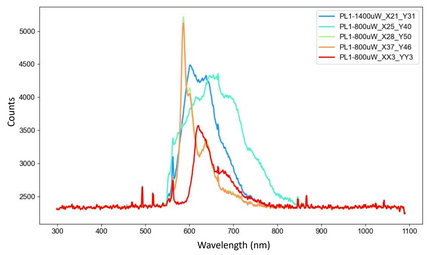
Photoluminescence Mapping of Pillar Array



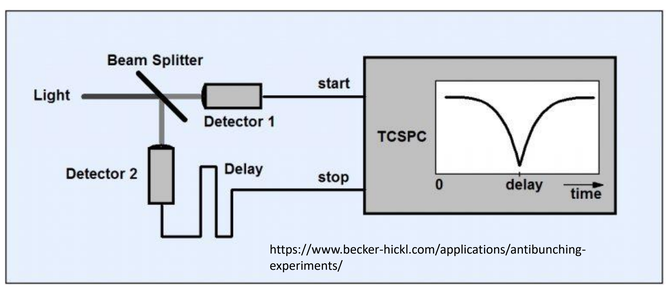
The photoluminescence (PL) emission from emitters is mapped using a homebuilt scanning microscopy stage.

The cross is an alignment mark in the center of the array. The PL emission is spatially broadened due to the diffraction limit.

The measured spectra of the pillar emission exhibits a variety of emission peaks. Most interesting of the set shown here are two different emitters with strongly overlapping and relatively narrow spectra.



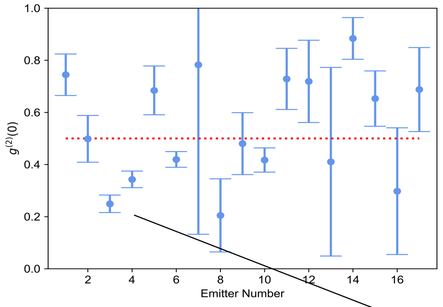
Are these emitters single emitters?



Single photon emission is assessed using the Hanbury-Twiss experiment

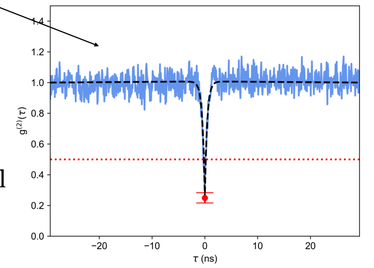
- Photon can only exist in one detector at a time at 0 time delay
- An SPE is considered single if at 0 time delay the coincidence rate is less than 0.5 after normalization

Deterministic Creation Yield



- 52% of measured emitters in a line showed single photon emitter characteristics.
- 100% showed antibunching

- The plot above shows the $g^{(2)}(0)$ values for 17 different emitters measured in a line.
- The plot to the right shows the full $g^{(2)}(t)$ curve for a single emitter.



Conclusions

- 52% of measured emitters showed $g^{(2)}(0)$ values below 0.5 indicating a single emitter
- 100% showed antibunching
- The precision of placement measured is +-85nm (radius of pillars)
- The emitter position is defined lithographically, and is compatible with future aligned lithographic processes
- This fabrication technique opens the way to extremely large integration of SiN SPEs with nanophotonic structures

Future Work