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Effective Masses in Dilute Nitride Bismide Semiconductor Alloys: Failure of the Band Anti-Crossing Model?

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Abstract: The semi-empirical band anti-crossing (BAC) model proposed by Shan et al has successfully explained the bandgap bowing effect in both dilute nitride and dilute bismide semiconductor alloys. Within this model, a higher (lower) lying localized N (Bi) band interacts with the extended host semiconductor band resulting in a split of the CB (VB) into two sub-bands. Although the BAC model qualitatively predicts the N composition dependence of the GaAsN bandgap, it does not quantitatively explain several extraordinary optical and electronic properties of GaAsN and related alloys. We have investigated the N-composition, x-, and T-dependence of the electron effective mass, m*, of $GaAs_{1-x}N_x$. Using Seebeck and Hall measurements, in conjunction with assumptions of parabolic bands and Fermi-Dirac statistics, we find a non-monotonic dependence of m* on *x* and an increasing *m** T-dependence with *x*. These trends are not predicted by the two-state BAC model but instead are consistent with the predictions of the linear-combination of resonant nitrogen states model, which takes into account several N-related states and their interaction with the GaAs conduction-band edge. Similar effects for the hole effective mass will be discussed in the GaAsBi system.