Towards Arsenic in Germanium Quantum Devices
STM-Characterised δ-layer Fabrication

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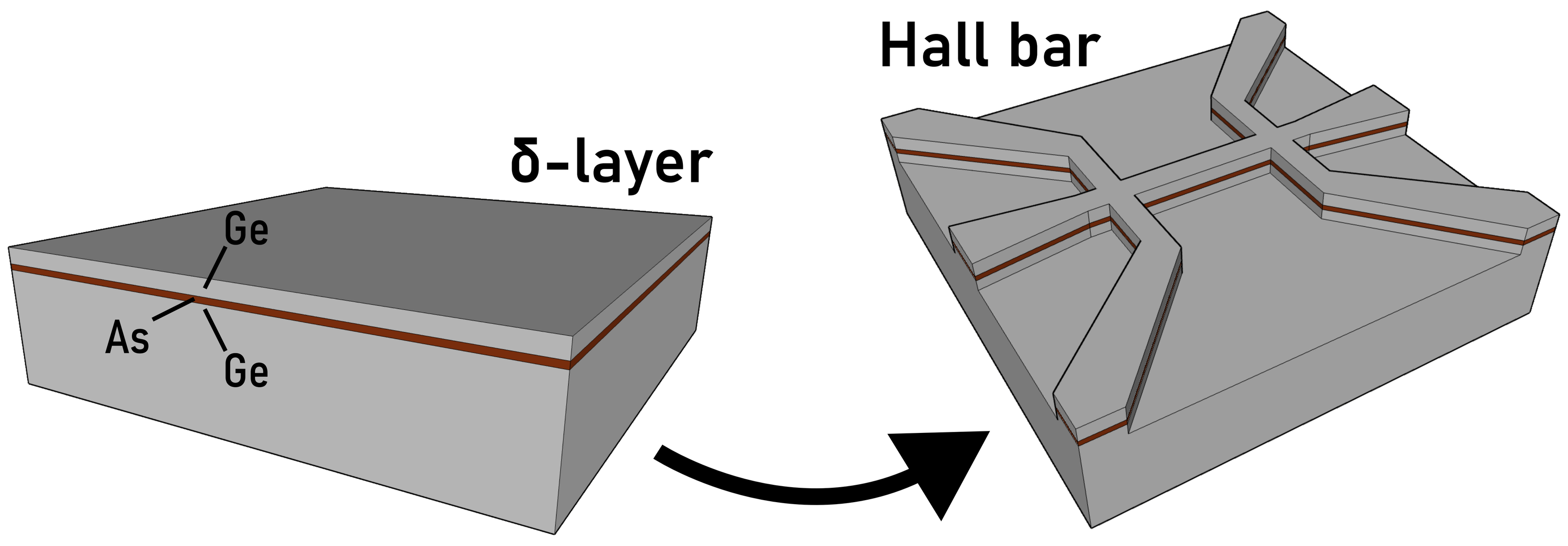
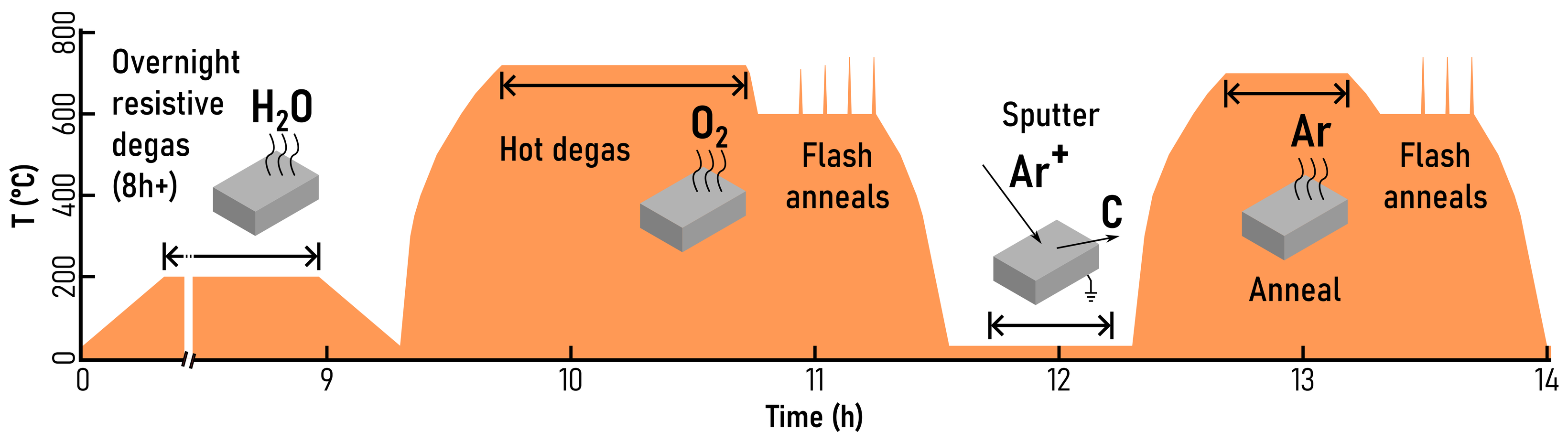
1. Introduction

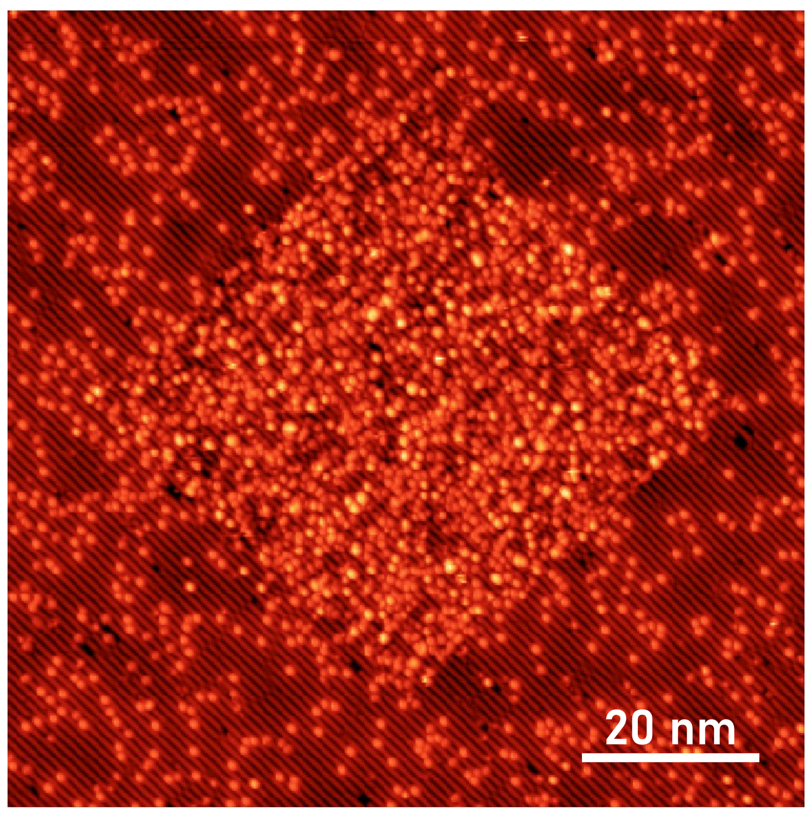
Arsenic in germanium (As-Ge) is a very promising material system for use in atomic-precision placement of dopants in semiconductors, potentially enabling the scalable fabrication of single-atom qubits. These may be interfaced with by conductive 2D dopant planes (δ-layers) that can be patterned alongside them, but the electronic properties of As-Ge δ-layers are not yet well-studied. Here, As δ-layers are produced in Ge(001), with fabrication quality confirmed by STM imaging. Subsequent patterning of Hall bar structures enables magnetotransport measurements that will elucidate their electronic properties.

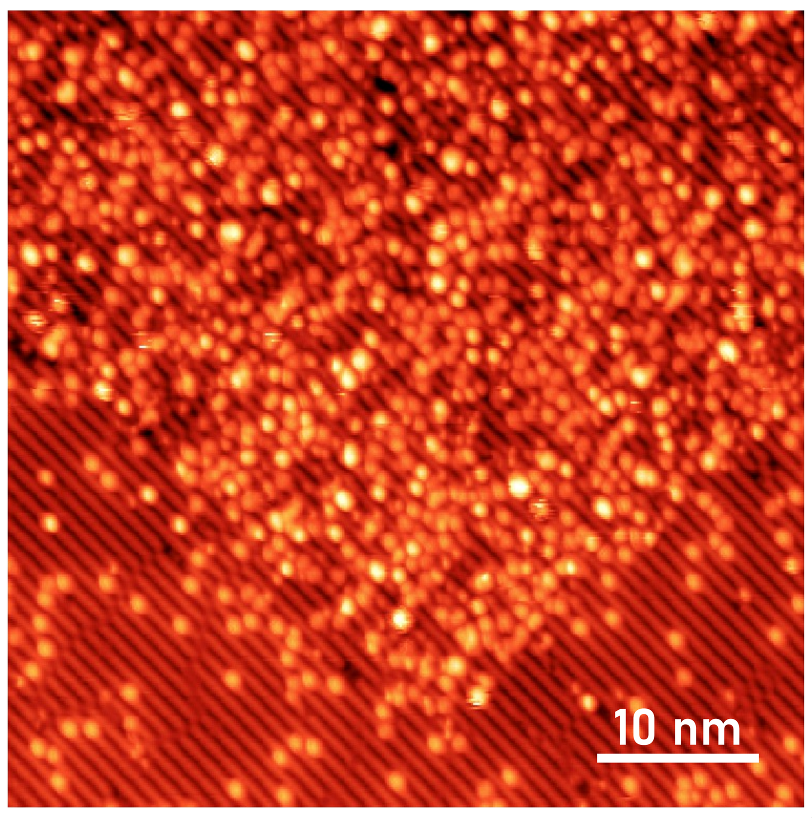


2. Germanium Surface Preparation and Arsine Dosing

Germanium is perpared by sputtering and annealing, then dosed with arsine (AsH_3). The saturation As coverage is 0.24 monolayers.

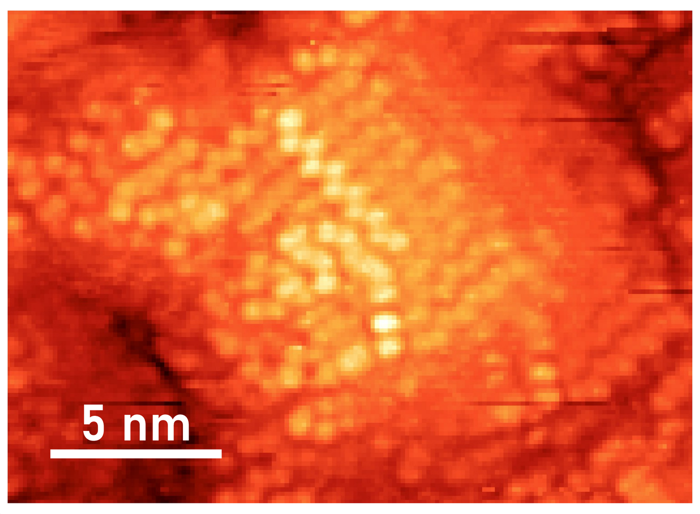


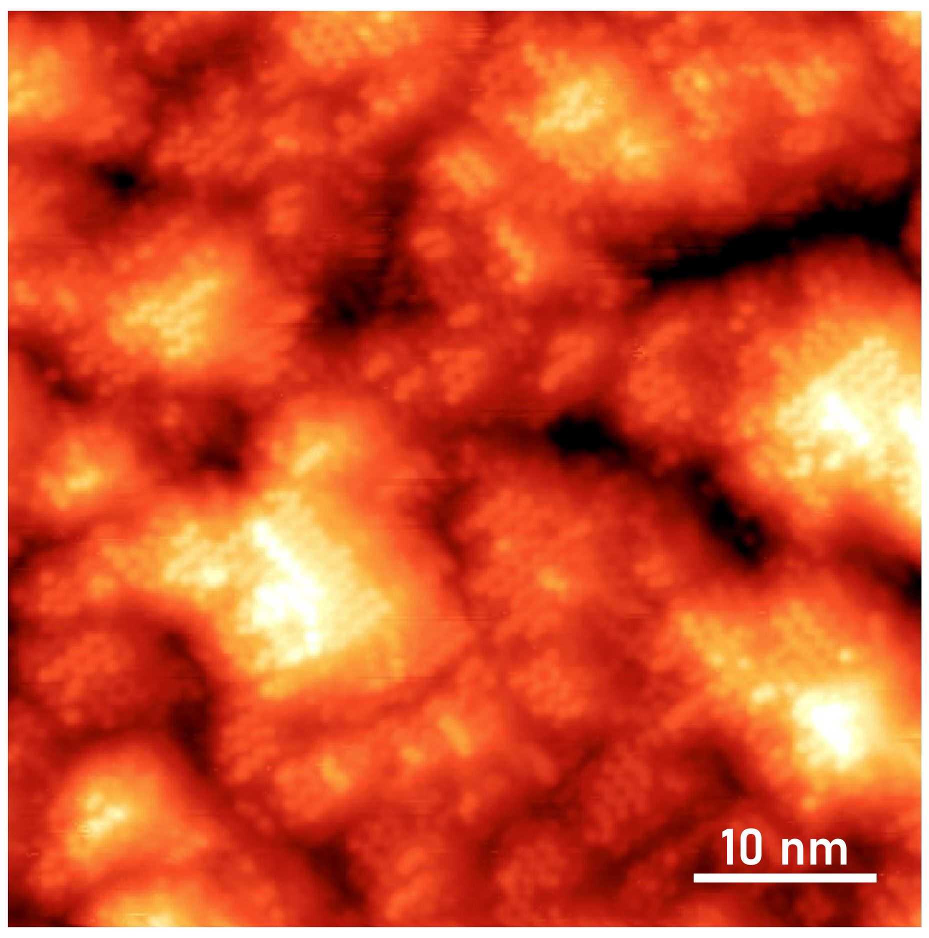




3. MBE Overgrowth

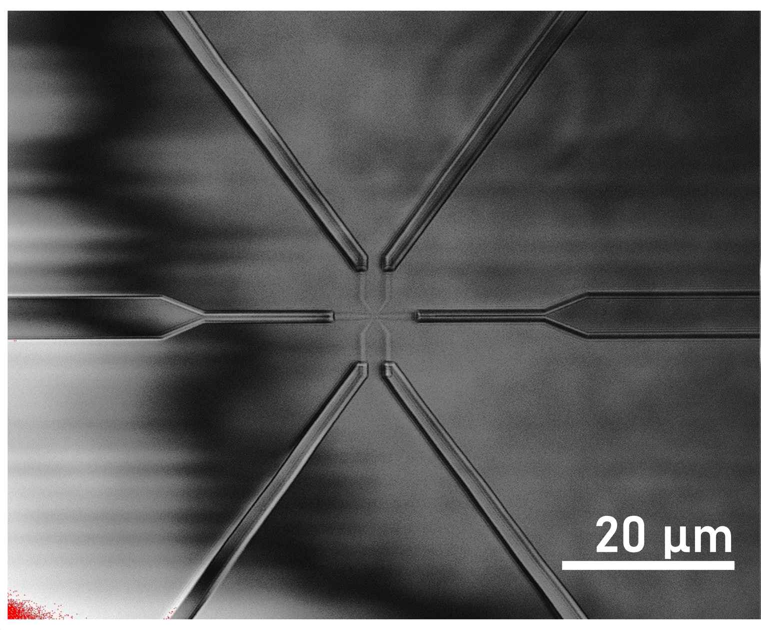
The saturation-dosed surface is overgrown with 15 nm of epitaxial Ge. Dopant confinement is maximised by growing at room temperature.

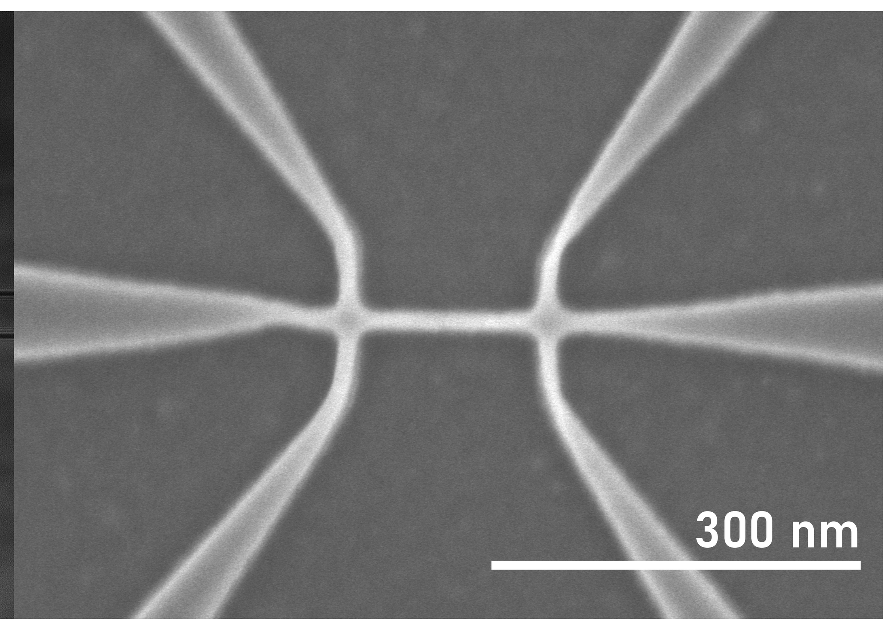




4. Hall Bar Patterning

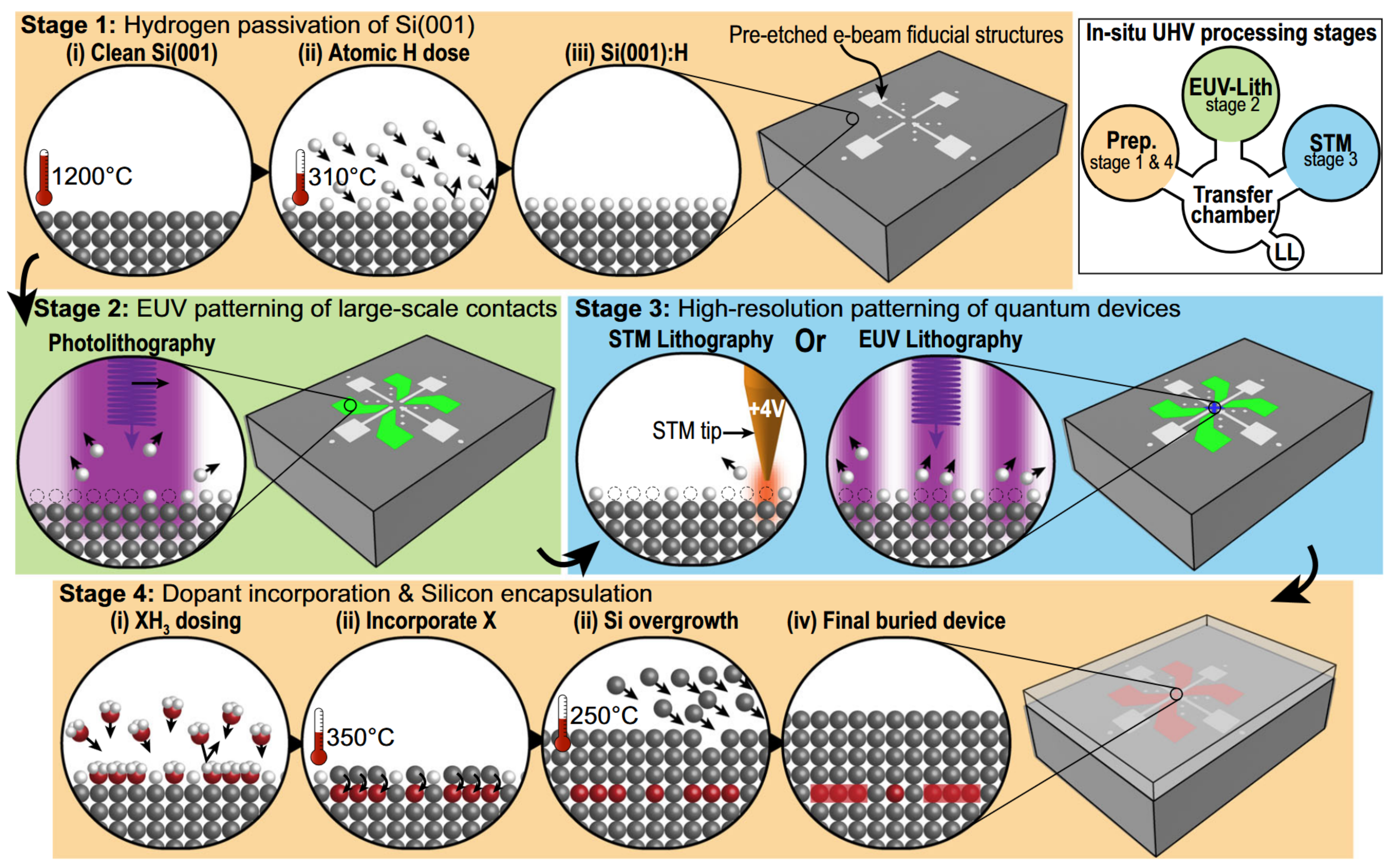
Hall bars of sizes between 20 nm and 10 µm are reactive ion etched at the Paul Scherrer Institute. In addition to standard magnetotransport measurement, it is expected that the mesoscopic nature of the smallest Hall bars will allow for observation of weak localisation effects.





5. Future Work

Overgrowth and fabrication optimisation is ongoing. Transport measurement results will form a vital component of work in the As-Ge system using the new method of extreme ultraviolet hydrogen desorption lithography (EUV HDL), which can perform nanoscale lithography orders of magnitude faster than existing methods. This will be a significant advancement towards scalable and commercially viable quantum device fabrication.



References

1. E. V. S. Hofmann et al. Room temperature tncorporation of arsenic atoms into the germanium (001) surface. Angew. Chem. Int. Ed. **62** (2023)
2. P. Constantinou et al. EUV-induced hydrogen desorption as a step toward large-scale silicon quantum device patterning. Nat. Commun. **15**, 694 (2024)

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