Challenges in Superconducting Chip Fabrication

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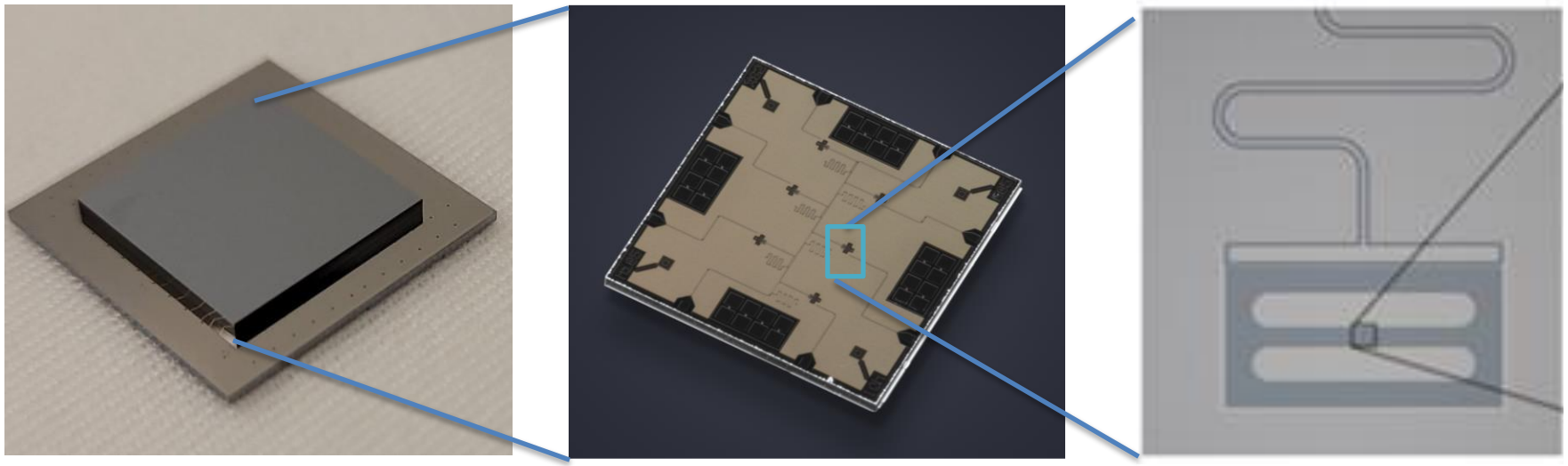
Superconducting Quantum Technology Platform

Superconducting technology is one of the most mature quantum technology platforms:

- Based on mature semiconducting fabrication techniques
- Large scale, high-quality QPUs and quantum computers exist

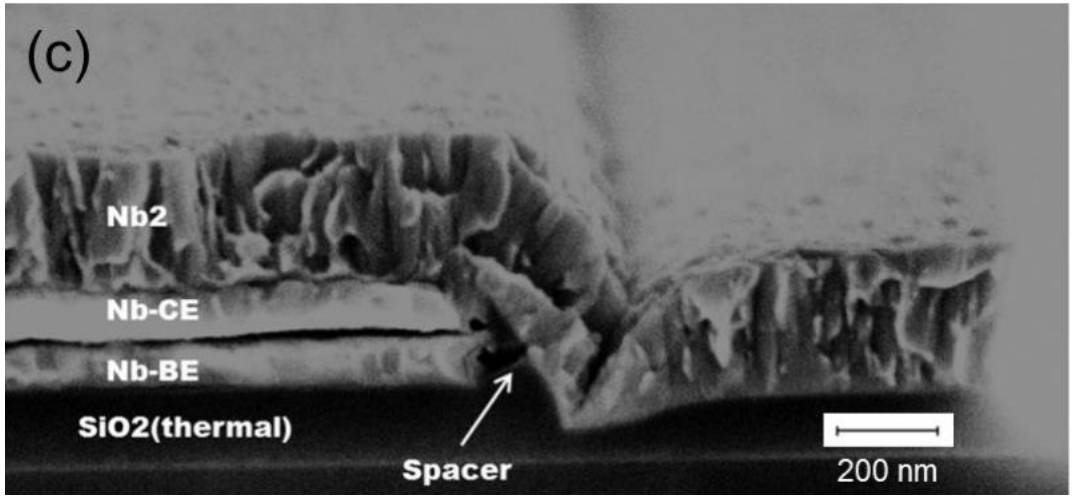


3D-integrated QPU module

Qubit chip

Qubit

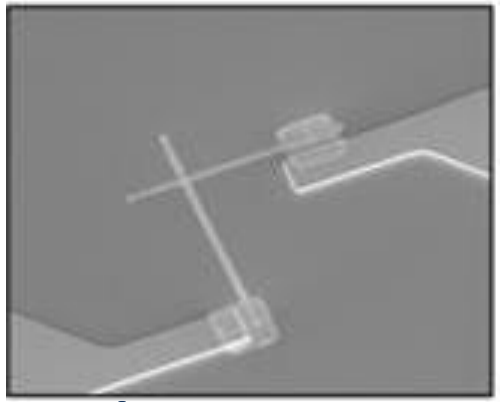
Josephson Junction



Josephson junction stack

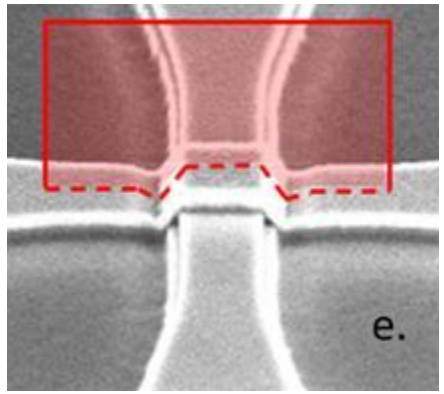
- Tunnel junction, typical stack Al/AlOx/Al, with oxide thickness ~1nm
- Size 100nm – several um
- Superconducting material stacks include materials not typically used in semiconductor industry: Aluminium, Niobium, Tantalum, Indium, Nitrides: TiN, NbN…
- Q-values 10^7 @ GHz range
- Two junction process types: angle evaporation and trilayer junctions

Fabrication and Scaling Challenges: Josephson Junctions



Angle evaporation

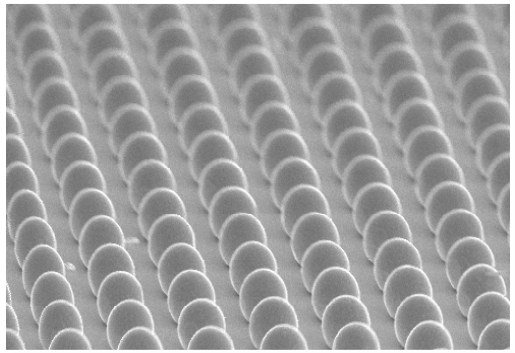
- Excellent quantum coherence
- Proces not widely used in semiconductor industry
- Small wafer sizes: 100-200mm
- Lower repeatability and yield, does not enable complex circuits with large number of junctions



Trilayer junctions

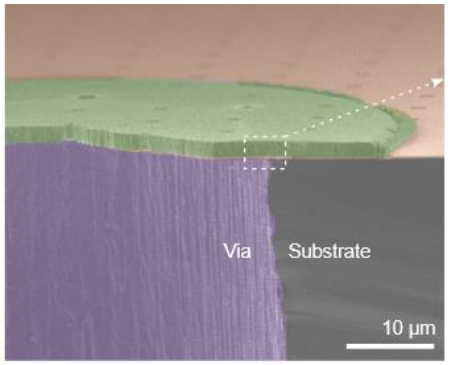
- Lower quantum coherence
- Standard sputtering and/or evaporation process
- Larger wafer sizes up to 300mm
- Higher repeatability and yield, enables complex circuits with large number of junctions

Fabrication and Scaling Challenges: 3D Integration



Bumping and Flip chip

- Superconducting bumps, typically Indium
- Density not as important as losses and quantum coherence
- Typically chip level flip-chip

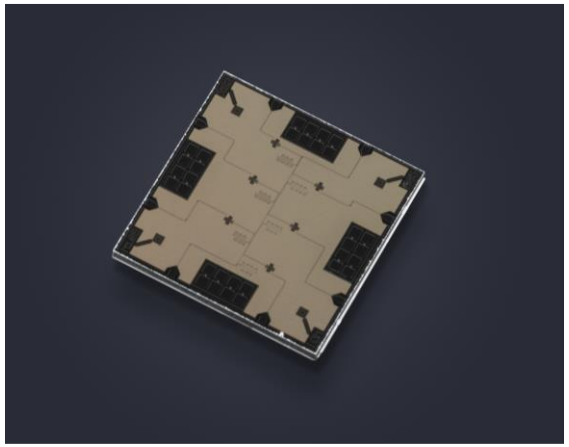


Superconducting TSVs

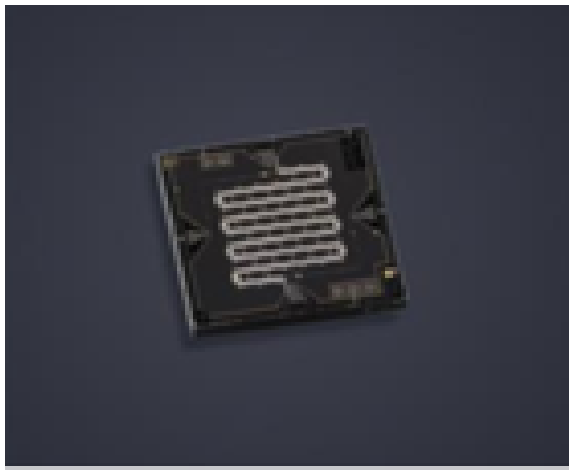
- Superconducting TSVs
- ALD superconductors, e.g. TiN
- Thick substrates >500 um
- Density not as important as losses and quantum coherence

The Superconducting Pilot Line

- Superconducting processes rely on mature processing techniques used in semiconducting industry, but require non-typical material stacks
- Market currently exists for QPUs and TWPAs, and certain sensor components
- The superconducting pilot line will develop stable and scalable high-quality quantum processes for superconducting devices
- The processes will be available for external users through PDKs and scheduled fabication runs



Qubits



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