X-ray Diffraction Study of In Segregation in MBE Grown $In_{1-x}Ga_xAs/GaAs$ superlattices

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ABSTRACT

X-ray diffraction (XRD) was used to study the composition modulation in $In_{1-x}Ga_xAs/GaAs$ superlattices grown by molecular beam epitaxy (MBE). Superlattice periods were 34.5, 57, and 93 Å, with a nominal $In_{1-x}Ga_xAs$ thickness of 10 Å and a composition x = 0.5 in all cases. The experimental θ-2θ XRD patterns were simulated using a kinematical calculation with a linear composition gradient at the interfaces. Roughness was simulated by using random fluctuations in the thickness of each layer and defects by random fluctuations in d-spacing. The $In_{1-x}Ga_xAs$ layers were assumed to be coherently strained to the GaAs since the layer thicknesses were less than the critical value for strain relaxation. Simulations using a symmetric composition modulation, as expected for interdiffusion, could not fit the experimental data. However, simulations using an asymmetric composition modulation, expected due to In segregation during MBE growth, produced good fits to the experimental data. For this case where In segregation was over distances greater than the $In_{1-x}Ga_xAs$ layer thickness, the In content increased linearly with distance during $In_{1-x}Ga_xAs$ growth, then decreased linearly after the In flux was stopped. Best fits were obtained for a maximum In concentration of x = 0.2, with a gradual decrease to pure Ga over ~ 35 Å, and interfacial roughnesses of ~ 1Å.