Lehrstuhl für Physik

Department Physik, Mechanik und Elektrotechnik
Montanuniversität Leoben

A-8700 LEOBEN, Franz Josef Straße 18, Austria
Tel: +43 3842 402-4601, Fax:+43 3842 402-4602
e-mail: physics@unileoben.ac.at

S E M I N A R
on
Semiconductor Physics and Nanotechnology

Mi, 22.05.2024, 16:15 Uhr,

Seminar in
person in the Physics lecture hall *or* via Zoom

"Prospects of Isotope-pure SiGe Heterostructures for Quantum Computing"

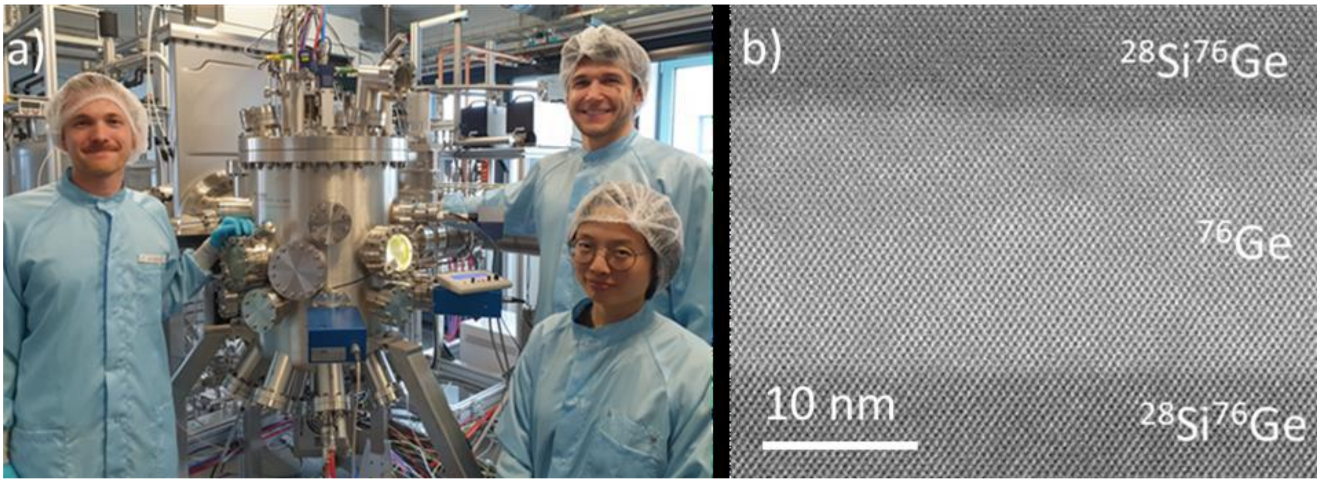
Dr. Kevin-Peter Gradwohl

Leibniz-Institut für Kristallzüchtung (IKZ), Berlin, Germany

Silicon (Si) and germanium (Ge) are the workhorses of the modern semiconductor industry, where decades of science and technology development yielded advanced device fabrication of extremely pure materials. This tremendous know-how, together with the possibility to produce isotopically enriched Si and Ge completely free of isotopes with nuclear spin, make them also extremely interesting for application in quantum computing utilizing spin qubits [1,2].

IKZ researches the processing, purification, and growth of isotope enriched ^{28}Si and ^{76}Ge volume crystals with ^{29}Si and ^{73}Ge concentrations as low as 30 ppm, and became a world-leading competence center in the field [3, 4]. These unique materials are utilized as source material in molecular beam epitaxy (MBE) for the development of novel quantum materials. Investigated material platforms include nuclear spin-free SiGe/^{28}Si/SiGe and SiGe/^{76}Ge/SiGe heterostructures for spin qubits, as well as ^{28}Si/SiO$_2$ structures (Silicon on Insulator, SOI) for optical quantum computing [5]. Hereby, material challenges encompass the fabrication of homogeneously strained quantum well layers, avoiding relaxation/formation of misfit dislocations, and control of interface sharpness, while maintaining high chemical and isotopic purity.

Our goal is the benchmarking of high-quality nuclear spin-free SiGe-based heterostructures for quantum computing, as well as the distribution of such MBE grown quantum materials to the European research market (e.g. for Q-device manufacturing) offered in collaborations in common R&D projects with interested partners.



a) nuclear spin-free molecular beam epitaxy, b) cross-section scanning electron microscopy image of strained ^{76}Ge quantum well heterostructure for qubit application

[1] Steger, M., et al. "Quantum information storage for over 180 s using donor spins in a 28Si “semiconductor vacuum”." Science 336.6086 (2012): 1280-1283.

[2] McJunkin, T., et al. "SiGe quantum wells with oscillating Ge concentrations for quantum dot qubits." Nature Communications 13.1 (2022): 7777.

[3] 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.

[4] 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.

[5] Liu, Yujia, et al. "Role of critical thickness in SiGe/Si/SiGe heterostructure design for qubits." Journal of Applied Physics 132.8 (2022).

Zoom – Link:

https://zoom.us/j/96375934537?pwd=RTlKTWhSdzRHU211YTY1bGFxTUtpZz09

Meeting-ID: 963 7593 4537

Kenncode: =r=4YQ