FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS
FRAUNHOFER INSTITUTE FOR APPLIED SOLID-STATE PHYSICS IAF

PRESS RELEASE

Kick-off of European project MATQu

Stable European industry-scale fabrication value chains for solid-state-based quantum computer development

The (computational) performance of quantum computers relies heavily on their core hardware element: the qubit. Several approaches to realize qubits exist, yet they still lack stable scalable fabrication value chains to become industrially viable technologies. Project MATQu aims to expand the European expertise in materials and processes and enables the European industry to further develop solid-state-based quantum computers. The two Fraunhofer institutes IPMS and IAF are contributing expertise in 300 mm manufacturing and low-temperature measurement technology.

Project MATQu, short for *Materials for Quantum Computing*, started in June 2021 with the goal to support the creation of a pan-European research infrastructure for advanced computing technologies. The project brings together world-class European research and technology organizations, industrial fabrication facilities and leading application partners in the domain of solid-state qubits – a subject of intense global competition – to realize the vision of a European supply chain for materials and processes. The project is led by the joint business office of the Fraunhofer Group for Microelectronics and the Research Fab Microelectronics Germany as well as Fraunhofer IAF.

The project will create a European eco-system to expand the applicability of core components of solid-state qubits – such as superconducting Josephson junctions (SJJs) – by improving materials, as well as processing and characterization technologies for quantum computing hardware. SJJs are currently the most mature solid-state platform to realize stable superconducting qubits.

Bringing superconducting qubits to market

Superconducting qubits are among the most promising components to realize a large-scale quantum computer. The relatively rapid success of Josephson junction based qubits can be attributed to design principles that are based on well-established production processes. Their performance, however, depends critically on the quality of the fabrication substrates, the materials used to make the circuit components, as well as the reproducibility of the processes applied in fabrication. A stable and controlled value chain is key to improving these parameters in future.

The main technical goal of the project is to improve and transfer materials and technologies for superconducting qubits from laboratories to the market. Several project partners have extensive infrastructures suited for this purpose and will contribute with

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their expertise in materials, process integration, and research to build robust and reproducible qubits. Industrial-grade fabrication infrastructures will allow optimizing process parameters and systematically improving the performance of superconducting qubits.

Reducing the variability of qubits

Often qubits are described as having a mind of their own, which is to say that very large device-to-device variability is measured. Complex methods to tune qubits are required to control the variability. This, in turn, adds to the complexity of quantum computer architectures compared to traditional (von Neumann) computer architectures. It is one of the main limiting factors for scaling the number of qubits in quantum computers today. MATQu aims to reduce this variability among qubit components. Researchers will investigate the impact on device variability of all material parameters and process steps. For this purpose, the consortium will gather broad knowledge and experience with developing process steps and designing experiments that allow reducing the impact of specific process parameters on device performance. "While we do not expect the same integration level as classical computer chips for the next 5 to 10 years, we will certainly take a big step towards variability reduction in superconducting qubits," explains Prof. Rüdiger Quay, project coordinator from Fraunhofer IAF.

Bringing silicon qubits from lab R&D to industrial manufacturing

The focus of Fraunhofer IPMS in the project is the scale-up of concepts and technology from a lab R&D level to industrial manufacturing using its established 300 mm Screening Fab, which already serves as industry standard CMOS computing platform. "In the project, we are gaining new insights into the material and process influences for the manufacturing process of superconducting qubits, especially in the area of deposition, patterning and the integration of superconducting films. Through novel fabrication processes and testing at cryogenic temperatures, we want to advance the fabrication of devices for quantum computing on a European scale," explains Dr. Benjamin Lilienthal-Uhlig, head of business unit Next Generation Computing at Fraunhofer IPMS. "A second focus for us is to work with industry and research partners to provide European SMEs and startups with access to state-of-the-art manufacturing facilities and know-how to significantly increase the maturity of superconducting qubit technology and strengthen the European quantum technology ecosystem," concludes Lilienthal-Uhlig.

Low-temperature measurement technology for variability investigation

Fraunhofer IAF will provide its experience and knowledge on low-temperature measurement technology to the project, especially in the field of variability investigation of superconducting films. The Institute contributes extensive characterization equipment for the field of quantum computing and cryogenic devices, which will help to step up the maturity of superconducting qubit testing. This will give European companies, especially SMEs and startups, access to state-of-the-art testing and characterization equipment alongside the necessary know-how, both of which are key components for quantum computer hardware development.

About project MATQu

Concerning substrate technology, process technology and tools, MATQu brings together major European actors in the field, including four large RTOs. The 18 MATQu partners complement each other in an optimal manner across the value chain to create a substantial competitive advantage, e.g., faster time-to-market and roll-out of technologies and materials for better qubits for quantum computing.
Please visit the project website www.matqu.eu for more information.

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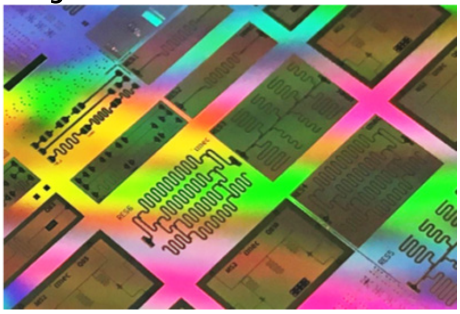
About Fraunhofer IPMS

The Fraunhofer Institute for Photonic Microsystems IPMS stands for applied research and development in the fields of intelligent industrial solutions, medical technology and improved quality of life. Our research focuses on miniaturized sensors and actuators, integrated circuits, wireless and wired data communication, and customized MEMS systems. With the Center Nanoelectronic Technologies (CNT), Fraunhofer IPMS contributes applied research on 300 mm wafers for microchip producers, suppliers, equipment manufacturers and R&D partners.

About Fraunhofer IAF

The Fraunhofer Institute for Applied Solid State Physics IAF is one of the world's leading research institutions in the fields of III-V semiconductors and synthetic diamond. Based on these materials, Fraunhofer IAF develops components for future-oriented technologies, such as electronic circuits, novel hardware components for quantum computing as well as quantum sensors for industrial applications. With its research and development, the Freiburg research institute covers the entire value chain – from materials research, design and processing to modules, systems and demonstrators.

Images:



Test chip with superconducting qubits in a 300 mm integrated process prototype.
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