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Unusual Bi-induced surfaces of III-V semicondcutors

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Abstract: Knowledge of surface properties of III-V semiconductors is essential to understand and control the epitaxial growth and heteroepitaxy of III-V device materials. Adjusting a proper atomic structure for the III-V growth front and for the starting substrate of a heterointerface (i.e., "surface engineering") has been found to significantly improve the properties of the produced III-V device materials. Understanding of Bi-induced III-V surface structures is important for (i) the epitaxy of III-V-Bi alloyed layers and for (ii) the Bi-surfactant mediated growth of III-V heterostructures. In this work, we have studied Bi-induced surface structures of GaAs, InAs, InP, and InSb by combining low-energy-electron-diffraction (LEED), photoelectron-spectroscopy, reflection-high-energy-electron-diffraction (RHEED), and scanning-tunneling microscopy/spectroscopy (STM/STS) measurements as well as ab initio calculations. The results show that bismuth induces various unusual surface structures on the III-V substrates as compared to the other group-V atoms. Here we focus on two findings: metallic Bi-induced (2x1) reconstructions of III-V(100) surfaces and Bi-induced differences in the GaAs(100) surface structures as compared to the As-induced GaAs reconstructions. The results are discussed in context of useful effects of the Bi surfactant. The phase diagrams, which show the relevant Bi-induced reconstructions with the substrate temperatures and Bi amounts to the III-V-Bi epitaxy and surfactant growth, are presented.