Selective area grown semiconductor nanowire networks with *in-situ* superconductor shadow deposition

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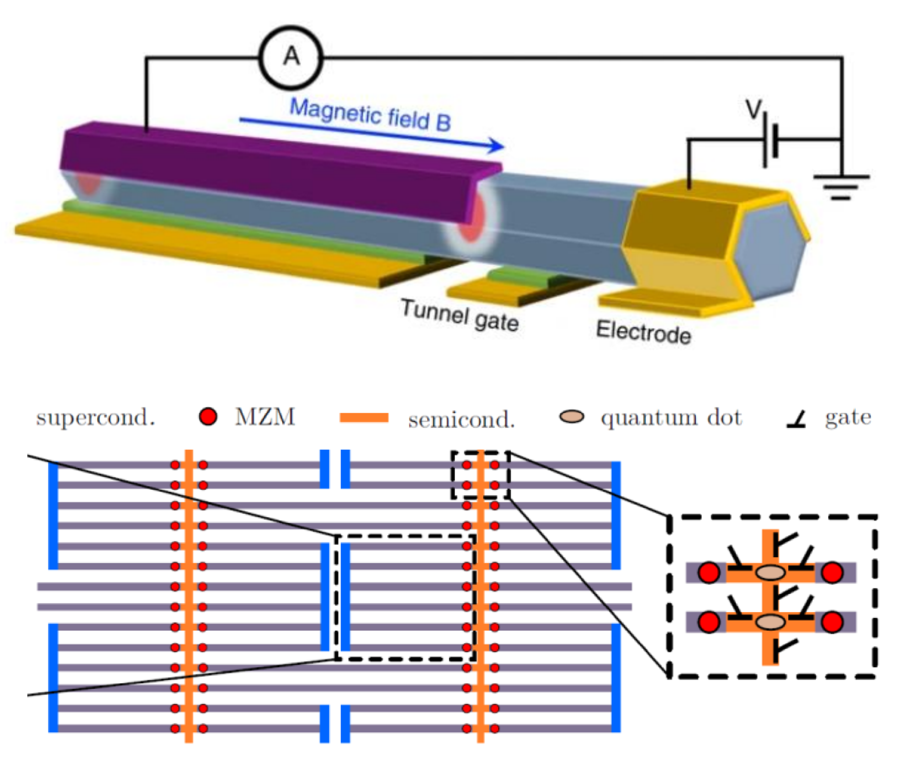
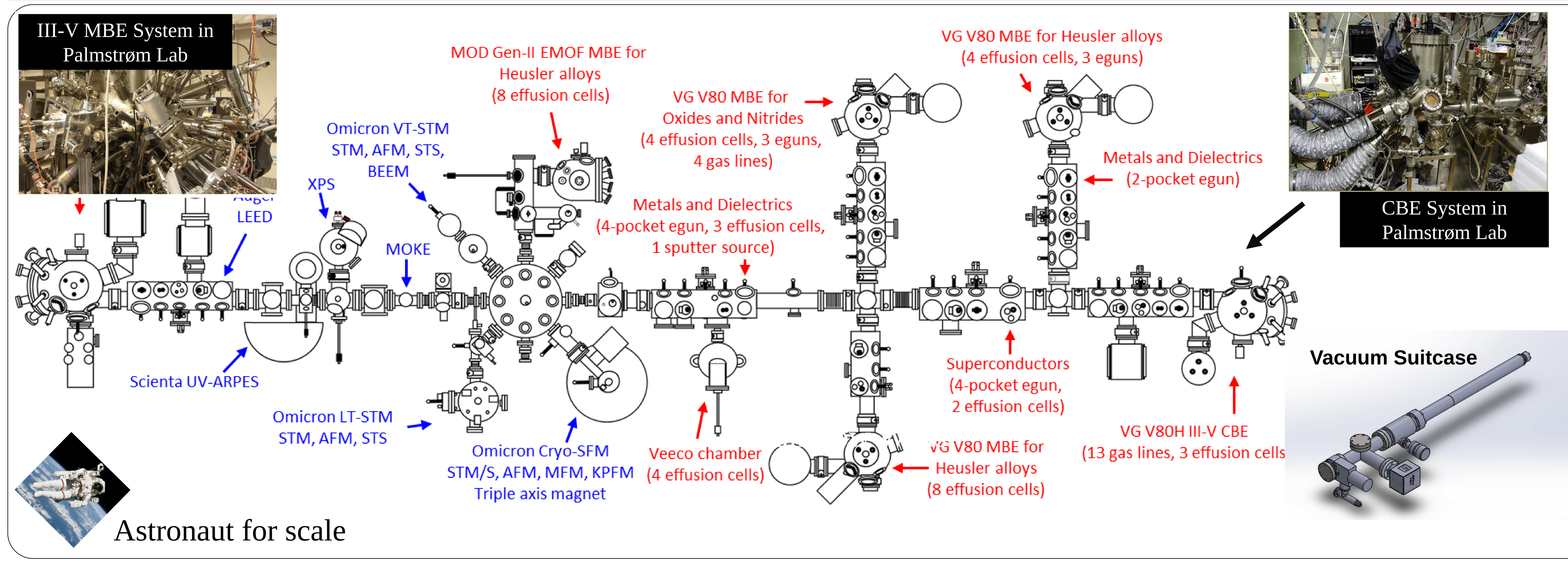
III-V Semiconductor/Superconductor Networks for Topological Quantum Computing

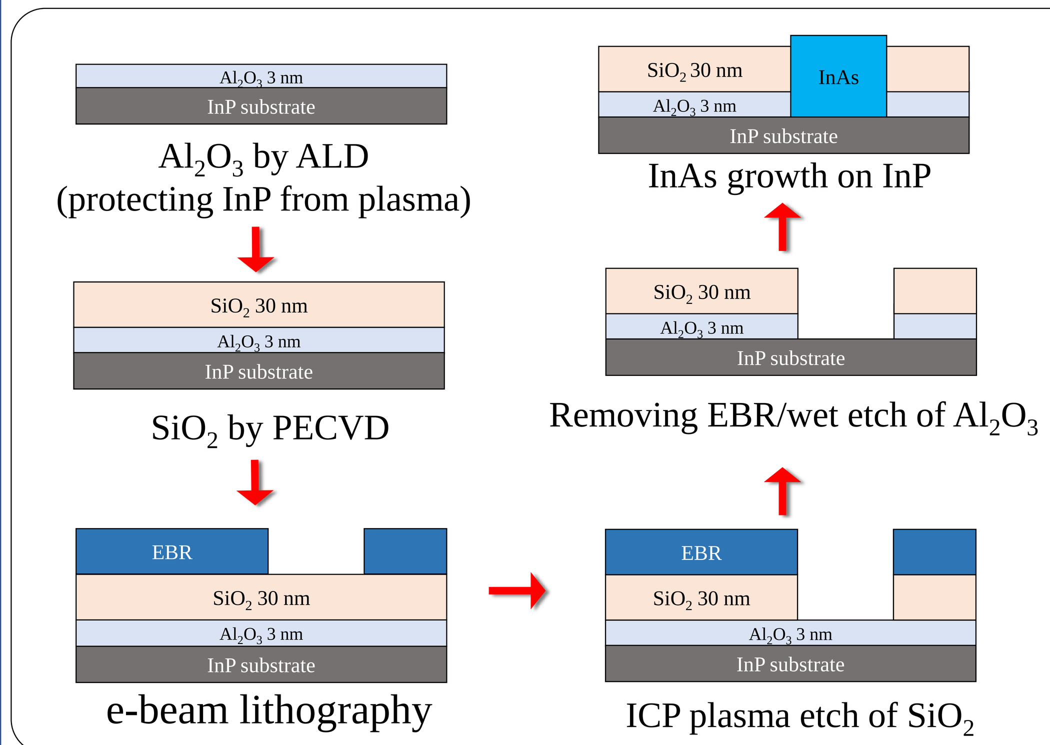


- III-V Nanowires with high spin-orbit coupling coupled to s-wave superconductors have been proposed as a platform for realizing Majorana fermions for topological quantum computing.
- Signatures of Majorana Zero Modes have been observed in such single nanowire systems.
- To perform braiding operations complex networks of nanowires are required**.**
- In addition, high mobility, lower defects and pristine interfaces in between the superconductor and semiconductors are essential.

III-V and superconductor growth chambers

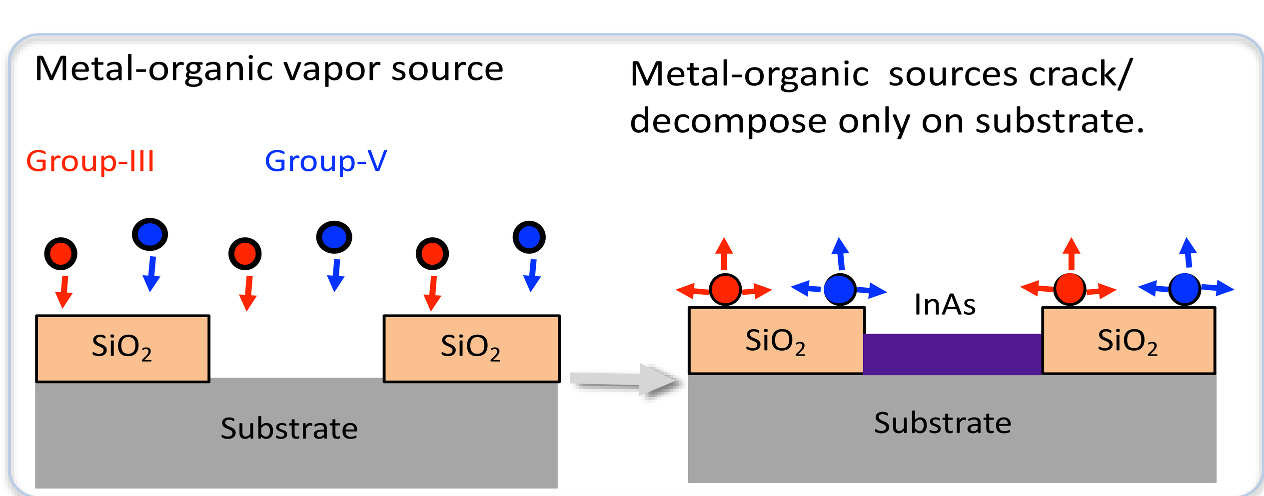


Fabrication of Nanowire Templates

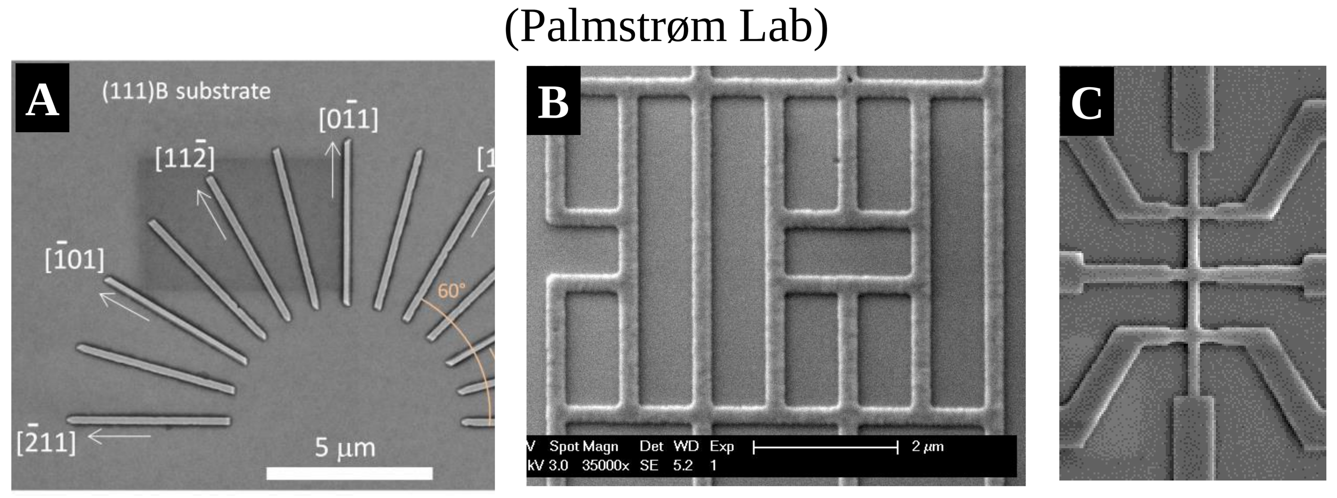


Schematic of the process-flow for fabrication of nanowire template

Selective Area Growth of III-V Nanowire Networks

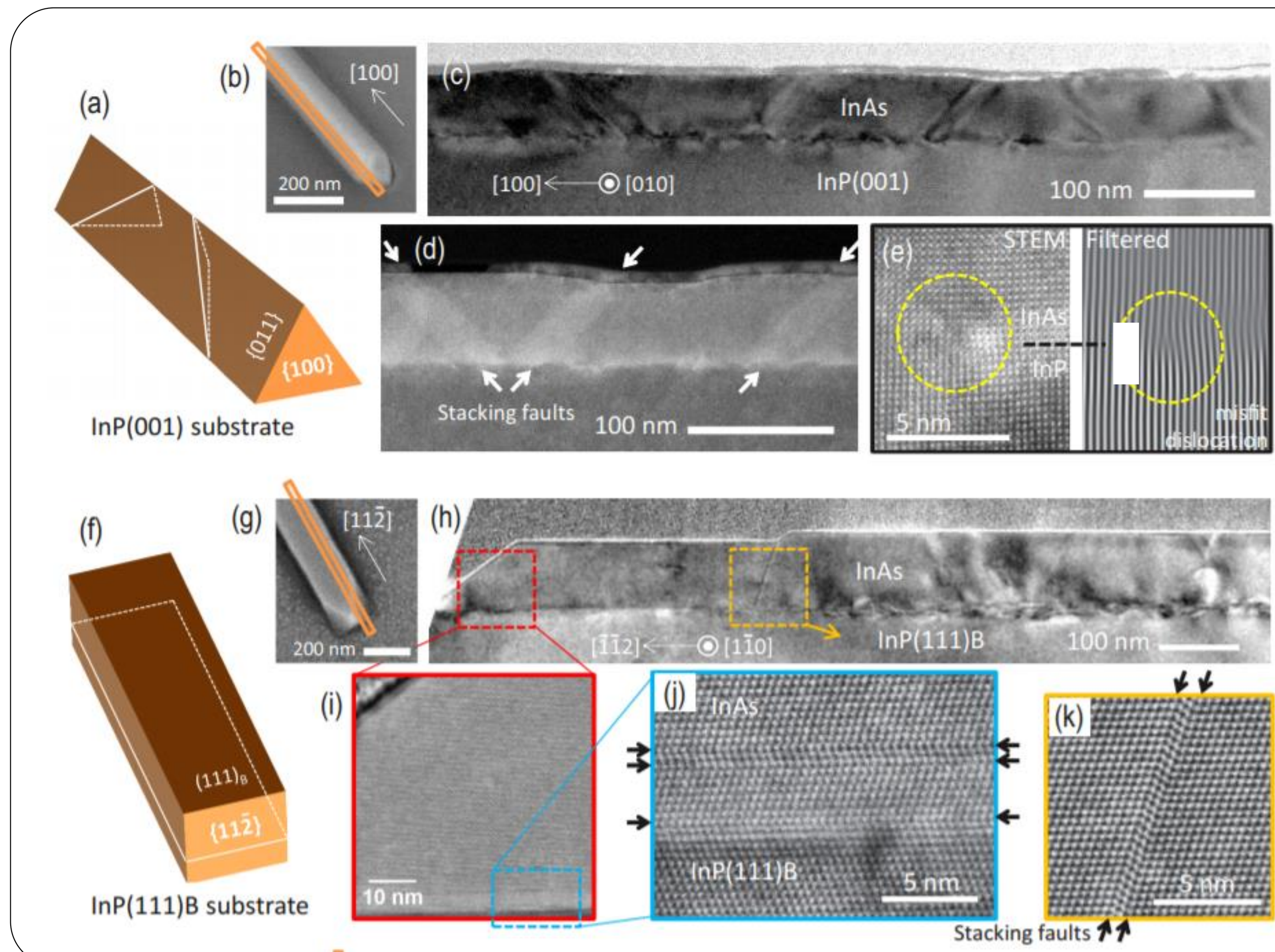


Samples are grown in UHV VG Chemical Beam Epitaxy System (Palmstrøm Lab)



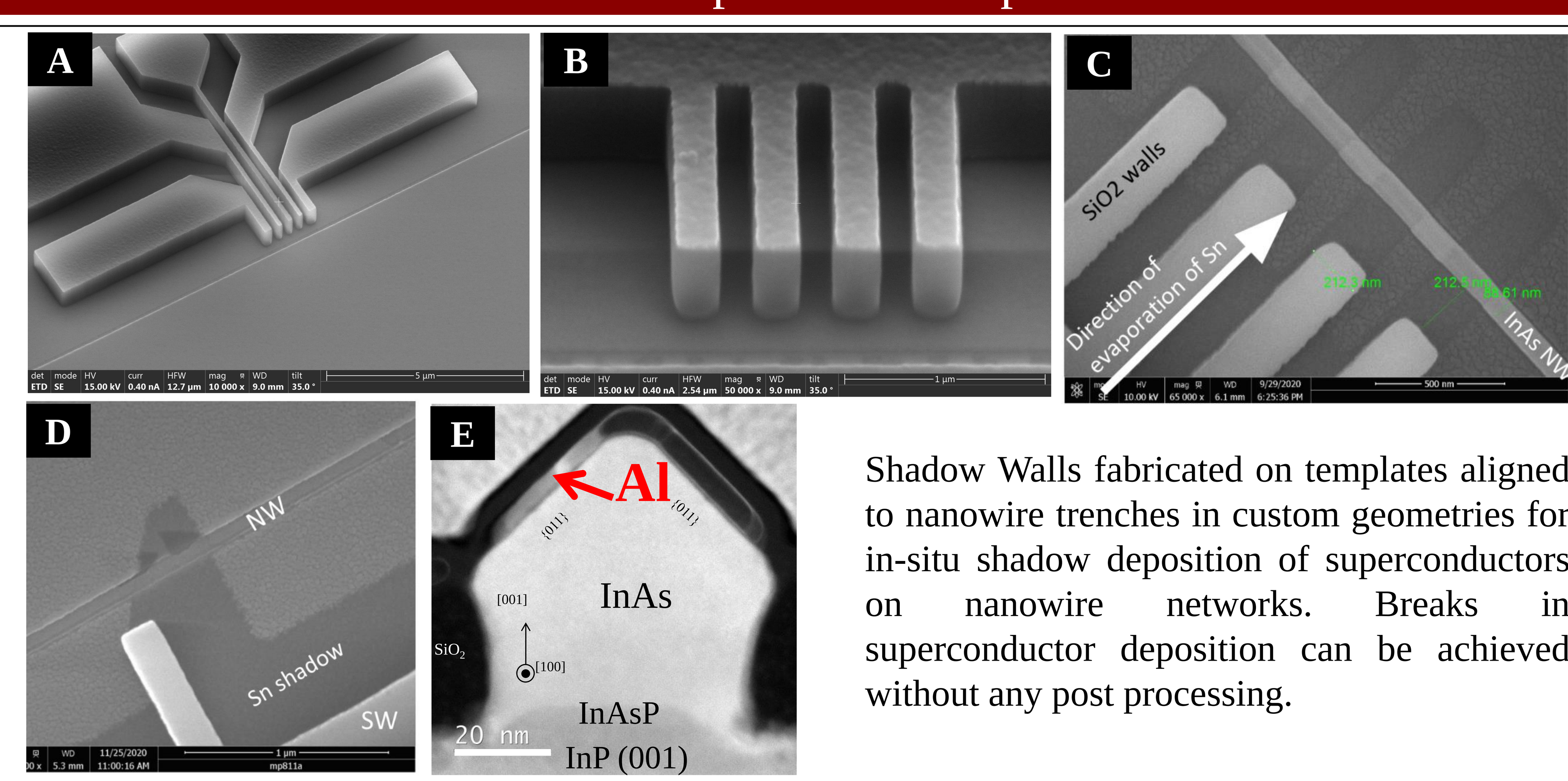
InAs SAG nanowires in various geometries grown on (111)B InP Semi-Insulating substrates. Networks (B) and Hall Bars (C) can also be directly grown.

Structural Analysis of SAG Nanowires



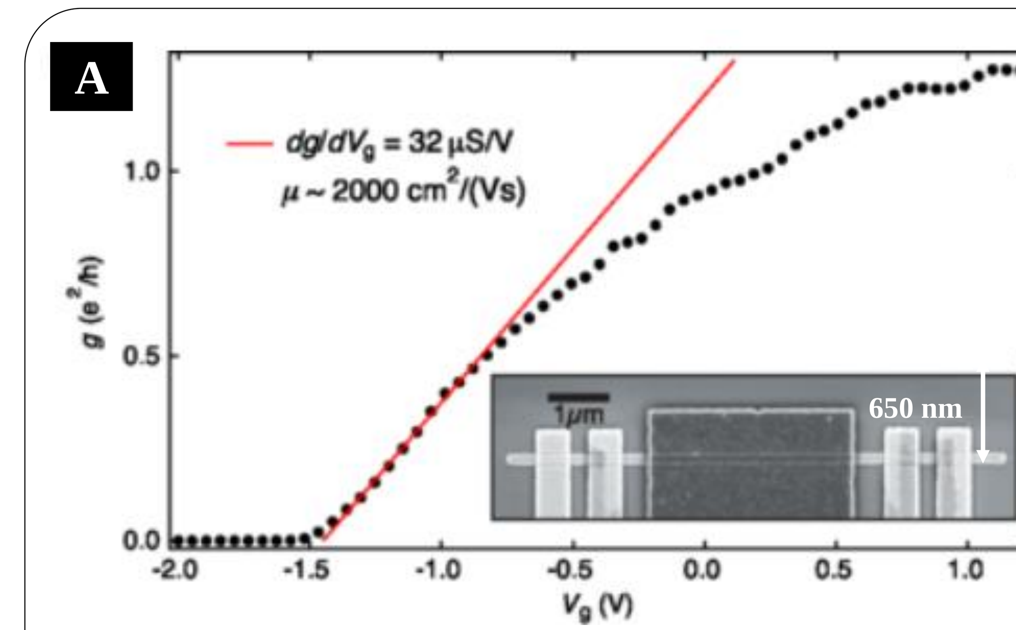
STEM shows misfit dislocations and stacking faults (SFs) in the {111} plane. The SFs intersect across the nanowire when grown on a (100) InP substrate, but on a (111)B InP substrate, the SF planes are parallel to the transport direction. This is reflected in higher mobilities in NWs grown on {111}B substrates.

In-Situ Shadow Deposition of Superconductors

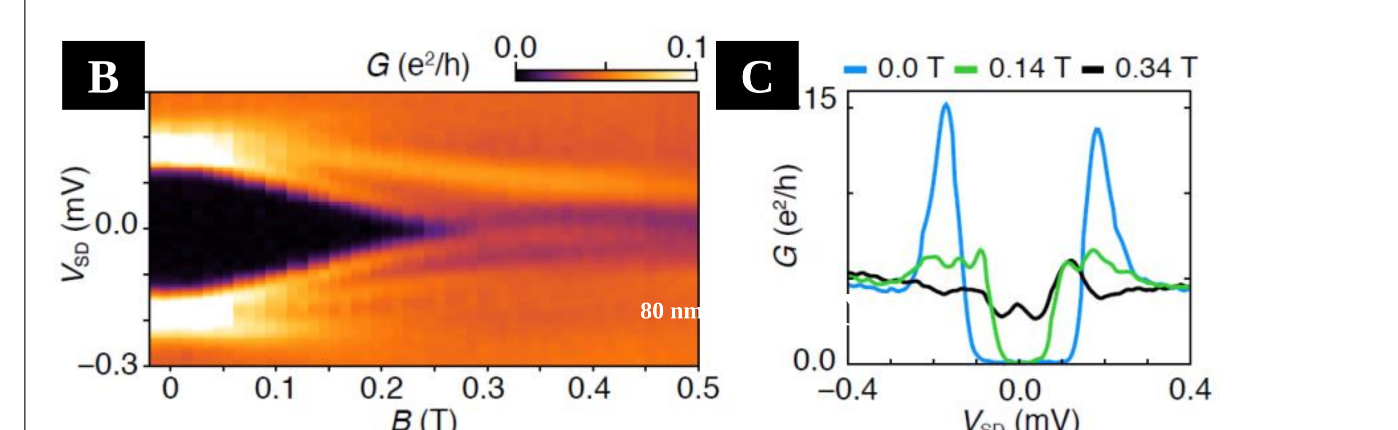


Shadow Walls fabricated on templates aligned to nanowire trenches in custom geometries for in-situ shadow deposition of superconductors on nanowire networks. Breaks in superconductor deposition can be achieved without any post processing.

Quantum Transport



Obtained carrier density and mobility of the InAs channels, measured at 2 K, are in the range of 0.9–2.1 × 10^{17} cm^{-2} and 1000–5000 $cm^2\,V^{-2}\,s^{-1}$



Superconducting hard gap observed in proximitized InAs SAG Nanowire with *in-situ* Aluminum deposition suggesting pristine semiconductor-superconductor interfaces.

Summary

We successfully demonstrated high-quality growth of semiconductor nanowire networks of InAs. We further demonstrated in-situ low-temperature shadow deposition of superconductors. These results pave the way forward for reducing defects, achieving higher mobilities in III-V nanowires and fabricating pristine interfaces with enhanced superconducting proximity effect - for a more robust platform to probe Majorana Fermions .

Acknowledgements

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