Atomic scale study of isovalent Bi atoms in the (110) InP surface

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Recent advances in semiconductor growth technology have led to the development of highly mismatched III-V semiconductors, such as dilute nitrides and bismides. This novel material class has attracted much attention from both a fundamental and application-oriented point of view [1,2]. Compared to the well-studied dilute nitrides, little is known about dilute bismides at the atomic length scale, which are in many ways complementary to dilute nitrides [3,4]. We address this issue in state of the art Bi:InP by cross-sectional scanning tunneling microscopy (X-STM) [5].

Bi atoms up to the second monolayer below the (110) InP surface are identified with the help of a geometrical hard sphere model [6] and complementary density functional theory (DFT) calculations. It is found that the contrast of Bi atoms in and directly beneath the (110) surfaces is mainly related to local strain effects of the large Bi atoms on the InP matrix. Besides these structural effects, the influence of Bi impurities on the local electronic structure is addressed in dI/dU point spectra. Here, specific Bi related resonances in the valence band of Bi atoms in the first three surface layers are discussed with respect to theoretical expectations. Bi:InP shows compared to other Bi doped III-Vs an unusual sub band gap photo luminescence. In this light, the short-range ordering of Bi atoms is addressed in Bi doped InP quantum wells and films. The X-STM measurements revealed an enhanced tendency for the formation of first nearest neighbor Bi pairs. At higher Bi contents additional Bi clustering is observed. Bi:InP/InP quantum wells show in contrast to dilute nitrides characteristic segregation patterns.

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