Thermodynamic analysis of III-V semiconductor alloys grown by metalorganic vapor phase epitaxy

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A thermodynamic analysis has been applied to systematically study III-V semiconductor alloy deposition, including nitrides grown by metalorganic vapor phase epitaxy. The predicted solid compositions of a number of ternary and quaternary alloys, including $Al_xGa_{1-x}P_yAs_{1-y}$, are compared with experimental data. For phosphorous-containing alloys, introduction of a parameter f representing incomplete PH_3 pyrolysis yields good agreement with experimental data. It is shown that the input mole fraction of the group III metalorganic sources influences the incorporation of P into the solid for these alloys. Solid composition is also calculated for nitride alloys as a function of inlet gas concentration. To date, thermodynamic models have been applied solely to predict N solubility limits for nitride alloys where mixing occurs on the group V sublattice. The present model is used to predict N solid compositions in ternary and quaternary alloys, and it is demonstrated that these values are below the theoretical solubility limits for In-containing nitrides. The role of H_2 in the carrier gas is investigated for III-N-V, III-III-N-V, and III-N-V-V systems.

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