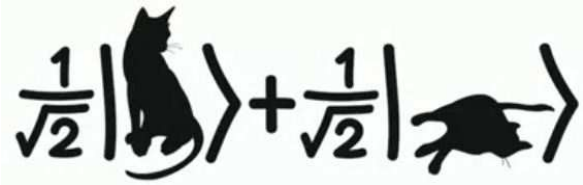
QUANTUM PROSPECTS FOR BEYOND MOORE

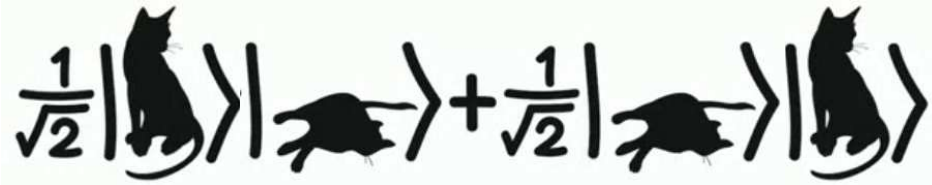
Leti Devices Workshop | Silvano De Franceschi| December 4, 2016

UNEXPLOITED QUANTUM PHYSICS

- Quantum Superposition



- Quantum Entanglement



EXPONENTIAL QUANTUM COMPLEXITY

- **Classical Computer with Binary Logic**

  Classical bit: 0,1
  N-bit state: single combination of N bits (e.g. 01001…01)

- **Quantum Computer**

  Single qubit state: $|\psi\rangle = a|0\rangle + b|1\rangle$

  2-qubit state: $|\psi\rangle = a|00\rangle + b|10\rangle + c|01\rangle + d|11\rangle$

  3-qubit state: $|\psi\rangle = a|000\rangle + b|100\rangle + c|010\rangle + \ldots$

  ….

  N-qubit state defined by 2^N complex numbers

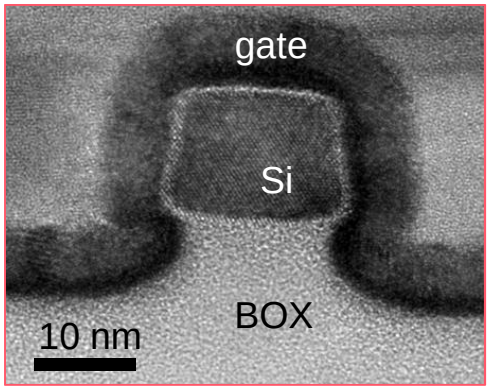
Naturally built-in parallelism

QUANTUM TECHNOLOGIES

- **Quantum Internet**
  - To ensure safe data transfer
- **Quantum Simulators**
  - To predict material properties, chemical compounds and reactions,…
  - Applications to many different areas (fertilizers, energy,…)
    - DO NOT REQUIRE FULL CONTROL OF EACH QUBIT
    - CAN BE USEFUL ALREADY WITH SMALL (~100) NUMBERS OF QUBITS
- **Universal Quantum Computers**
  - Optimization tasks
  - Database searching
  - Machine learning
    - REQUIRE LARGE NUMBERS (~10^6) OF INDIVIDUALLY CONTROLLED QUBITS

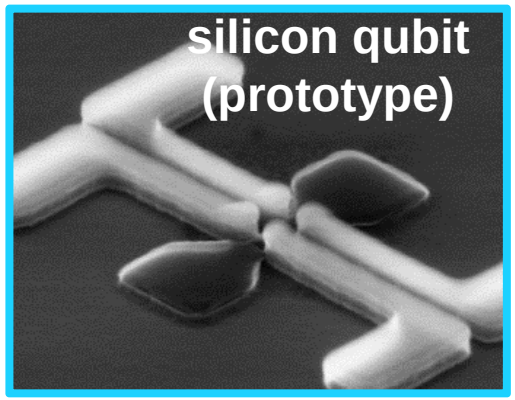
[Further reading: http://qurope.eu/manifesto]

TURNING TRANSISTORS INTO QUBITS



Leveraging FDSOI technology

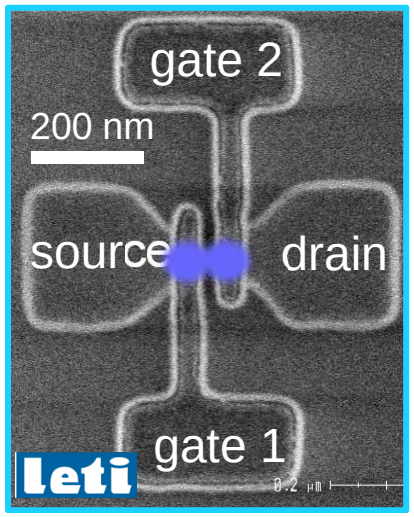
- Back-gate control
- Corner-state confinement
- 3D stacking (CoolCube™)

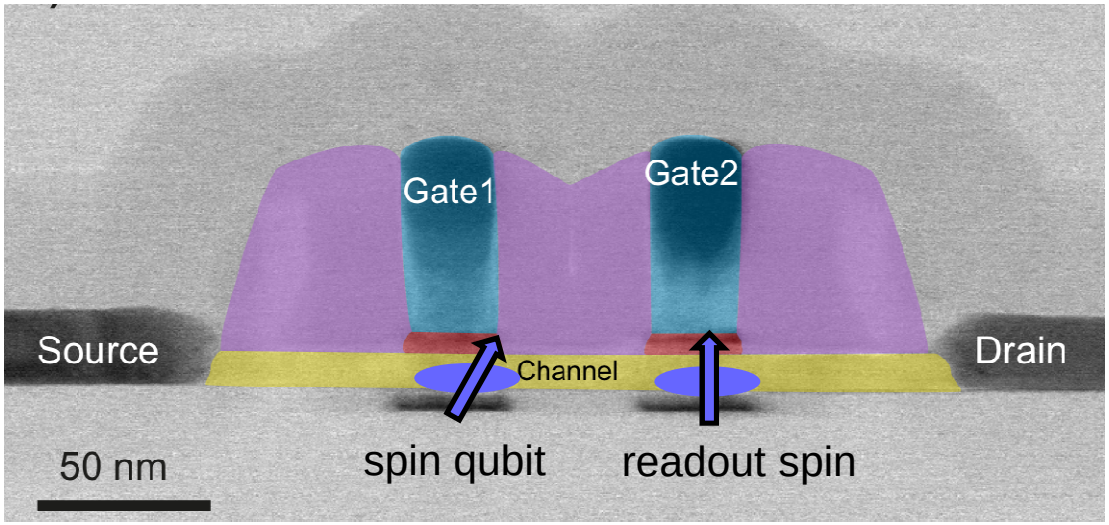


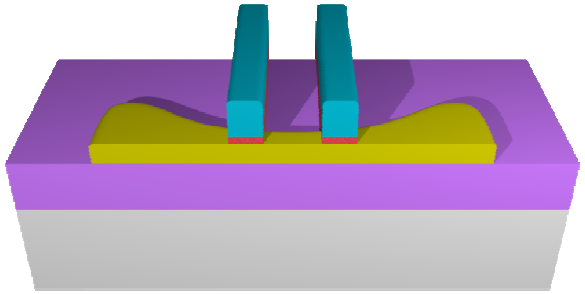
scalable quantum processor

QUANTUM SILICON @ GRENOBLE

FIRST QUBIT ISSUED FROM FAB LINE



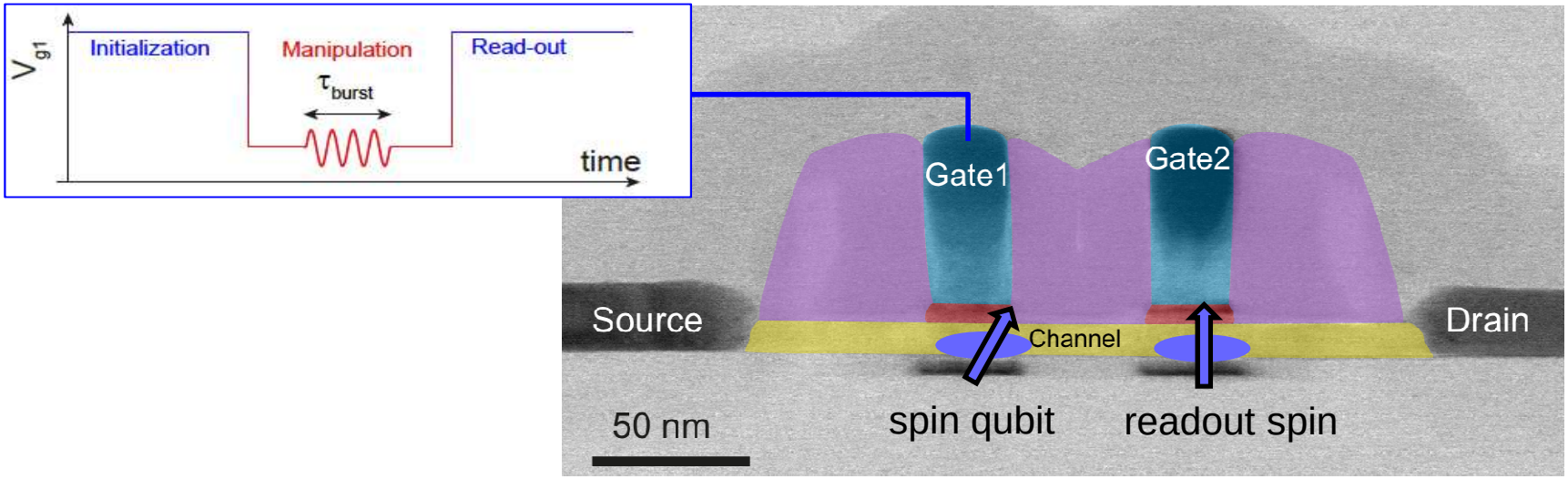




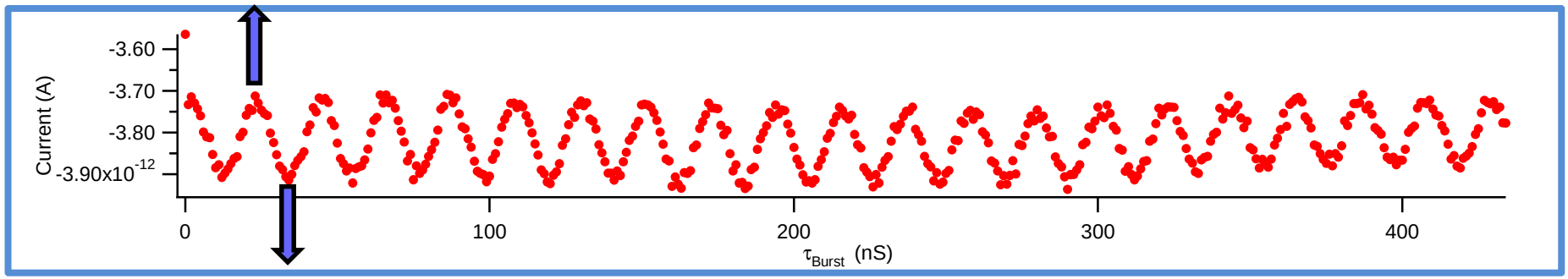
- **Compact Design**
- **Qubit-Based on Hole Spin**
  - All-electrical control
  - Lower hyperfine coupling
  - No valley degeneracy

Maurand et al., Nature Comm. (2016)

FIRST QUBIT ISSUED FROM FAB LINE

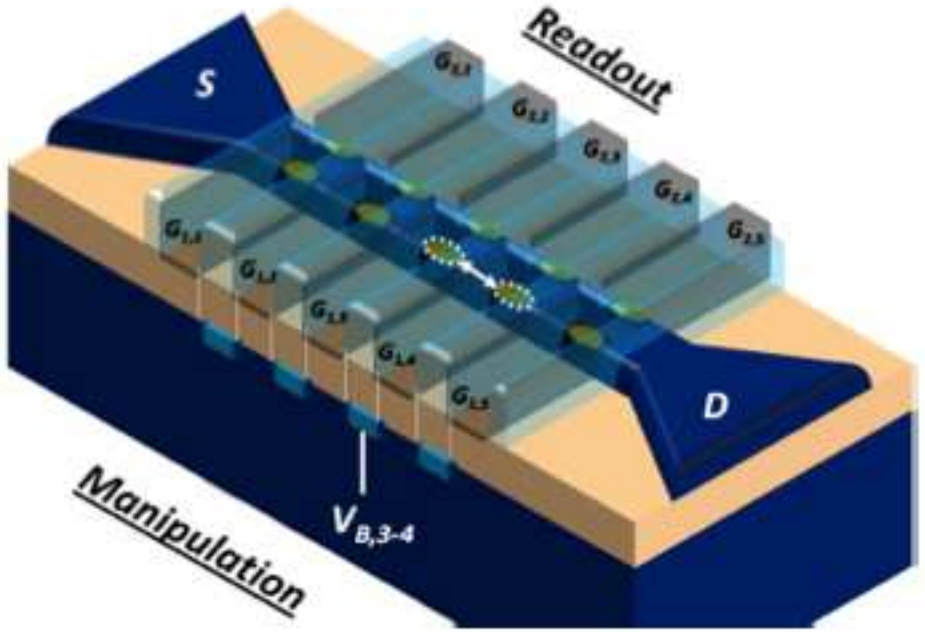


- **Electrically Induced Rabi Oscillations**



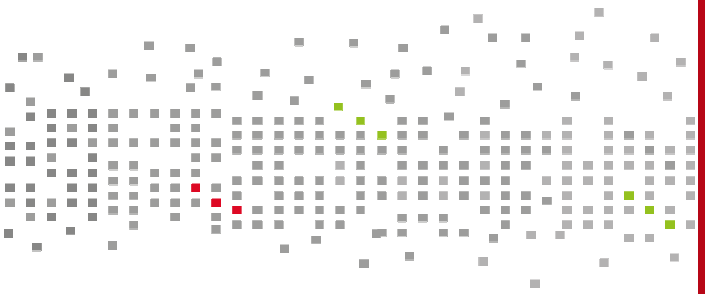
TOWARDS A SCALABLE QUANTUM PROCESSOR

- First Target: Linear Qubit Array



- Step-up: 2D Qubit Architectures

Thank you for your attention



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