



A selection of various oxide single crystals grown at the IKZ

WHAT WE OFFER

At IKZ, we provide tailored crystalline materials and advanced materials for quantum technologies.

- **Isotope-enriched semiconductor materials**
High-purity, isotopically pure Si and Ge (e.g. ^{28}Si , ^{72}Ge , ^{76}Ge) layers for quantum computing and quantum sensing applications
- **Custom nuclear spin-free SiGe heterostructures**
MBE-grown structures with precise control of composition, interfaces, and doping for spin qubits or quantum optics
- **Oxide substrate crystals**
Novel, low-impurity substrates with optimized lattice matching for thin films and quantum devices
- **Wafer-scale materials**
High-quality materials and epi-ready substrates
- **Process and material development**
Feasibility studies, benchmarking and optimization for specific device requirements
- **Collaboration & technology transfer**
Cooperation with academic and industrial partners, including customized solutions and joint development projects

We are offering combination of crystal growth, epitaxy, and advanced characterization to deliver reproducible, application-ready materials.

Patents

Diamagnetic Solid Solution Crystal, Layer Stack, Microwave Device Comprising the Layer Stack, and Method for Fabricating a Diamagnetic Solid Solution Crystal, US Patent 19/295,255



If you are interested in our research and services, please contact us:

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Photo: Sebastian Rost

THE LEIBNIZ-INSTITUT FÜR KRISTALLZÜCHTUNG IKZ

The Leibniz-Institut für Kristallzüchtung (IKZ) in Berlin-Adlershof is an international state-of-the-art competence center for science & technology as well as service & transfer for innovations in and by crystalline materials. The R&D spectrum thereby ranges from basic over applied research activities up to pre-industrial research tasks.

Crystalline materials are key technology enabling components to provide electronic and photonic solutions to today's and future challenges in society such as artificial intelligence (communication, mobility etc.), energy (renewable energies, power conversion etc.) and health (medical diagnosis, modern surgical instruments etc.).

The IKZ provides innovations in crystalline materials on account of its combined in-house expertise on plant engineering, numerical simulation and crystal growth, enabling it to achieve highest-quality crystalline materials with tailored properties.

Nanostructures, thin films and volume crystals are investigated, the latter being the unique selling point of the institute. Cutting-edge theoretical and experimental materials science know-how is a strong asset for IKZ's R&D activities.

Together with partners from institutes with technology platforms as well as industry companies, the institute will in future also drive innovation by crystalline materials, namely the reliable evaluation and benchmarking of innovative crystalline prototype materials for disruptive technology approaches.



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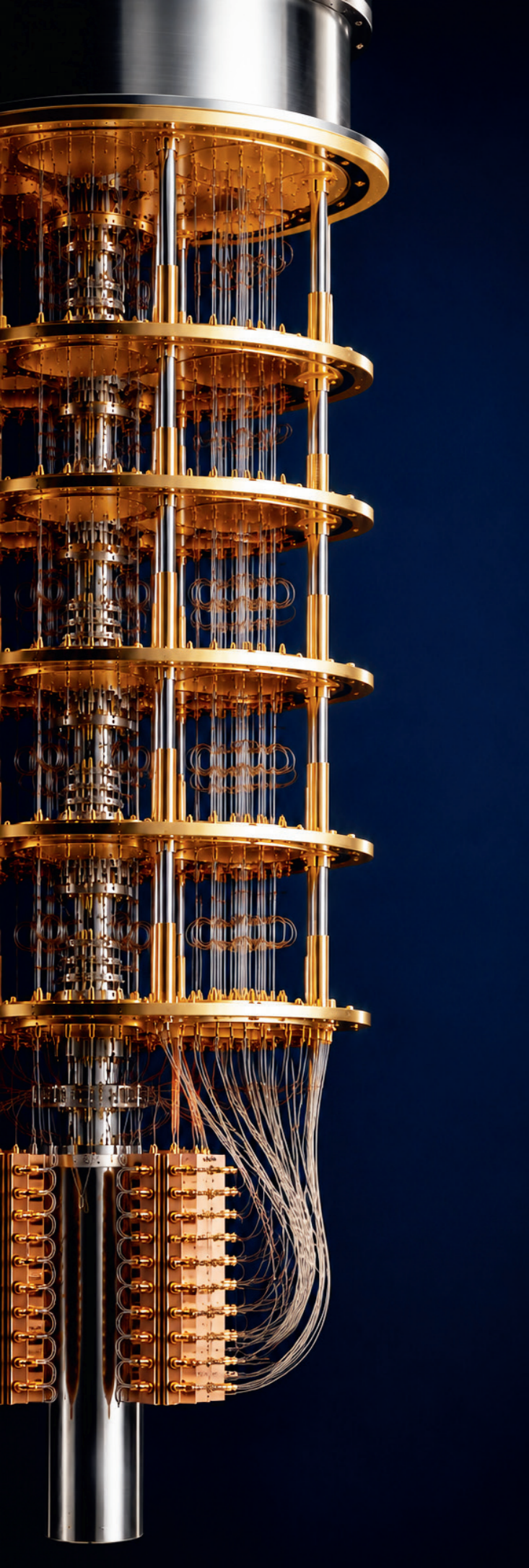
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QUANTUM MATERIALS FROM ELECTRONIC GRADE TO QUANTUM GRADE





Conceptual visualization of a quantum computer cryostat

OUR QUANTUM MATERIALS

Quantum technology, especially quantum computing, holds enormous potential because it leverages the strange but powerful principles of quantum physics to solve problems far beyond the reach of today's computers. By processing information in fundamentally new ways, quantum computers could revolutionize fields like medicine, climate science, finance, and cybersecurity—making breakthroughs in drug discovery, optimizing complex systems, and cracking problems previously thought unsolvable. As this technology develops, it promises to reshape entire industries and open doors to innovations we can barely imagine today.

The development of these technologies requires new materials in qualities that are beyond what is currently achievable. At the Leibniz-Institut für Kristallzüchtung (IKZ), we specialize in the research and development of such high-quality crystalline materials essential for advancing quantum technologies. Our primary focus areas include SiGe quantum materials and novel oxide substrate crystals. So, there is a paradigm change in materials science: We move today from electronic grade to quantum grade materials with unprecedented quality.

Silicon (Si) and germanium (Ge) have been indispensable from the inception of semiconductor transistors through all phases of semiconductor technology. Recently, they have emerged as one of the most promising material platforms for the ongoing quantum revolution. SiGe's uniqueness from a material standpoint lies in its processability into crystals of exceptional chemical purity and crystalline quality. Additionally, Si and Ge can be manufactured entirely free of nuclear spin through isotopic enrichment, facilitating quantum technologies in an ideal 'semiconductor vacuum.' This, coupled with compatibility with the existing silicon industry, ensures high scalability and seamless integration of quantum technology with traditional electronics.

At IKZ, we leverage our extensive expertise in processing isotopically enriched, nuclear spin-free semiconductor materials such as ^{28}Si , ^{72}Ge , and ^{76}Ge , to deliver top-tier quantum materials. Furthermore, we supply novel oxide substrates with low impurity content and optimal lattice match for e.g. magnetic thin films for integrated magnonic superconducting quantum technologies.

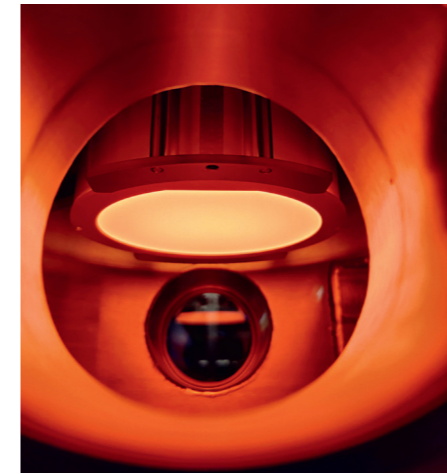
Our Mission

- research in the field of fabrication and characterization of high-quality MBE grown SiGe based heterostructures
- benchmarking of SiGe-based heterostructures for application in quantum technologies
- distribution of nuclear spin-free SiGe-based MBE quantum materials for the European research market (e.g. for quantum device manufacturing)
- research and development of novel oxide materials for magnonic quantum technologies

MOLECULAR BEAM EPITAXY OF ISOTOPE-PURE SI AND GE



IKZ's MBE equipment



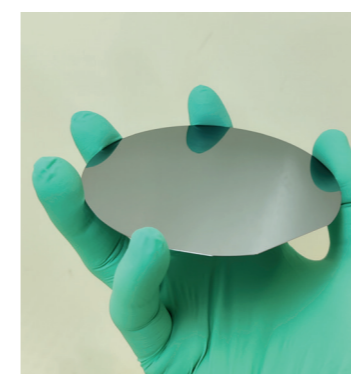
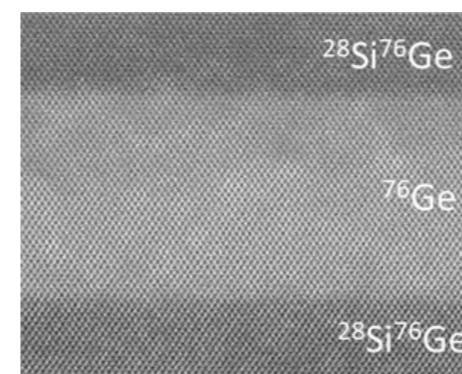
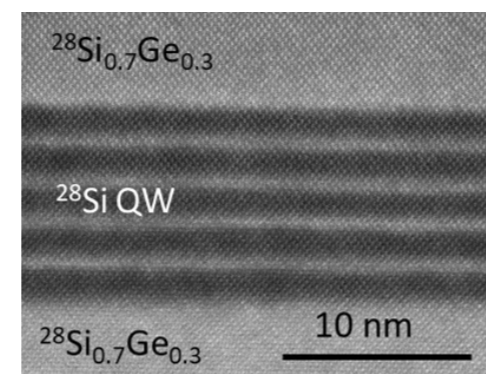
CUTTING-EDGE MBE EQUIPMENT FOR ULTRA-PURE MATERIALS

At the Leibniz-Institut für Kristallzüchtung (IKZ), we utilize advanced Molecular Beam Epitaxy (MBE) techniques to produce ultra-pure, isotope-enriched silicon (Si) and germanium (Ge) materials.

For this purpose, we commissioned a state-of-the-art MBE system in 2023, with the unique feature to be used for nuclear spin-free SiGe epitaxy only. This MBE equipment allows us to achieve unparalleled compositional control paired with chemical purity and crystalline quality, essential for the development of quantum technologies.

OUR MATERIAL PORTFOLIO

We provide a variety of isotope-pure SiGe heterostructures for various quantum applications ranging from electronic spin quantum computing, quantum optical approaches, to quantum transduction.

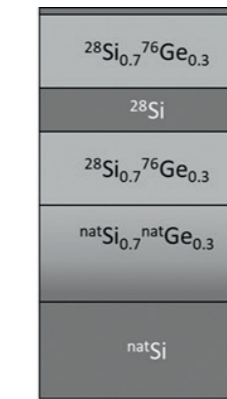


All our materials can be provided on a wafer-scale up to 100 mm diameter.

OUR UNIQUE SOURCE MATERIALS

IKZ has acquired a unique competence in the purification and crystal growth of isotopically enriched Si and Ge crystals through various projects. Within the scope of the international Avogadro Project and the redefinition of the kg using fundamental constants, IKZ produced the necessary defect-free bulk crystals of highly enriched (up to 99.999 at%) ^{28}Si crystals by the Float-Zone technique. [1] Furthermore, IKZ is part of the LEGEND collaboration and researches the purification and crystal growth of enriched high-purity ^{76}Ge . [2]

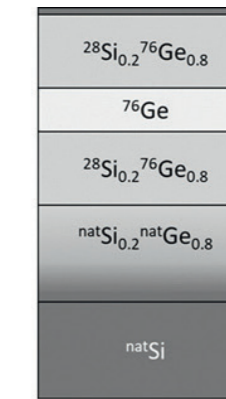
These materials are critical for creating high-purity, nuclear spin-free environments necessary for quantum applications. Isotopically enriched Si and Ge, such as ^{28}Si , ^{72}Ge , and ^{76}Ge , are processed in our facilities to ensure the highest standards of purity.



$^{28}\text{Si}/^{28}\text{Si}^{76}\text{Ge}$ Qubits

Electron Spin Qubits in Gate-defined Si Quantum Dots

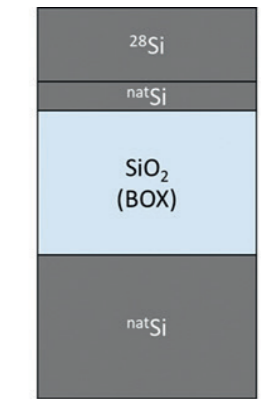
- Low threading dislocation density ($<10^6 \text{ cm}^{-2}$)
- Sharp interfaces ($<0.5 \text{ nm}$ width)
- low nuclear spin concentration ($<100 \text{ ppm}$)
- Undoped + high chemical purity ($<10^{16} \text{ cm}^{-3}$)



$^{76}\text{Ge}/^{28}\text{Si}^{76}\text{Ge}$ Qubits

Hole Spin Qubits in Gate-defined Ge Quantum Dots

- Low threading dislocation density ($<10^6 \text{ cm}^{-2}$)
- Sharp interfaces ($<1.0 \text{ nm}$ width)
- low nuclear spin concentration ($<100 \text{ ppm}$)
- Undoped + high chemical purity ($<10^{16} \text{ cm}^{-3}$)



$^{28}\text{SiOI}$ Quantum Optics

Single Photon Emitters in ^{28}Si , Er, Colorcenter (G,W)

- Telecom compatible layers (220 nm thickness)
- High isotopic purity ($>99.99\% \text{ }^{28}\text{Si}$)
- low impurity atom concentrations ($<10^{16} \text{ cm}^{-3} \text{ O}$, $<10^{17} \text{ cm}^{-3} \text{ C}$)

[1] Abrosimov, N. V., et al. "A new generation of 99.999% enriched ^{28}Si single crystals for the determination of Avogadro's constant." *Metrologia* 54.4 (2017): 599. <https://doi.org/10.1088/1681-7575/aa7a62>

[2] Gradwohl, K-P., et al. "Hydrogen reduction of enriched germanium dioxide and zone-refining for the LEGEND experiment." *Journal of Instrumentation* 15.12 (2020): P12010. <https://doi.org/10.1088/1748-0221/15/12/P12010>

[3] Gradwohl, Kevin-P., et al. "Enhanced Nanoscale Ge Concentration Oscillations in Si/SiGe Quantum Well through Controlled Segregation." *Nano Letters* 25.11 (2025): 4204-4210. <https://doi.org/10.1021/acs.nanolett.4c05326>

NOVEL OXIDE SUBSTRATES FOR THE DEVELOPMENT OF LOW-LOSS MAGNETIC MATERIALS FOR INTEGRATED MAGNONIC SUPERCONDUCTING QUANTUM TECHNOLOGIES

The groups "Substrate Crystals for Advanced Functional Oxides" and "FZ-Si" within the department "Volume Crystals" create the material basis for low-loss, miniaturized and integrable components based on magnonic and superconducting circuits for quantum technologies.

For this purpose, new oxide substrate crystals grown by the Czochralski method are under development, which will be used by the collaboration partners in form of epi-ready substrates to lower the magnetic damping of epitaxially grown thin films at low-temperatures and to create new types of components. In general, the development of novel oxide substrates with low impurity content and optimal lattice

match for magnetic thin films is one of the major parts of the IKZ activities within the framework of collaborative projects. These activities are in line with the process development activities of ultra-high purity silicon crystals, as the use of such zone-melted silicon substrate crystals will improve the relaxation times of the superconducting quantum bits and thus increase the efficiency and stability of the quantum technology based on them.