Superconducting devices

1 Application

Goal: Reproducible manufacturing of superconductive qubits and layers

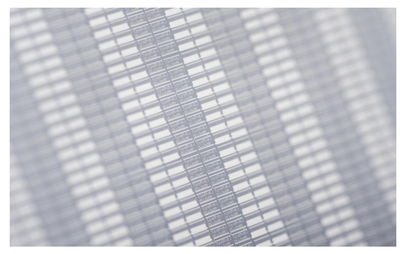
- Challenge: reproducible manufacturing of qubit chips with high coherence times und precise control of qubit frequency
- Our enabling technologies:
  - Complete qubit-chip pilot line on 200 mm wafers
  - Development of resonators with high quality based on alternative materials
- Challenge: deposition and structuring of reproducible superconducting films for quantum sensing
- Our enabling technologies:
  - Deposition and structuring on 200 mm / 300 mm wafers with high uniformity

2 Fabrication of Josephson Junctions

1. Metal layer

Conditioning and oxidation

2. Metal layer



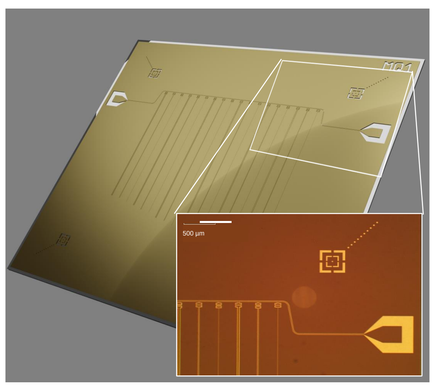
200 mm wafer with single Josephson junctions

- Aluminium based CMOS process (sputtering)
- Statistical process control (SPC) of electrical parameters
- Correlation room temperature measurements vs. cyro properties
- Continuous improvement of devices
- Current minimal junction size: 350 nm x 350 nm

3 Superconducting resonators

Coplanar-waveguide resonators

- Based on e.g. Ta or TiN
- Frequency range 5.3-7 GHz
- For superconducting and spin-based qubits and determination of quality of superconductors
- Structuring by i-Line stepper and electron beam lithography and RIE

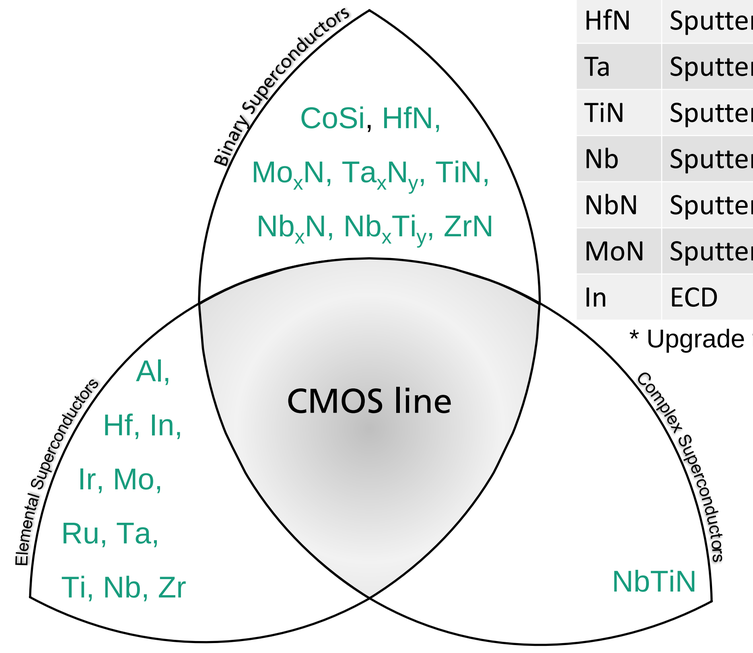


Superconducting coplanar-waveguide resonators

4 Available superconductors

Material	Deposition	Critical Temp. (K)	Max. wafer size
ZrN	Sputter	7,3	300 mm
HfN	Sputter	5,8	300 mm
Ta	Sputter	3,7	300 mm
TiN	Sputter	2,8	300 mm
Nb	Sputter	8,3	200 mm*
NbN	Sputter	13,1	200 mm*
MoN	Sputter	7,3	200 mm*
In	ECD	2,6	300 mm

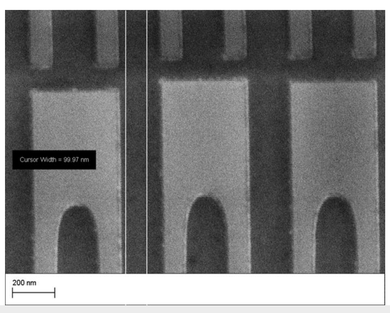
* Upgrade to 300 mm in planning



5 Quantum photonic components

Scalable processes for quantum photonic components

- Deposition and structuring of thin (<10nm) superconducting metal structures for sensor applications with high uniformity



NbTiN superconducting sensor structure

6 Summary and Outlook

Summary:

- Deposition and structuring technologies for superconducting qubits and sensor devices on 200 mm and 300 mm wafer size available

Outlook:

- Further optimization of the processes for higher qubit T1 and T2 times
- 2025: Electron beam lithography up to 50x50 nm
- Development & integration of alternative materials

For inquiries, email us at experts@module-qnc.de

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