Aberration-corrected TEM study of Interface Structures and Defects in III-V semiconductors grown on Si

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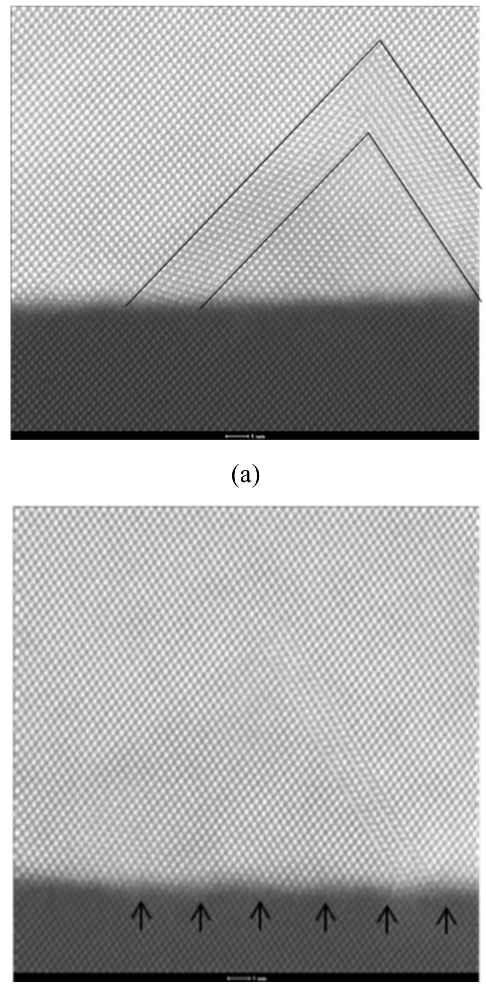
Heteroepitaxial semiconductor layers grown on silicon have the potential to provide a range of new optoelectronic properties making new applications beyond the Si-roadmap possible. In particular, III-V compound semiconductors and their alloys provide a range of tunable bandgaps that vary from 0.17 eV for InSb to 1.45 eV for GaAs allowing these materials to emit and absorb photons over a wide range of energies. This wide range makes them suitable for various applications from light-emitting diodes, microwave ICs and high-power transistors to solar cells [1-4]. The lattice mismatch between Si and the heteroepitaxial layers, however, is a major limitation for growth of high-quality films. Various interface properties and defects depend on the structure and the preparation of Si surface prior to growth, the thickness of the films, the growth conditions, lattice parameter of the heteroepitaxial layers and buffer layers used. Of particular interest is the misalignment of group III and group V sublattices at surface steps of the Si substrate which eventually result in antiphase domain (APD) formation [4-6].

In this work we study the structure of interfaces in GaSb thin films deposited on miscut Si substrates by gas-source molecular beam epitaxy (MBE). Using aberration-corrected high-resolution transmission electron microscopy (HRTEM) and high-angle annular dark-field (HAADF) imaging we have studied the GaSb/ Si interface structure and strain distribution around defects. With HRTEM and HAADF imaging, we have observed APDs and dislocations emanating from the interface (Figure 1a,b). Based on these images, and with the geometric phase analysis method, we have measured the displacement of atoms in proximity of the APD and the interface to determine if these defects are present when an interfacial dislocation network is also present. The role of these defects and their effect on the nature of the surface roughness of the films and their transport properties will be discussed.



(a)

(b)

Fig. 1(a) HRTEM image of antiphase domain (APD) (b) periodic steps at the interface.

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