Goal 6 Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security by 2050.

Development of scalable Silicon quantum computer technology

Project manager

(selected in 2022)

TARUCHA Seigo

RIKEN Center for Emergent Matter Science and Quantum computing

Leader's institution

RIKEN

R&D institutions

RIKEN
The University of Osaka
The University of Tokyo
Kobe University
AIST

Summary of the project

This project aims to develop scalable multi-qubit devices toward realization of Silicon quantum computer. We will use sparse integration and medium-distance quantum coupling to implement a unit structure of qubits and scale up the qubit system by integrating the unit structures. Based on this method we will develop technology bases appropriate to implement large-scale quantum computers by 2030, and expand them in cooperation with the semiconductor industry to realize universal quantum computers by 2050.

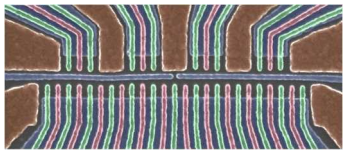
Milestone by 2030

We establish technology bases for fabricating multi-qubit devices toward development of large-scale quantum computers in cooperation with semiconductor industries. In parallel, we perform characterization and high-fidelity quantum operation of the multi-qubit devices, development of quantum channels suitable for connecting distant qubits, and production of isotopically enriched silicon/silicon-germanium (Si/SiGe) substrate, and in addition, demonstration of the principle of quantum error correction.

Figure 1 Qubit transfer channel.

Milestone by 2025

We use high-quality substrate of Si/SiGe to establish fabrication technologies for implementing multi-qubit devices with a one-dimensional qubit array as a fundamental structure, and use them to construct a prototype of small- to middle-scale quantum computers. In addition, we inspect new principles for quantum gate circuits constructed by electron wave packets as propagating qubits.



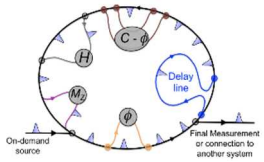


Figure 2 One-dimensional qubit array (left); Quantum gate circuit with electron wave packets as qubits (right).

Project structure

Seigo Tarucha, Project Manager (RIKEN)

- **Development of scalable fault-tolerant Si quantum bit devices**
  Takashi Nakajima, RIKEN
  Takuji Miki, Kobe University
- **Development of middle-distance quantum link**
  Takafumi Fujita, The University of Osaka
- **Development of isotopically controlled Si/SiGe substrate technology**
  Satoru Miyamoto, AIST
- **Development of electron wave-packet qubits with new principle**
  Michihisa Yamamoto, RIKEN, The University of Tokyo
  Shintaro Takada, The University of Osaka

Figure 3 Silicon qubit device and the device operation setup: control electronics (left) and a dilution refrigerator (right).

JST Japan Science and Technology Agency