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Atomic Structure of InGaAs Alloys

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The surface structure of a seemingly random alloy layer has a great impact on the compositional homogeneity and subsequent interface formation. For example, it has been suggested that random fluctuations in composition may initiate lateral composition that propagates through the remainder of the film. Our group studies the morphology and surface reconstruction of InxGa1-xAs alloy layers during growth and after annealing. Films of different compositions were grown by Molecular Beam Epitaxy on GaAs and InP to thicknesses less than the critical thickness for 3D islanding or misfit dislocation formation, and examined using in-situ Scanning Tunneling Microscopy and ex-situ Atomic Force Microscopy. The surface reconstruction of these layers is generally more disordered than those of their binary counterparts, and consists of different reconstruction domains. In particular, both surfaces show domains of a mixed-terminated (4x3) reconstruction, which is better ordered for the high In composition. In addition, there are pockets of a2(2x4) in the case of In0.27Ga0.73As/GaAs, and b2(2x4) in the case of In0.81Ga0.19As/InP. The coverage of both (2x4) reconstructions decreases during annealing, concomitant with a decrease in In surface concentration due to In desorption, suggesting that the (2x4) reconstructions are enriched in In compared to the (4x3)/(nx3). The coverage of different reconstructions also changes with film thickness, following changing surface composition and increasing strain energy. In the case of the In0.27Ga0.73As films, the In composition at the surface increases with film thickness and reaches a saturation level, in agreement with previous reports. The coverage of the (4x3) reconstruction reaches a saturation level at the same time, suggesting that a high and stable In concentration at the surface and/or a high strain energy favor a better ordered (4x3). The coverage of the a2(2x4) reconstruction increases initially with film thickness, then it decreases as the strain energy continues to increase, despite the fact that the surface reaches a stable composition. These results point out the importance of considering the effects of strain energy and inhomogeneous composition in the understanding of alloys surface structure.