# Atomic Functionalities on Silicon Devices (AFSID)

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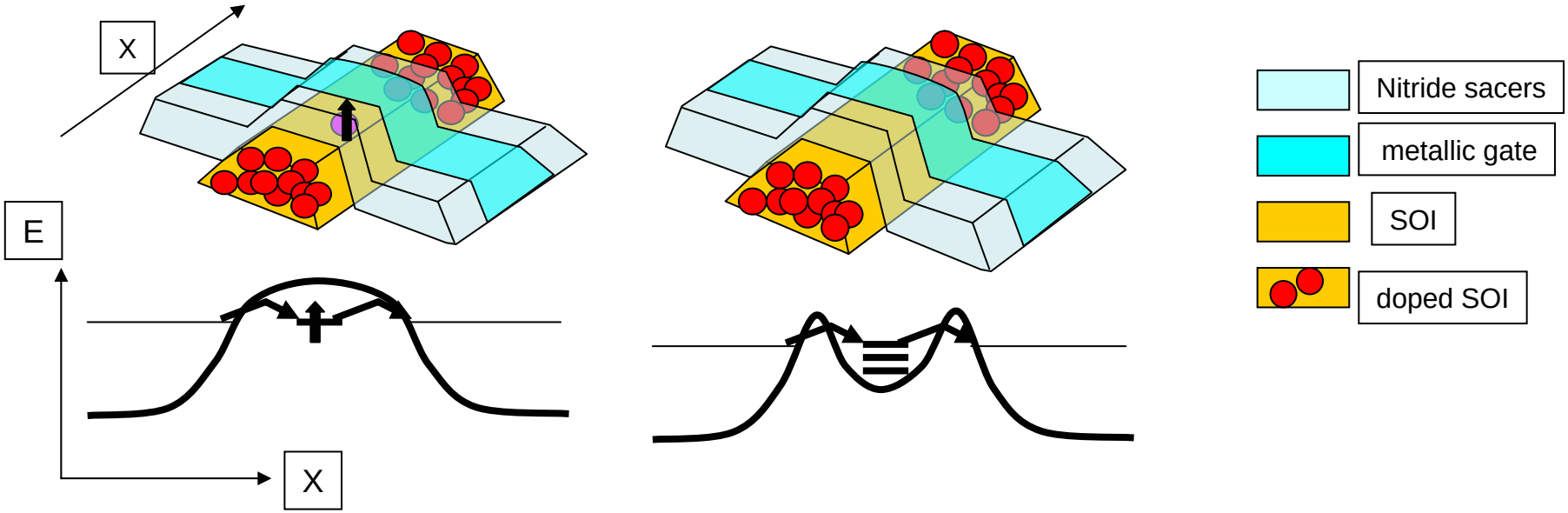
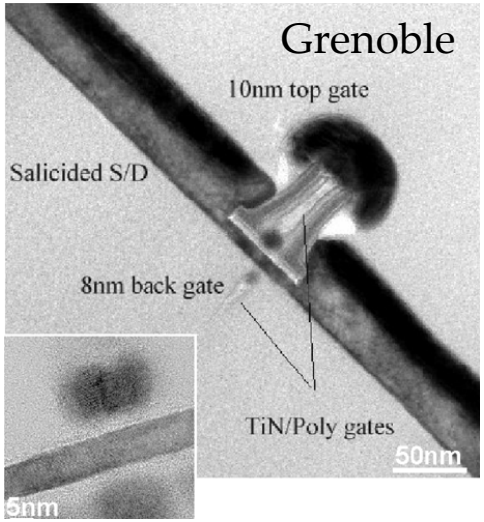
on behalf of the coordinator *Marc Sanquer*, CEA, France

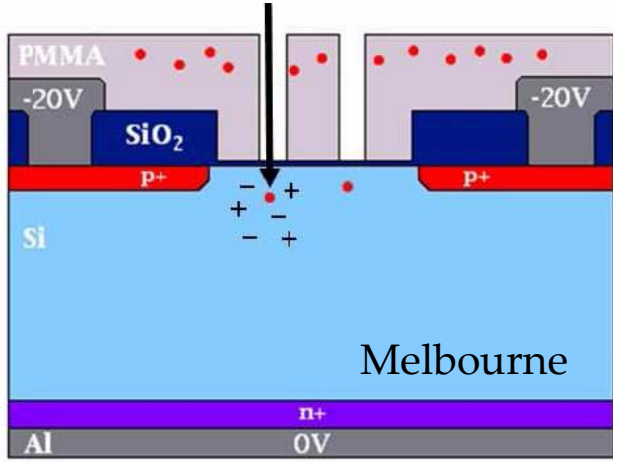
# Objectives of AFSID

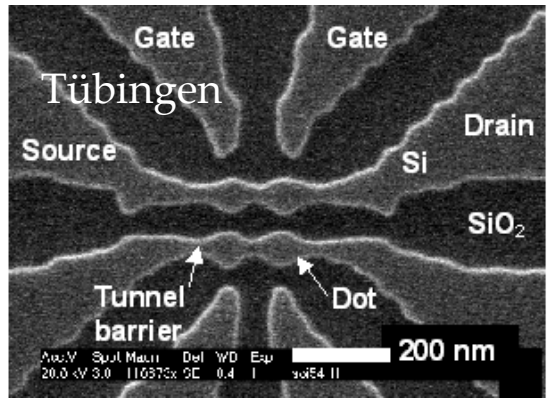
- Electrical switch based on the gate control of a *single atomic orbital*, *i.e.* a single atom transistor (SAT)
- Coupled SAT-FET or SAT-SET devices to:
  - (i) measure the spin of carriers
  - (ii) use the non-monotonic transfer Id-Vg characteristics for multi-valued logic and memory functions
  - (iii) measure coherence and entanglement in the molecular orbital formed by two coupled atoms (dopants or artificial atoms)

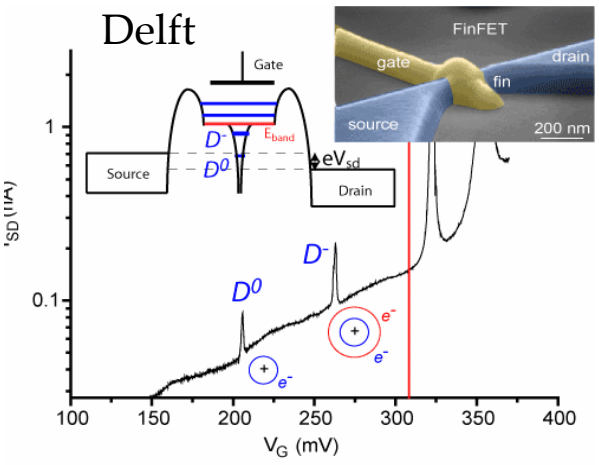


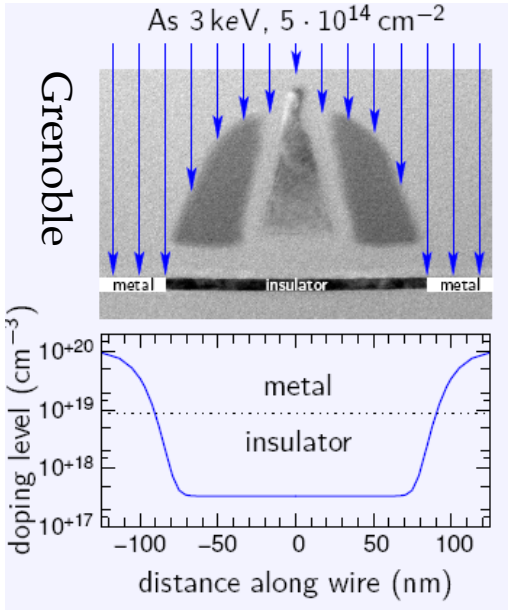
# Approach: CMOS

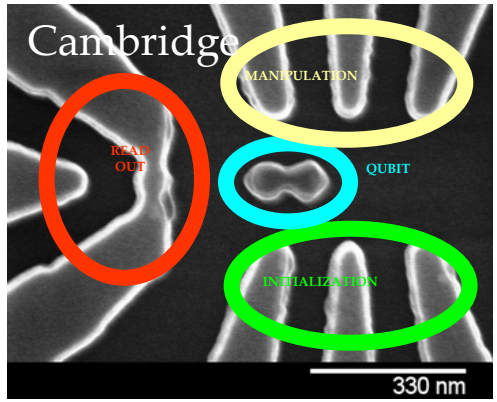


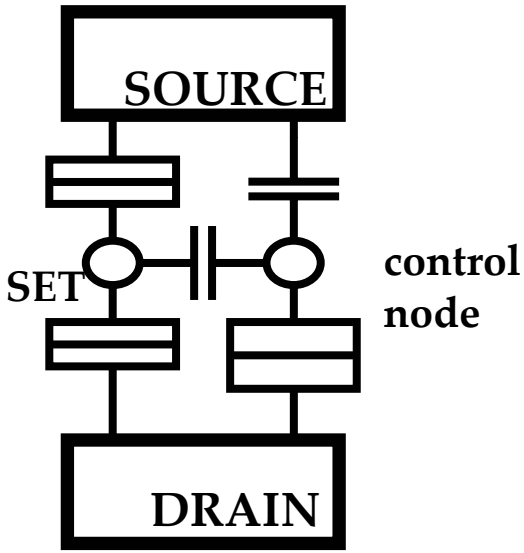



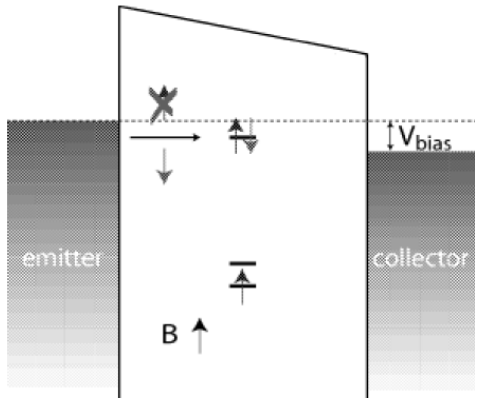



# Expected results

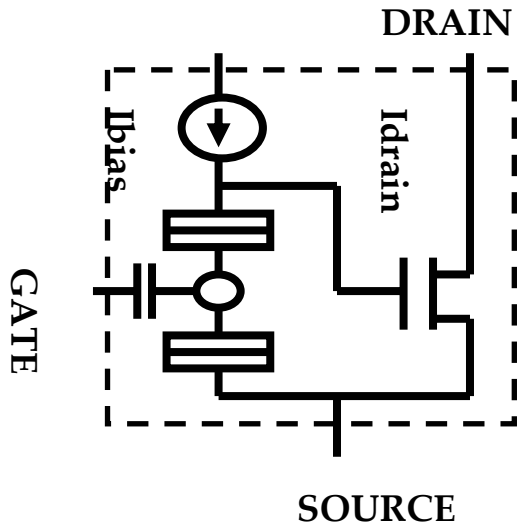
- fabrication of a single atom transistor (artificial atom or real dopant) *with a better gate control as compared to a FET.*
- a silicon SET used as an electrometer *with an operating temperature much larger than 4.2K*
- a SET-FET hybrid made on-chip
- a silicon device where single spin is detected




A latching switch (two-terminal, bistable device with hysteretic *I* – *V* curves)




A spin sensitive SET




A SET-FET hybrid with non monotonic Id-Vgs characteristics, high current drive

# Expected impact of AFSID

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|---|
| *Unconventional use of dopants* in silicon<br>Transport measurements to get atomic precision<br>*Ultimate size* (the Bohr radius) |
| *Single dopant implantation or dopant modulation SET* ➔ switches with low power dissipation (switch based on action on a single electronic charge), and large integration density. |
| Quantum mechanical effects ➔ *new functionalities* based on the non-monotonic transfer function and on quantum correlations in coupled dopants or dots. |
| • Prepare future applied RTD project relying on the full control of single dopants or coupled dopants.<br>• Establish the conditions for use, stability, robustness … of an atomic switch<br>• Compare with other atomic or molecular switches<br>• Delivered Hybrid SAT-CMOS devices are bricks for new ICT architectures (neuromorphic networks…) |

# Consortium

| | |
|---|---|
| **Commissariat à l'Energie Atomique** | **M. Sanquer & M. Vinet** |
| **Delft University of Technology** | **S. Rogge** |
| **University of Tübingen** | **D. Kern** |
| **CNR-INFM** | **M. Fanciulli** |
| **Hitachi Cambridge Labs** | **D. Williams** |
| **University of Melbourne** | **D. Jamieson** |

# Proactive Initiative Collaboration

- Participation to joint publications and events
- Comparison of obtained characteristics for our silicon SET devices and switches with molecular, CVD Nanowires, or Carbon nanotubes based devices and switches.
- Collaboration with the NoE NANOSIL
  (Silicon-based nanostructures and nanodevices for long-term nanoelectronics applications )
- International collaborations in particular with Australia
  (Centre of Excellence for Quantum Computer Technology)