Towards Crystal Phase Control of Sn in Hybrid Nanowires

Sara Martí-Sánchez[1]

Sabbir A. Khan[2], Maria Chiara Spadaro[1], Peter Krogstrup[2] and Jordi Arbiol[1,3]

[1]Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Campus UAB, Bellaterra, 08193 Barcelona, Catalonia, Spain
[2]Center for Quantum Devices, Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark
[3]ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Catalonia, Spain

sara.marti@icn2.cat

Hybrid systems of semiconductors connected to metals/superconductors provide interesting platforms to explore exotic topological properties for topological quantum computing purposes. In particular, Sn is a promising material as it can present two main structural phases when deposited on III-V semiconductor nanowires (NWs): semimetallic α-Sn (cubic) and metallic β-Sn (tetragonal) which also presents superconductivity below 3.7 K. In addition, α-Sn can turn into a topological insulator under strain [1] and β-Sn has the potential to turn into a topological superconductor when hybridized with a strong spin-orbit coupling 1D semiconductor [2]. However, coexistence of both phases in III-V NWs has been reported [2] and control on phase formation remains challenging.

In this work we perform a (Scanning) Transmission Electron Microscopy - based study of Sn phase dynamics based on structural parameters of the involved materials. In a first approach, examination of different growth stages of Sn on InSb (zinc blende) permits to draw a map of phase dynamics. A monophase α-Sn shell evolves to β-Sn rich shell with increasing β-Sn density with layer thickness. In a second step, poorly lattice matched NW templates of InAs (wurtzite) were employed for Sn growth, where only β-Sn presence was detected.

Our studies reveal that Sn phase control is mostly driven from structural arrangement of the nanowire template. Therefore, this work provides a key to control Sn phases on hybrid NWs to permit the tuning of the topological properties by unveiling the insights of Sn growth.

References

[1] Barfuss *et. al.*, Phys. Rev. Lett. 111 (2013), 157205
[2] Pendharkar *et. al.*, Science 372 (2021), pp. 508-511

Figures

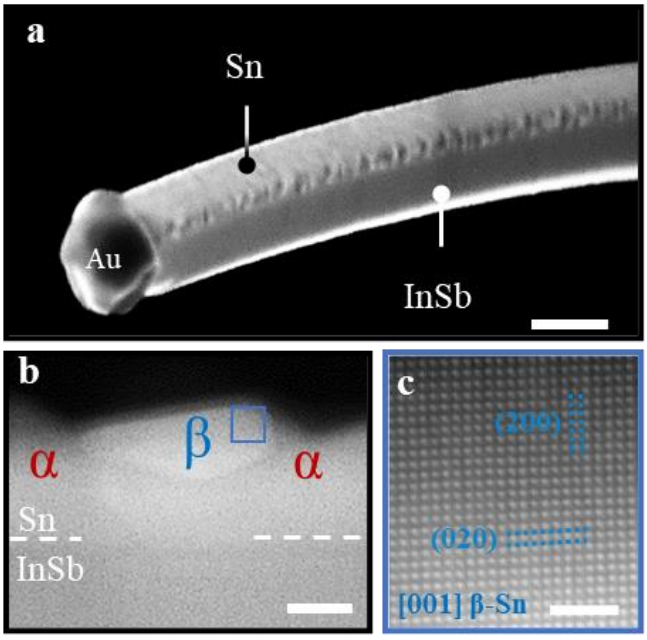

Figure 1: Electron microscopy analysis of one hybrid InSb-Sn nanowire sample of our study. **a** Tilted SEM image of the NW. **b** Low-magnification TEM micrograph of a multiphase shell. **c** Atomically resolved zoom-in of a β-Sn grain embedded in α-Sn with its orientation and plane indications. Scale bars (a-c): 100 nm, 20 nm, 2 nm.