Advanced group-IV heterostructures and devices enabled by ultra-low temperature epitaxy

Ultra-low-temperature (ULT) epitaxy of semiconductor heterostructures in the group-IV system might be the key to unraveling advanced device applications in Si photonics, Si-based nanoelectronics, quantum optics, and, potentially, quantum transport.

This presentation will elaborate on the molecular beam epitaxy growth of group-IV crystals at temperatures between 100°C and 350°C. Noteworthy, this temperature range cannot be accessed by chemical vapor deposition methods, as precursor decomposition comes to a halt at a low thermal budget. For the same reason, we will highlight that excellent vacuum conditions are necessary when employing such growth temperatures to ensure high crystal quality mediated by a low density of point defects.

ULT enables the pronounced supersaturation of strained heteroepitaxial layers [1], i.e., leading to the formation of defect-free nanolayers of, until now, unreachable alloy contrast and layer thickness [2]. Examples of device applications presented here include double heterostructure diodes in the Si/SiGe/Si system [3] and reconfigurable field-effect transistors with highly symmetric on/off currents for both electrons and holes [2,4,5].

Carbon doping of ULT Si layers leads to unique properties of Si-based color centers that can be used as telecom quantum emitters, compatible with Si integration technology.

References:

[1] A. Salomon et al. physica status solidi (a) 219, 2200154 (2022)

[2] L. Wind et al. Small 18 (44), 2204178 (2022)

[3] M. Brehm, A. Salomon, J. Aberl, T. Fromherz, patent pending

[4] A. Fuchsberger et al., Advanced Electronic Materials, 2201259 (2023)

[5] A. Fuchsberger et al. (submitted) (2023)