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Application of Exit-Plane Wave Function Images in High-Resolution Transmission Electron Microscopy for Compositional Analysis of III-V Semiconductor Interfaces

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Existing methods based on high-resolution transmission electron microscopy (HRTEM) for compositional analysis of III-V semiconductor interfaces are applicable only to ternary systems [1-4]. Furthermore, they require optimal specimen-thickness and imaging conditions which depend on the material system under investigation. In this work we investigate the applicability of exit-plane wave function (EPWF) images, retrieved from HRTEM images, for quantitative chemical analysis of III-V semiconductor interfaces. By using the focus variation technique for EPWF retrieval [5] in combination with factorial analysis of correspondence for quantitative analysis [6], we show that compositional profiles along the group-III and group-V sublattices can be independently extracted. The present approach is more general, enabling compostional analysis of other III-V semiconductor heterostructures, such as InGaSb/InAs and InGaP/GaAs, which exhibit intermixing in both group-III and group-V sublattices. Application of the proposed method to the analysis of interfaces in epitaxially grown $Al_xGa_{(1-x)}As$/GaAs and $In_xGa_{(1-x)}Sb$/InAs heterostructures yielded compositional sensitivities with standard deviations equal to 0.06 (x_{Al-Ga})and 0.08 (x_{In-Ga} and x_{As-Sb}), respectively. The validity of this approach is verified by an image simulation study performed on model interfaces with abrupt and linear grading in the interface composition profiles.

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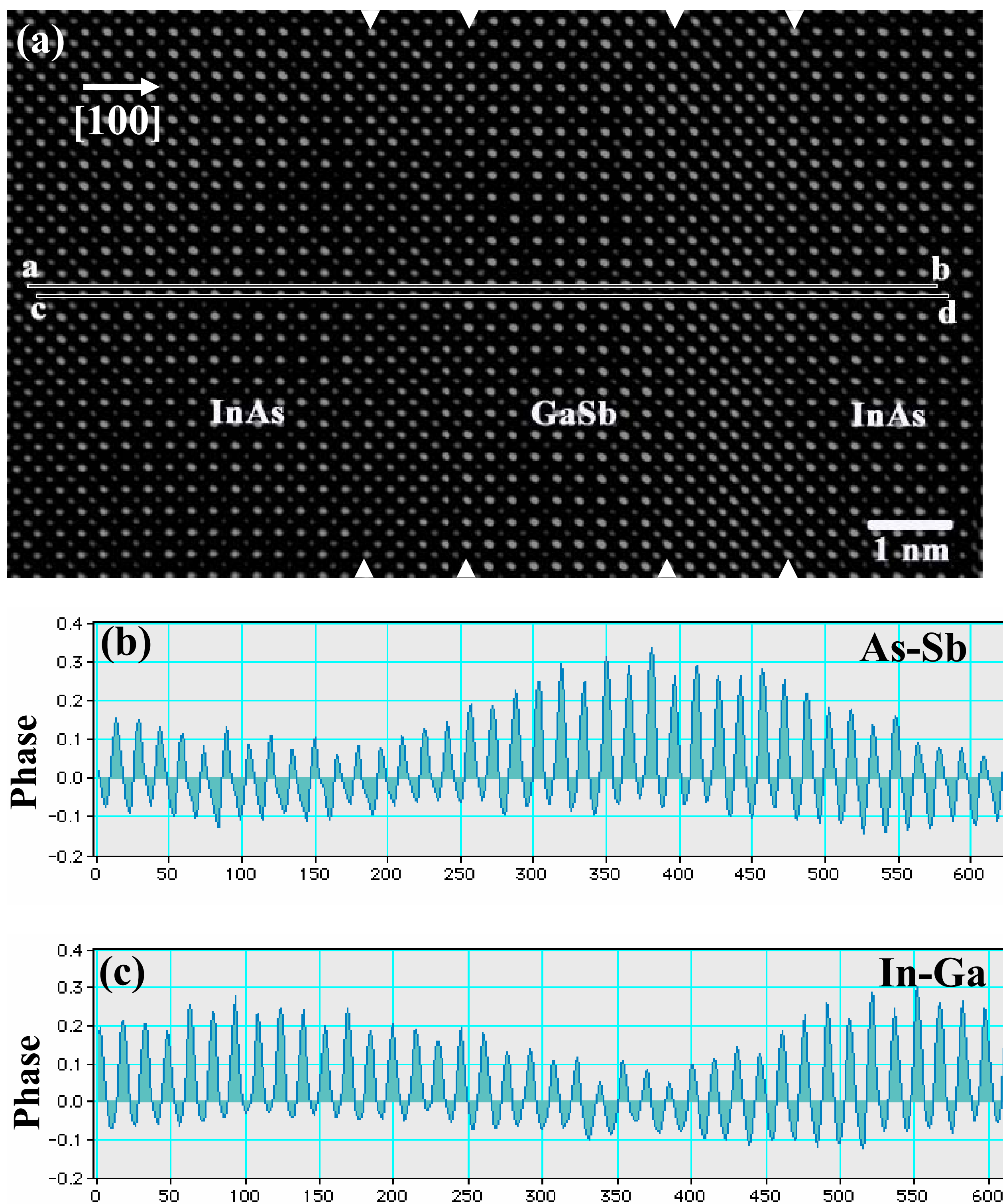

Fig. 1 (a) Exit-plane wave function phase component image of an InAs/GaSb/InAs structure, wherein the arrows mark interfacial regions adjacent to the two interfaces, (b) a line profile across the As-Sb sublattice, denoted by the line a-b in (a), and (c) a line profile across an adjacent In-Ga sublattice, denoted by the line c-d in (a).

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