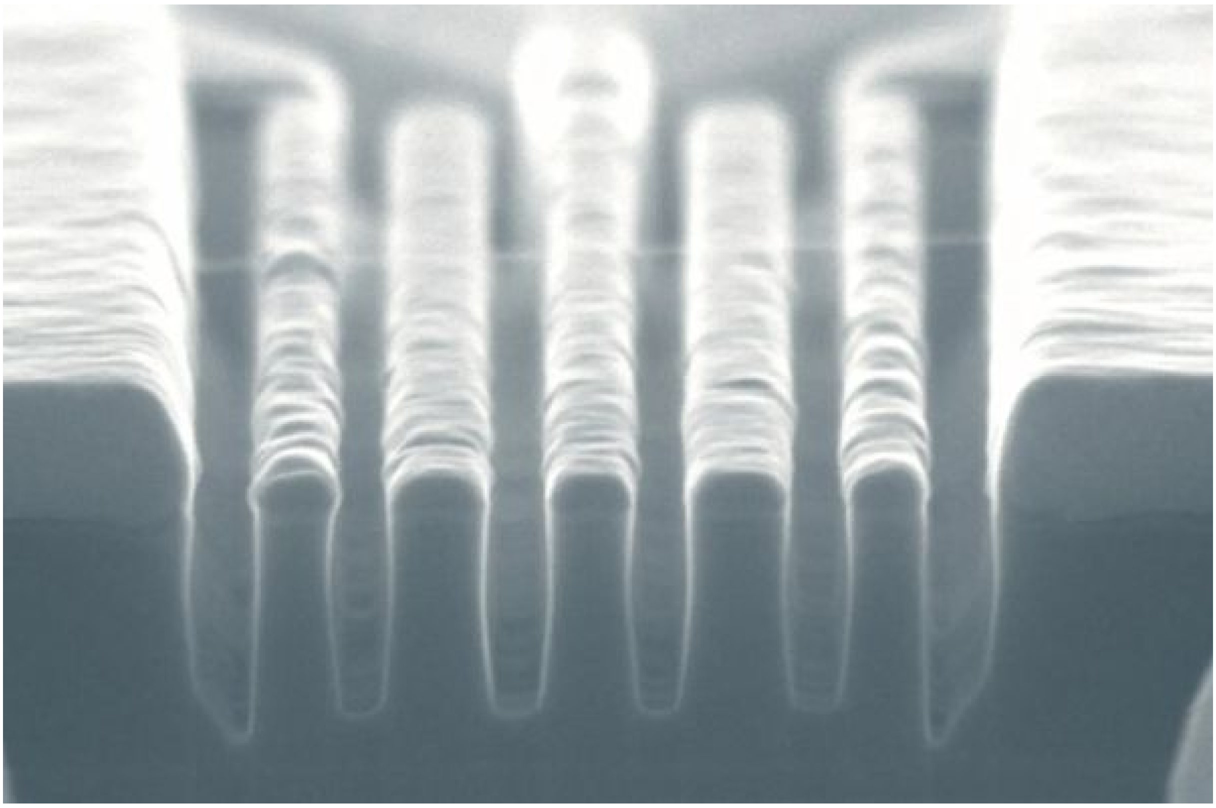

A mechanical qubit for long-coherence quantum computing

The new project MECHQUBIT, coordinated by ICFO, will build a new type of mechanical qubit with long coherence time, small footprint area, high-gate fidelity and compatible with silicon-based fabrication processes.

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Quantum computers tackle challenges that are simply out of reach of classical systems by harnessing quantum phenomena such as superposition and entanglement. Yet one of the main barriers to practical quantum computing remains a stubborn one: today's qubits lose their fragile quantum state almost as quickly as it forms. This short coherence time makes quantum information difficult to store, process, and scale up reliably.

The performance and scalability of quantum computers depend heavily on the physical platform used to build qubits. Superconducting circuits, trapped ions, and semiconductor systems currently lead the field, but all face significant limitations in coherence, scalability, and integration.

The project MechQubit will explore a different approach, a qubit platform based on

nanomechanical systems, where quantum information is encoded in the vibrational motion of nanoscale devices. Mechanical systems of this kind offer unique advantages, including higher coherence, strong coupling to multiple physical degrees of freedom, and compatibility with hybrid quantum architectures.

From a long-standing idea to a funded project

ï¿½We had a long-standing collaboration with Fabio on the idea of a nanotube mechanical qubitï¿½, says **Prof. Adrian Bachtold**, leader of the Quantum NanoElectronics and NanoMechanics group at ICFO and coordinator of the project. In 2021, ICFO and Fabio Pistolesi's team at CNRS published the idea of a mechanical qubit in an article in Physical Review X, which was later validated in 2023 with the first experimental results. Then, the contacted Christoph Stampfer at RTWH Aachen, who, as Bachtold comments, fabricate among the best graphene devices in the world and has experience with mechanica resonators. Heidi Potts and Zurich Instruments joined the collaboration soon after contributing their expertise in time-resolved measurements and high-performanc electronics. Shortly after that, the project was selected under the 2025 Horizon Europ Pathfinder call

MechQubit's overall objective is to **design, fabricate, and experimentally demonstrate a nanomechanical qubit**. In the short term, the team will focus on producing graphene electromechanical resonators. **ï¿½**We first had the idea to make a mechanical qubit in a nanotube, a system that we know well, and then we asked ourselves, is graphene more suitable for such an experiment?ï¿½, explains Bachtold. The aim is to push the fundamental mode oscillating at a frequency never achieved before, and to improve coherence times reaching the millisecond regime. In the longer term, such a mechanical qubit could open the door to ultrasensitive quantum sensing experiments that remain out of reach today.

Lost in the jargon? Our quick glossary is your cheat sheet to our key concepts.