quobly

SCREEN: Innovation for a Sustainable World

A quantum leap in the relationship with sustainable computing

Nicolas Daval
Quobly Senior VP of Engineering

Agenda

Overview of Quobly

Building Quobly's spin qubit technology on FD-SOI

Transferring our tech from research to industry

Some highlights on our realizations towards industrialization

Quobly was launched in November 2022.

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Our networks: IEC, ISO, Minalogic, EIC Scaling Club Selected Club Member, le lab quantique, QuIC, QuantAlps, #QEI, Quantum Flagship, France 2030, Les Maisons du Quantique, France Deeptech, Creative Destruction Lab, Le HUB Quantique

QUANTUM COMPUTING

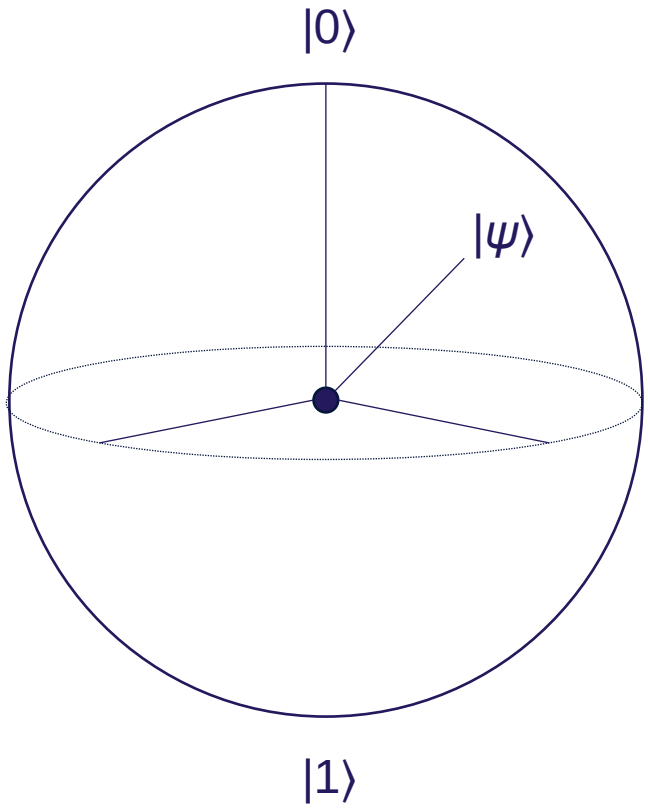
Classical bits

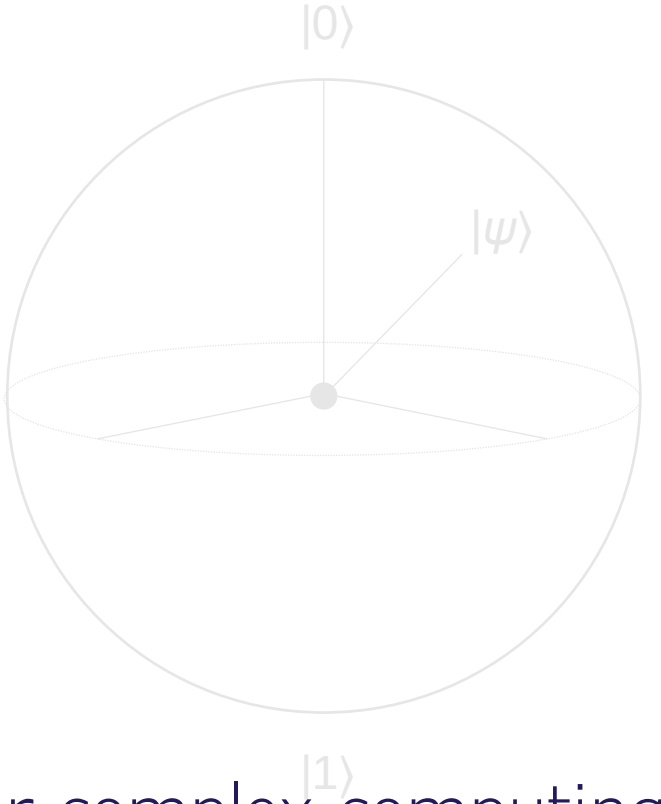
0

1

Limited binary system

Quantum bits

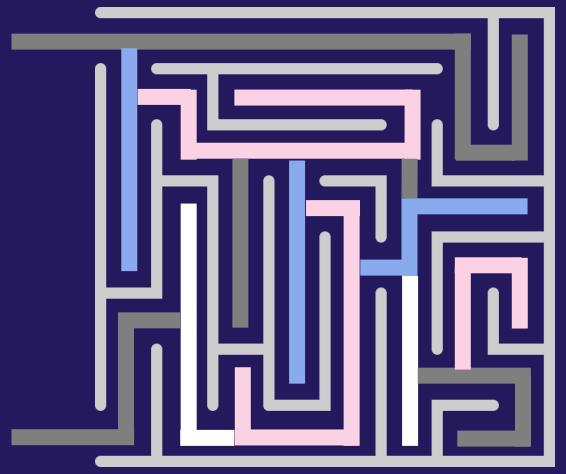




Exponential opportunities for complex computing

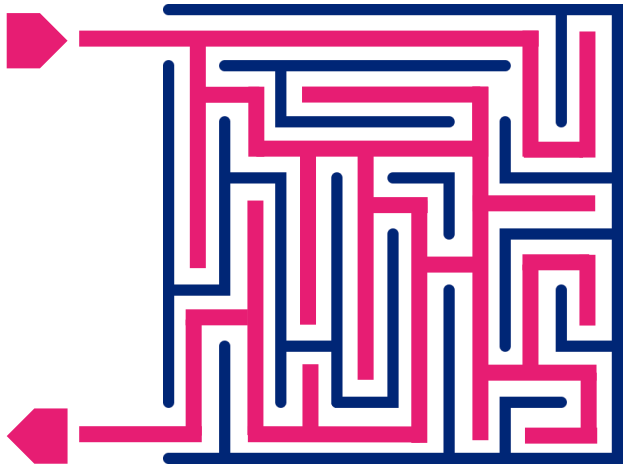
NEW POSSIBILITIES ARISE

Classical computing



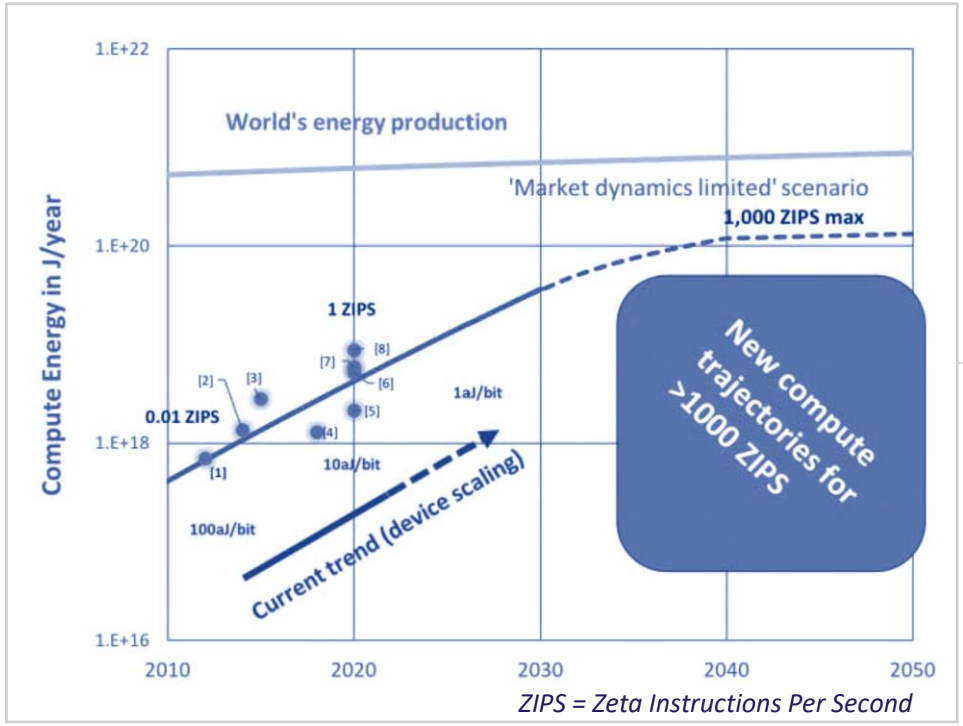
Each dead-end requires a separate operation

Quantum computing



All operations can take place in parallel. For many problems, this makes computation faster.

At its current growth rate, classical computing will be limited by a lack of energy resources within years.

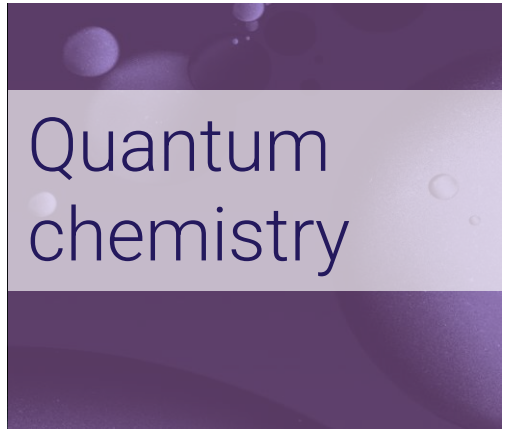


SRC report, 2020

"Revolutionary changes to computing will be required soon. Computational loads continue to grow exponentially as evidenced by the growth in "artificial intelligence" (AI) applications and training demands. New approaches to computing such as quantum computing, or other solutions will be necessary and will need to be combined in a heterogeneous manner." - SRC report, 2020

Quantum computing provides a solution: a disruptive, yet complementary, paradigm for offloading compute-heavy tasks.

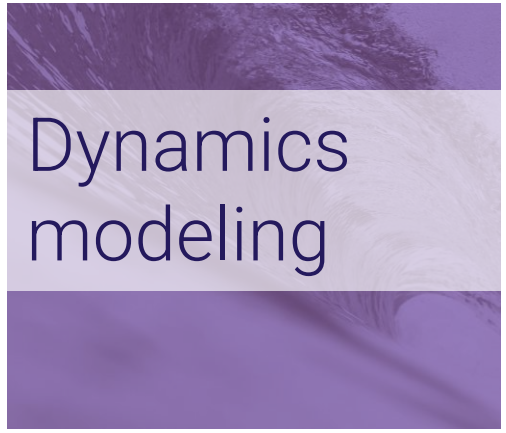
When quantum computing will have reached the maturity of full fault tolerant quantum, it will open new market segment opportunities:



Faster development of molecules for lifesaving drugs and groundbreaking materials to revolutionize medicine and manufacturing

Faster, more accurate AI algorithms and support for computationally-intensive AI tasks like optimization and large-scale simulation

Enhance transportation and logistics flow to guarantee optimal use of energy and other precious resources



Climate simulations to generate new insights into our environment and support evidence-based decision-making. Fluids deplacement for better aircraft design or nuclear reactors optimization

Value creation at stake: $ 450B - 850B(1)

(1) The Long-Term Forecast for Quantum Computing Still Looks Bright, July 18, 2024, Boston Consulting Group

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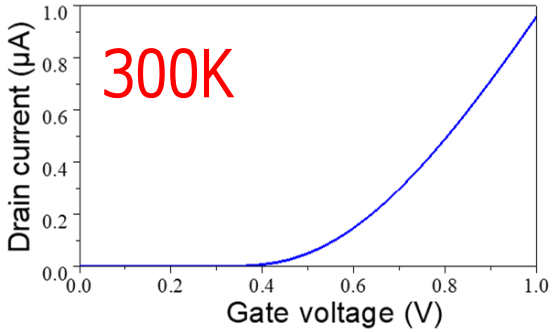
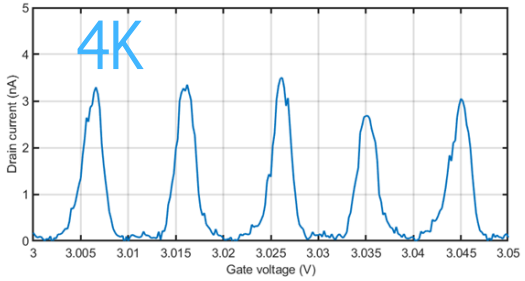
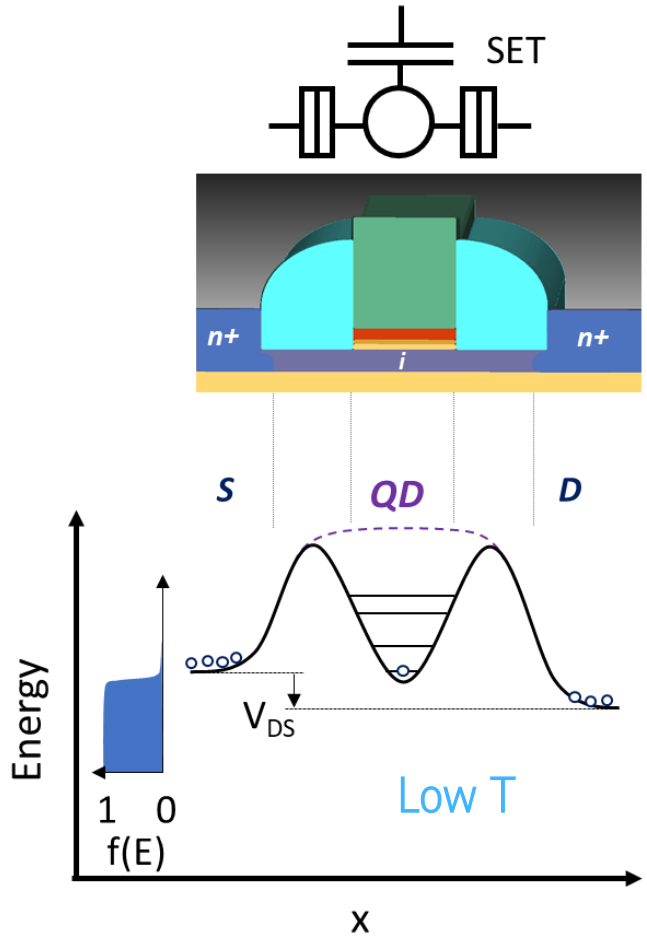
Basic principle of spin qubit

@Low T: Energy quantization in the quantum dot defined under the gate = Coulomb Blockade regime



From MOSFET to SET

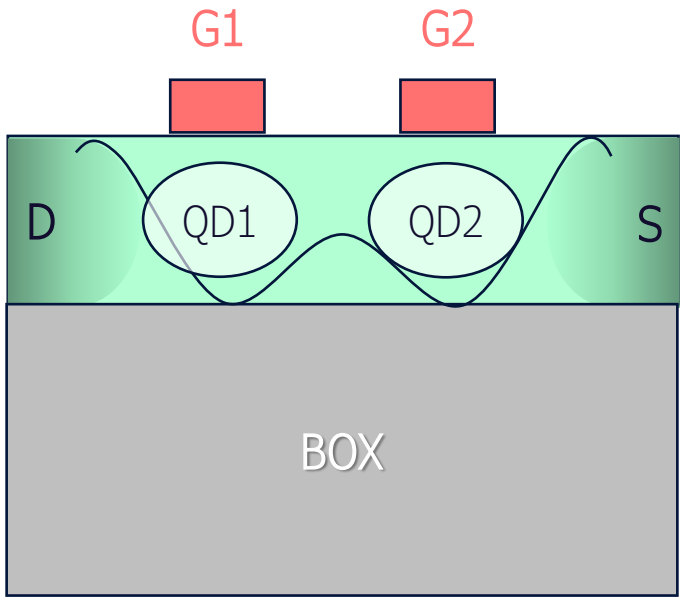


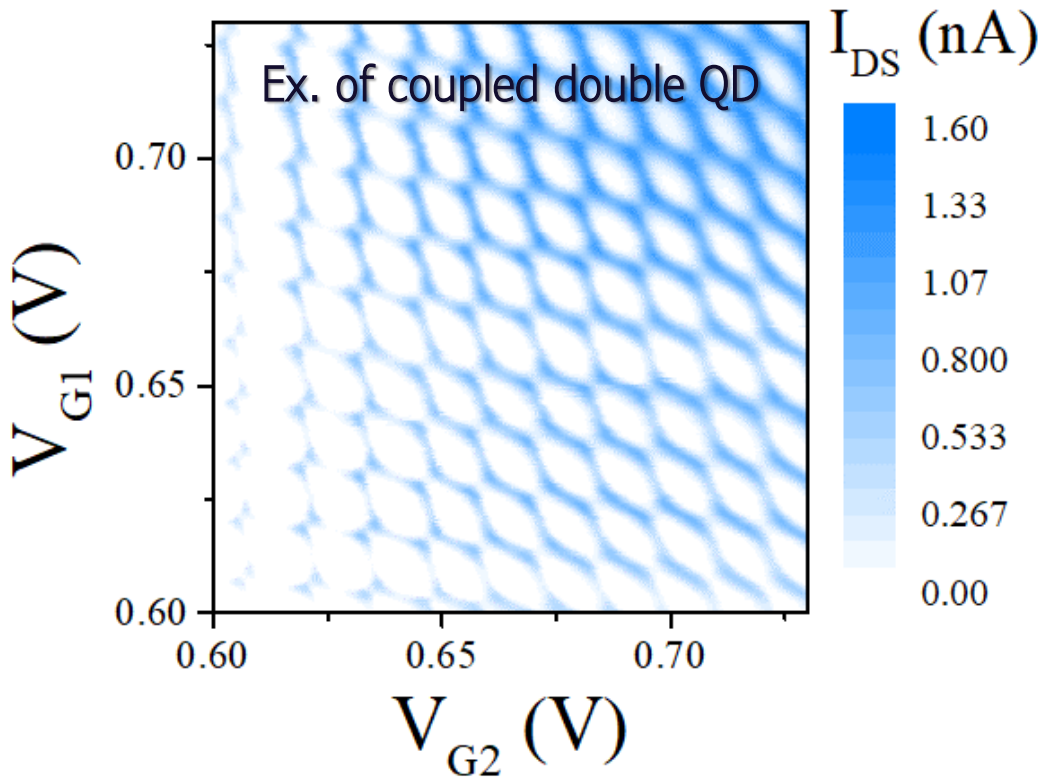


L. Hutin et al., IEDM 2018

Qubit interaction

Stability diagrams = 2D maps of I_{DS}(VG1, VG2) = Formation of QDs and coupling/position.





Qubit interaction

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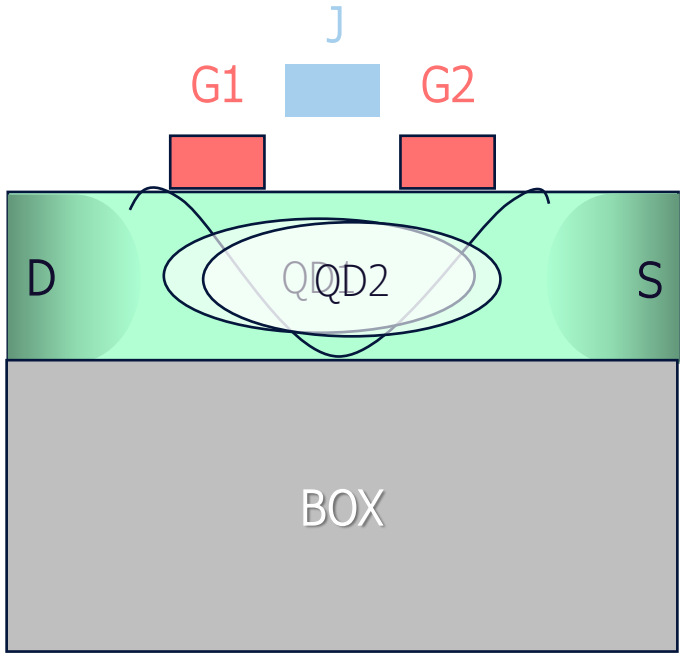
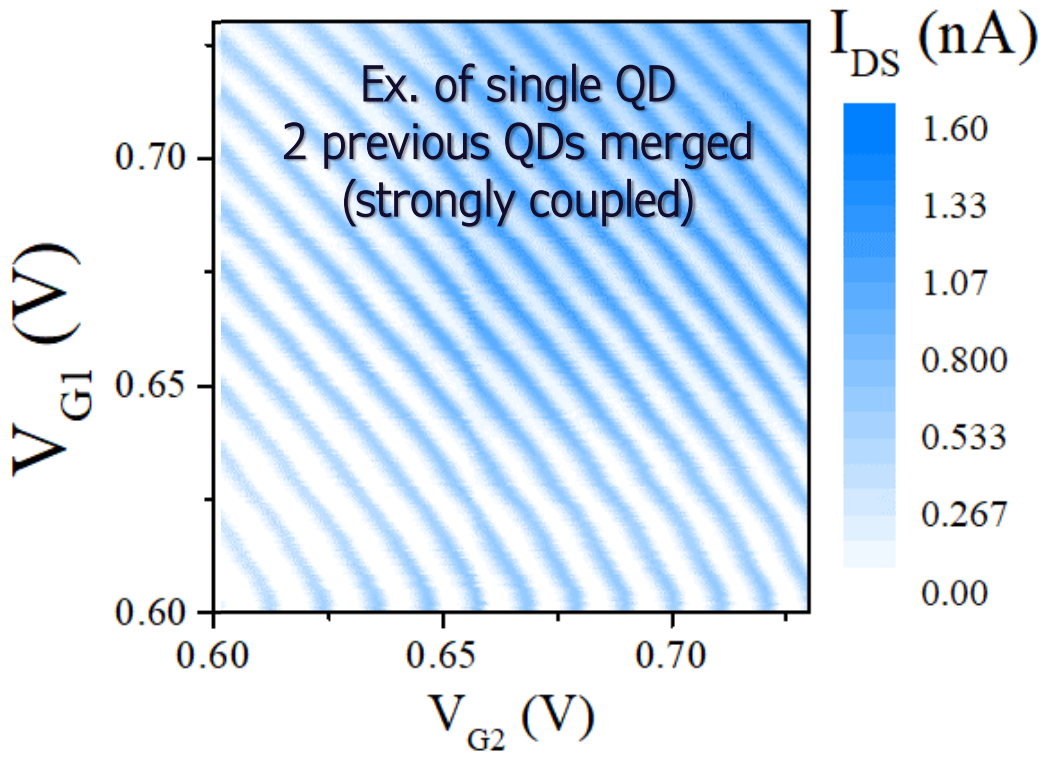
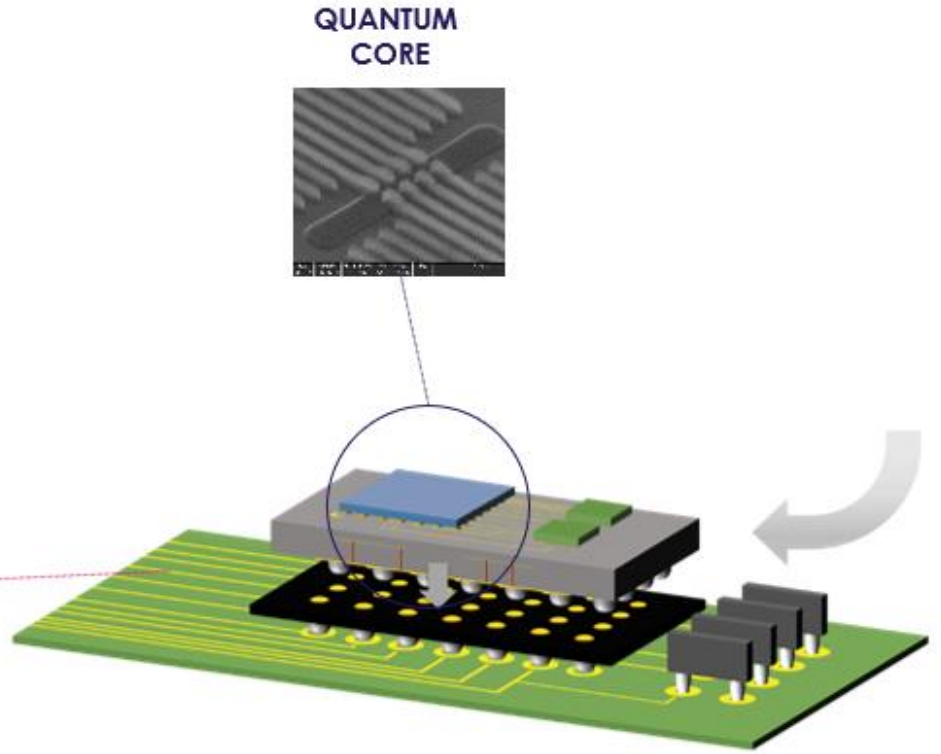




Our future product

A universal quantum server



With quantum µprocessor (QPU) based on FDSOI

Deliverables

*Delivered.
Industry-compatibility demonstrated
Seed funding deliverable

>Tech transfer from pilot line to Tier-1 foundry

Scalability demonstrated
Series A deliverables

>100 physical qubits
>Cryoelectronics on chip

1st QC with QEC PoC GtM demonstrated
Series B deliverable

>100 logical qubit chip

Product Roadmap

Quobly emulator 1.0

to show what Si-spin qubits can do

2025

Remote access

to play with Quobly's computing capacity

2025

Gen 1 QPU servers

2027

Gen 2 QPU servers

2031

Gen 3 QPU servers

2033

NISQ era

LSQ era

R&D milestones

2023

*Delivered.

Proof of QEC

Control electronics

1D array

2025

System in package (SiP)

2027

1D multicore

1D SoC

2029

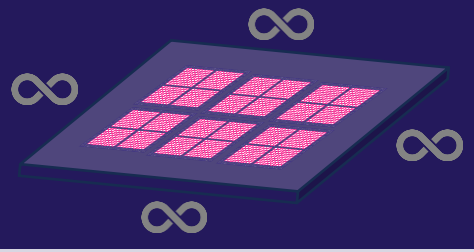
2D array

2030

2D multi-core

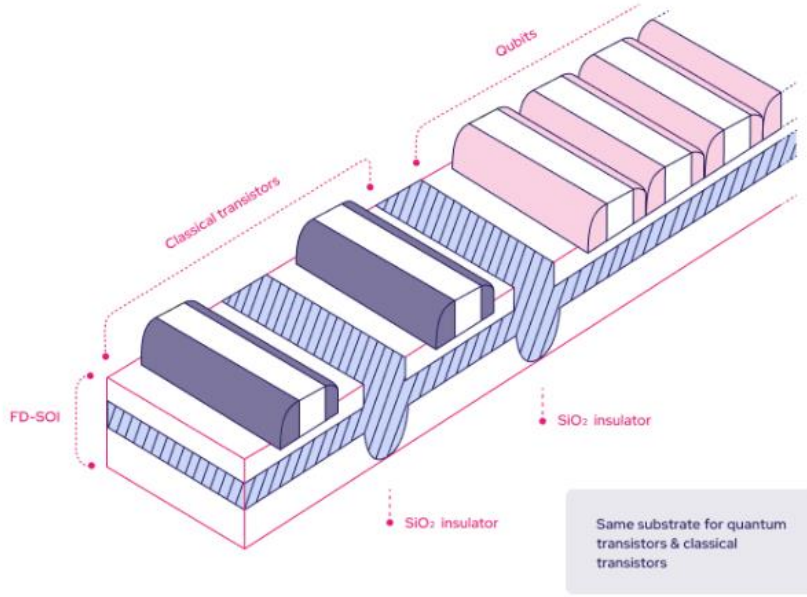
2032

2D multicore SoC with quantum links



To leverage the semiconductor industry's 60+ years of experience, we have a fabless approach using commercial FD-SOI technologies.

It's the fastest and most cost-effective path.

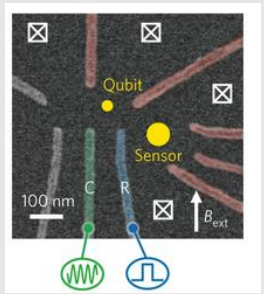


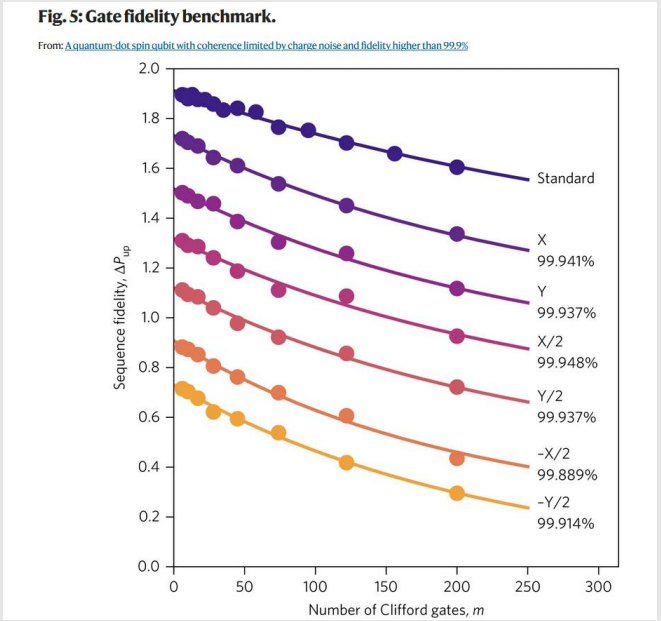
Quantum integrated circuit in cryogenic enviroment

Protected by **40+** patents

Qubits have been made successfully in silicon

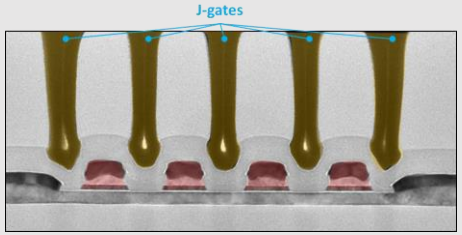
How do we make them reliably, with excellent reproducibility in very large quantities?

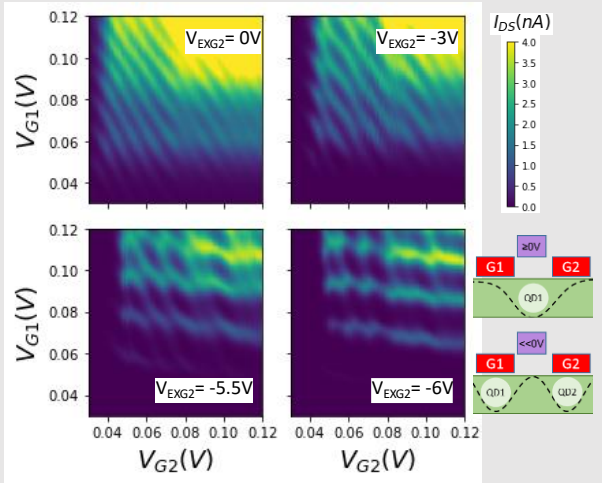




High-fidelity Si qubits demonstrated

J Yoneda, S Tarucha et al Nature 2018





Quobly's qubits foundations

T Bedeccarats, M Vinet et al IEDM 2021

Management team

Maud Vinet
CEO & co-founder
cea IBM

Tristan Meunier
CTO & co-founder
cnrs QuTech

François Perruchot
CSO & co-founder
cea tronics microsystems

Annick Gingras-Genois
SVP Operations & RH
EDF

Nicolas Daval
SVP Engineering
soitec IBM

Jean-Marc Volle
SVP Software & Architecture
BD ST

Andrea Busch
Chief of Staff
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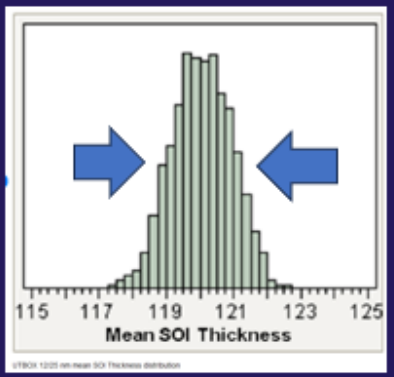
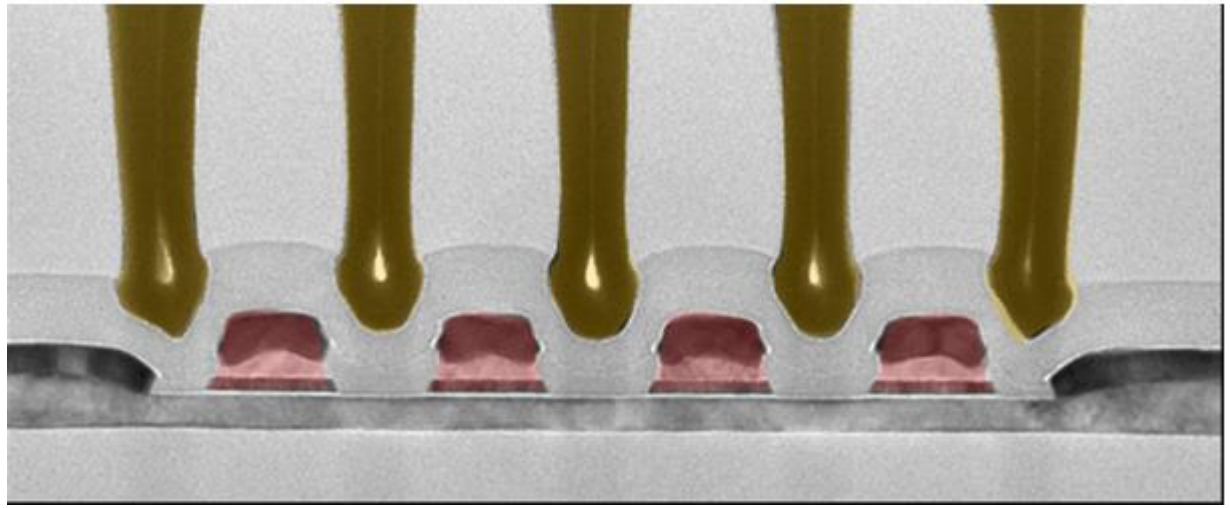
60+ years of experience in delivering high yield semicondutor technologies



W. Schwarzenbach et al. JES 2013

Starting point for the industrialization



T Bédécarrats et al, IEDM 2021

- Highly similar to CMOS FD-SOI technology
- New modules needed
- New physics: we need to optimize the process

Result of €15M R&D investment

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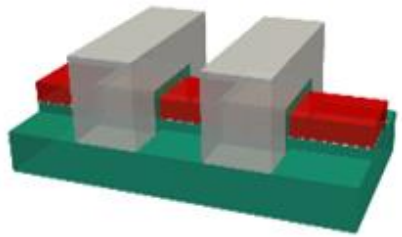
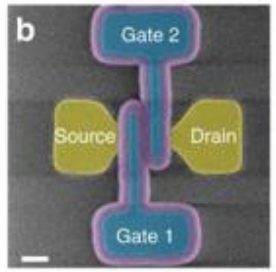
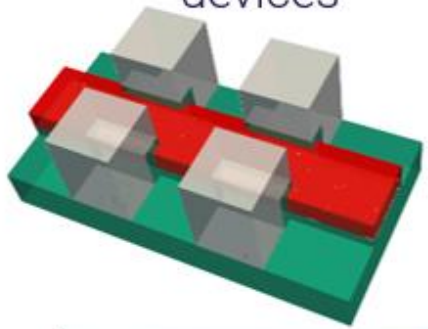
Nanowire devices with series gates

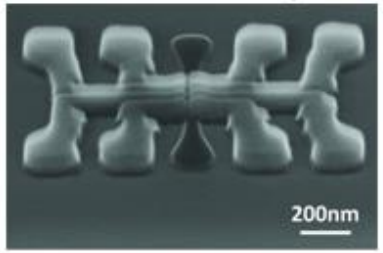




S. De Franceschi, *IEDM* 2016

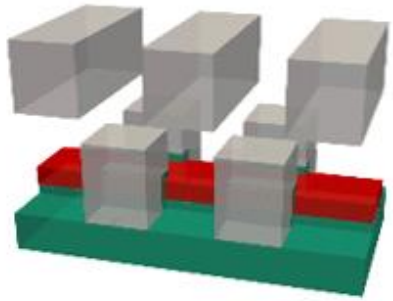
Face-to-Face (FF) devices

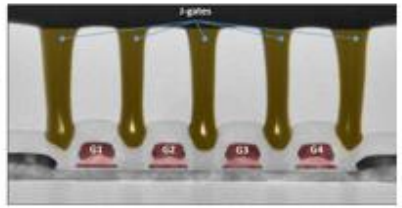




L. Hutin, *IEDM* 2018

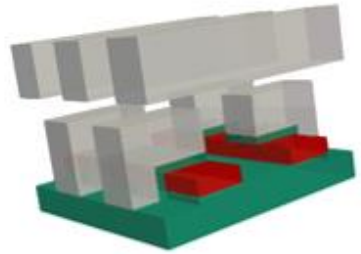
FF with J-gates

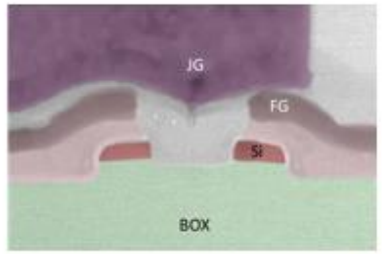




T. Bédécarrats, *IEDM* 2021

FF with J-gates and trench cut





B. Bertrand, *IEDM* 2023

Time

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

Gen. 1 Gen. 2 Gen. 3 Gen. 4

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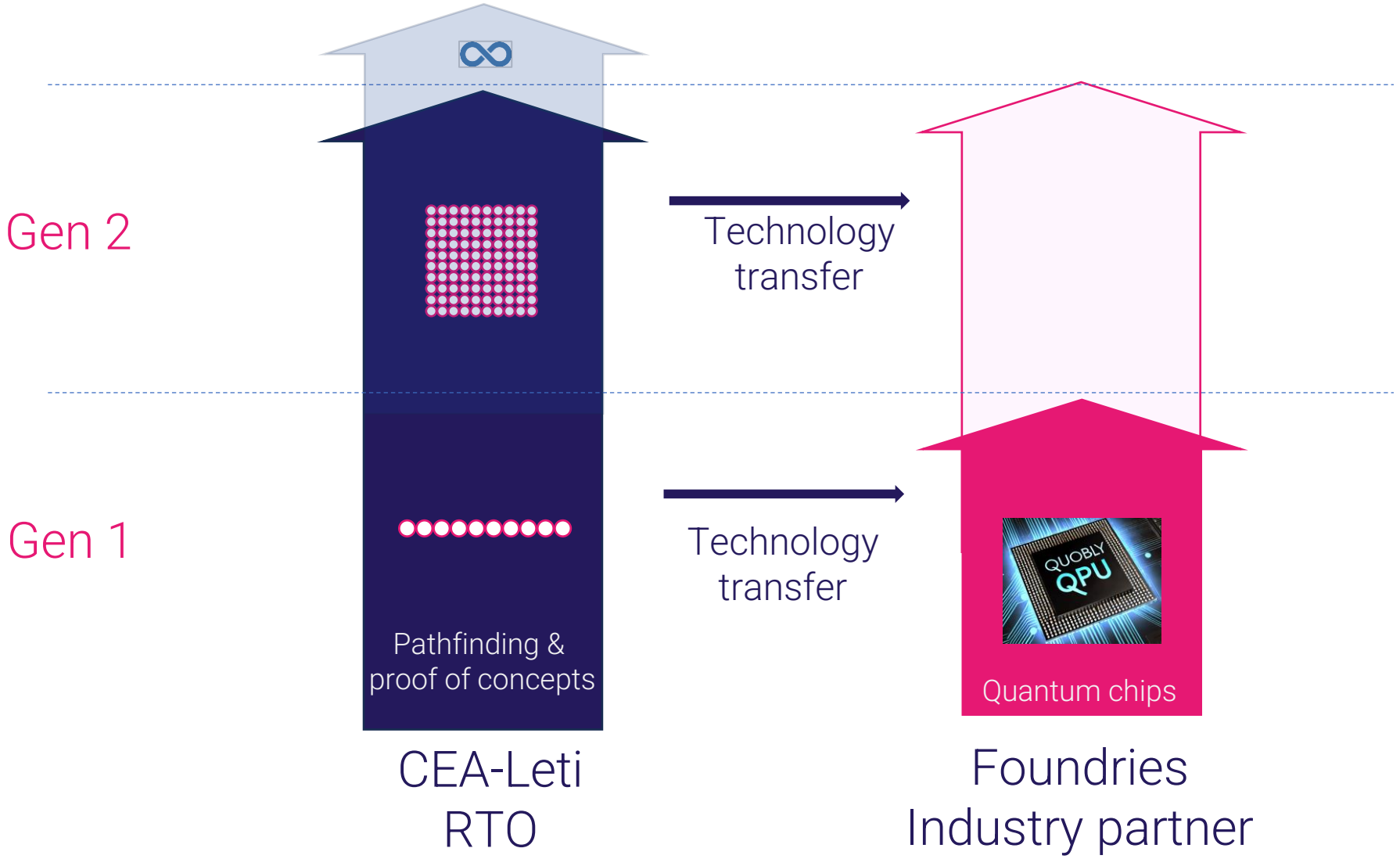
Some highlights on our realizations towards industrialization

From RTO to Industry



FD SOI fabrication ecosystem around Quobly

Facilities	Platform:	Quobly substrate
Quobly has acces to: 2 foundries 1 pilot line 3 labs	300mm wafers FD SOI - 80nm pitch	Complete 300mm Silicon-28 supply chain developed for QPU production

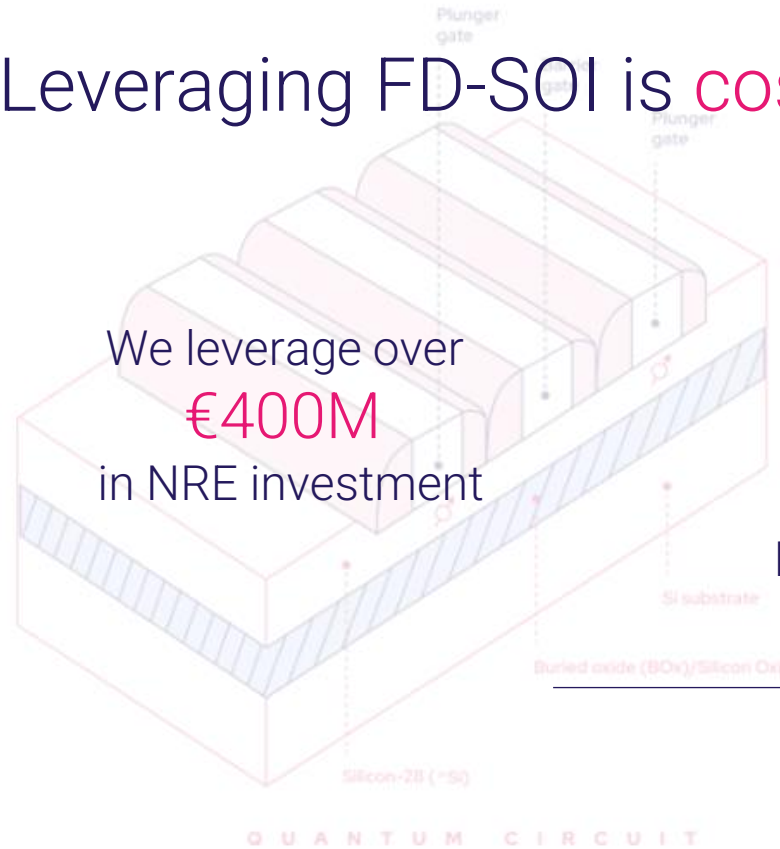
For better performance, energy & cost-efficiency, we do on-chip control electronics – a feature only available with FD SOI.

quobly

HW and enabling partnerships

Si-28 substrate	orano, soitec, Air Liquide
EDA, simulation & modeling	cadence, SYNOPSYS, NANOACADEMIC TECHNOLOGIES, SIEMENS
Equipment	BLUEFORS, KEYSIGHT TECHNOLOGIES, FormFactor, Radiall
Foundries	life.augmented, GlobalFoundries
R&D labs	cea leti, NEEL institut

Leveraging FD-SOI is cost efficient.



We leverage over
€400M
in NRE investment

We add qubits while respecting the stringent fabrication guidelines of FD-SOI

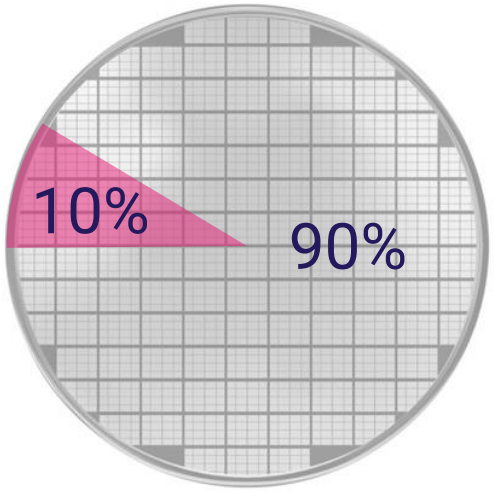
Ensures short qualification

This makes our qubits:

- Cost efficient
- Large-scale production-compatible

We modify 10% of fab processes.

90% follow standard semiconductor processes & use standard EDA tools



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Quobly's overview

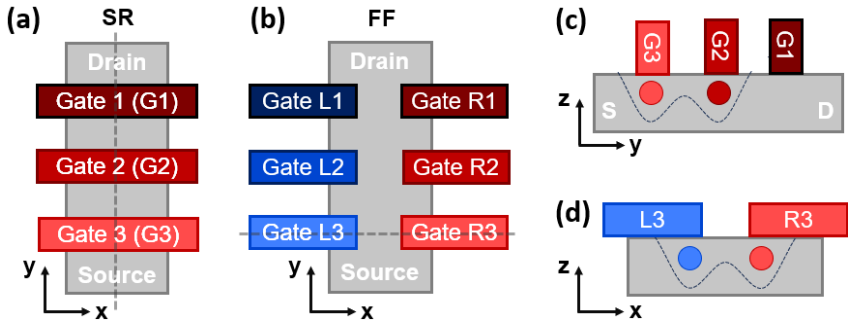
Building Quobly's Spin Qubits technology on FDSOI

Transfer from research to industry

Some highlights on our realizations towards industrialization

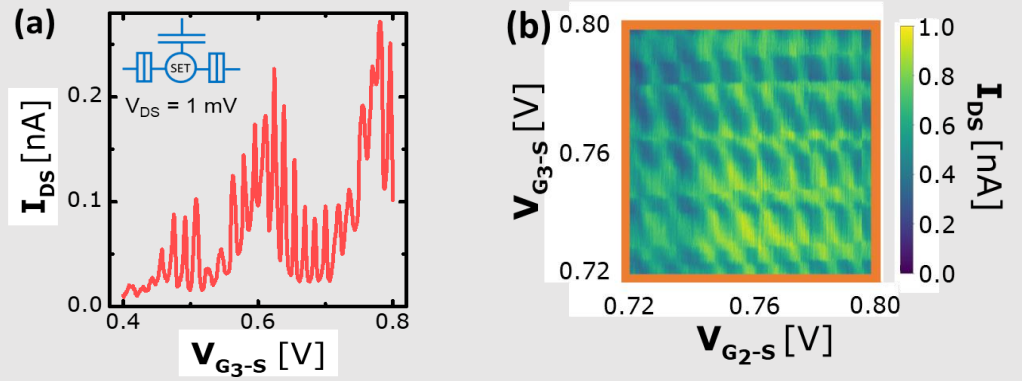
Successful formation of coupled quantum dots in 22FDX® qubit devices

Quobly: G. Elbaz et al - SiQeW 2024

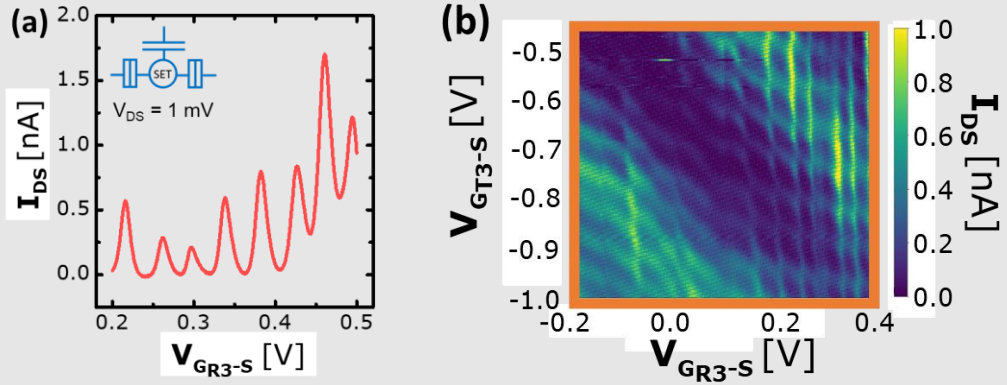


Using the commercial 22FDX® platform, we successfully show that we can form coupled quantum dots in devices expressly designed for spin qubits

QuDot and QuDot coupling in a SR device (G3/G2)

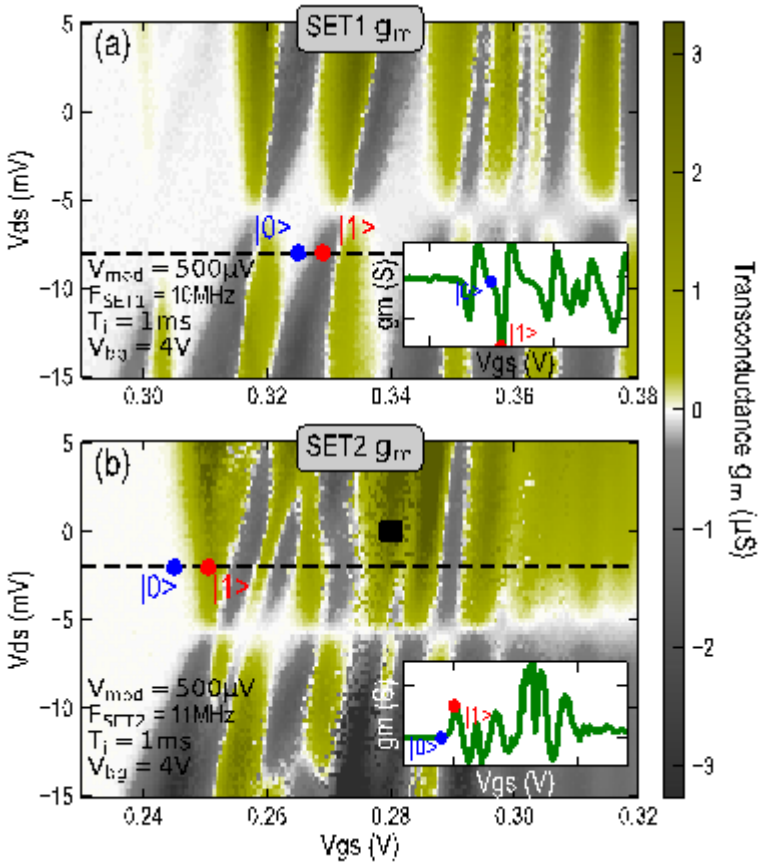


QuDot and QuDot coupling in a FF device (L3/R3)



Compact frequency multiplexed readout of silicon quantum dots in monolithic FDSOI 28nm technology

Leti: Quentin Schmidt, Quobly: T. Meunier et al - ESSERC 2024



This paper demonstrates the first on-chip frequency multiplexed readout of two co-integrated single-electron transistors without the need for bulky resonators.

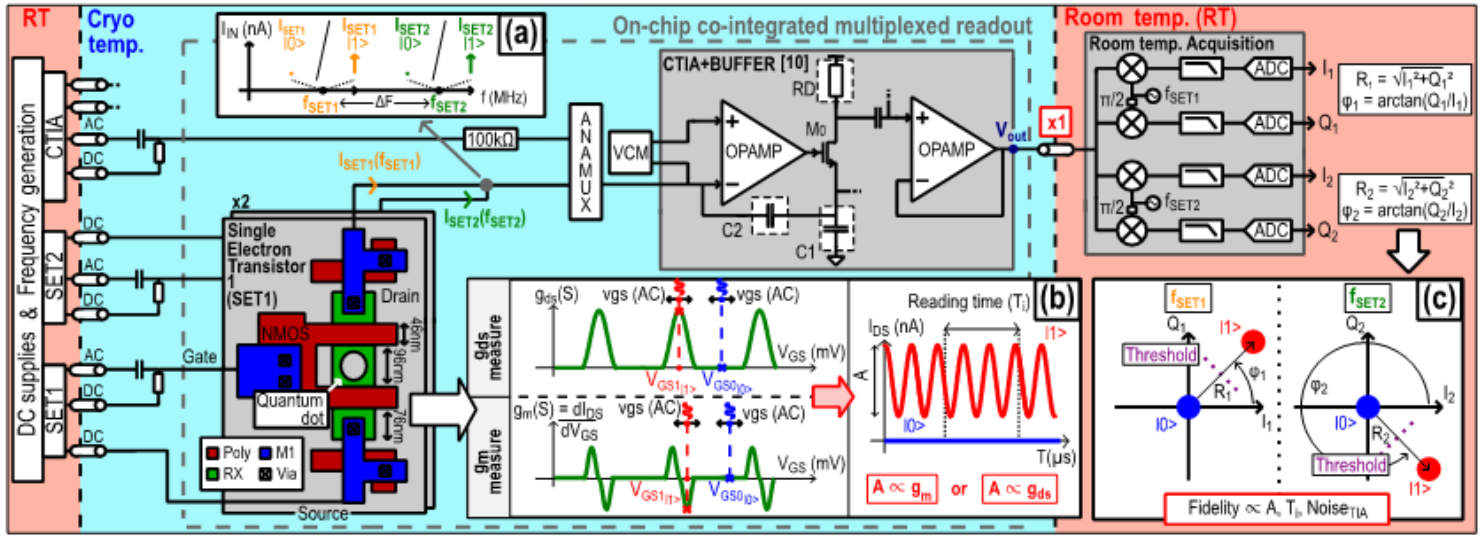


Fig. 2. Single electron transistors (SETs) geometry and block diagram of the proposed frequency multiplexed TIA-based readout. (a) Input signal frequency representation. (b) Illustration of the different measurable parameters. (c) Depiction of the thresholding algorithm for I/Q signals.

Take-away

- Quobly has the knowledge to deliver good qubits from a FD-SOI technology
- Quobly has an ecosystem to develop a scalable, industry-compatible version of its technology
- Quantum computing is a way to continue to grow the computation power the world is needed for the future with a better energy efficiency
- Reusing semiconductor assets to make quantum computer technology will heavily reduce the manufacturing fabs investment.