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Self-Assembly of Few-atomic-layer Sb and Bi on Inert Substrates

Few-atomic-layer Bi and Sb are 2D semiconductors and potentially also topological insulators useful in spintronics. On graphite and MoS2 with vapor deposition, we observed the self-assembly of several types of Sb and Bi ultrathin films. These nanostructures can be in either the rhombohedral or black phosphorus (BP) crystal structures. Systematic STM-based investigation reveals the crucial roles of diffusion and dissociation of deposited species, as well as the surface stress of these nanostructures in determining the types of crystal structure and lattice periods observed. In particular, they start as compressed highly isotropic cubic- or square-phase nuclei. In a later growth stage, the nuclei undergo a symmetry-breaking transition as strain relaxation occurs. The compressive-state of these nanostructures is attributed to an enormous Laplace pressure induced by surface tension in a nanostructure. The stochastic growth and strain relaxation processes lead to the formation of either straight or branched nanobelts. Based on these understandings, certain morphological control of Sb and Bi nanostructures self-assembled on inert substrates has been accomplished. At a relatively high substrate temperature with a low deposition flux, straight nanobelts form exclusively, whereas at a low temperature and a high flux, branched nanobelts can be dominant. In addition, an organic molecular layer can be used to modify the morphology of Bi nanobelts. The result of our attempt in self-assembly growth of phosphorus and arsenic nanostructures will also be discussed.

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