Bismuth-trimer adlayer on In- and Sb- terminated InSb(111) surfaces

Rohit Yadav[1,2], ShengPeng Huang[3], Rainer Timm[1,2]

[1] NanoLund, Lund University, Sweden, [2] Division of Synchrotron Radiation Research, Department of Physics, Lund University, Sweden, [3] Max Plank Institute for Solid State Research, Stuttgart, Germany

Introduction: Bismuth-semiconductor interfaces are important from both fundamental and application point of view. For example, a monolayer of bismuth on SiC and GaAs is expected for 2D topological insulators [1,2], and Bi-trimers on Si(111) have been reported for giant Rashba splitting.[3] Here, we investigate atomic Bi incorporation on InSb(111)A and B surfaces due to their large spin-orbit coupling and small lattice mismatch. Furthermore, individual Bi-based compounds like InBi and Sb1-xBix have been predicted to induce non-trivial topological states. [4,5]

Methods: We have employed scanning tunneling microscopy/spectroscopy (STM/S) and synchrotron X-ray photoemission spectroscopy (XPS) to investigate surface topography, electronic properties, and chemical composition.

Results: STM topography of oxide-free InSb(111)A shows (2X2) reconstructions with In-trimers. Upon Bi incorporation, Bi mainly forms a smooth periodic bilayer, which highlights the formation of a Bi-induced (2X2) reconstruction, along with some larger (3X3) structures. A bias-dependent STM study shows that Bi-films are decorated with Bi-trimers, where STS indicates metallic character and discrete surface states in the bandgap, indicating possible band engineering upon Bi incorporation. However, Bi-incorporation into InSb(111)B results in mixed surface topography of Bi-trimers and Bi-monomer structures. Bi 5d core-level XPS for both InSb(111)A and B reveals that Bi-incorporation results in mainly Bi-Sb bonding with metallic Bi-Bi bonds. Interestingly, the Bi-Sb layer thickness remains self-limiting in the case of Bi/InSb(111)B, i.e., the amount of Bi-Sb remains unchanged irrespective of the number of deposition cycles.

Conclusion: Bi deposition can form several novel 2D structures on InSb, including a BiSb layer of self-limiting thickness.