Aberration-Corrected STEM Imaging of Compound Semiconductors

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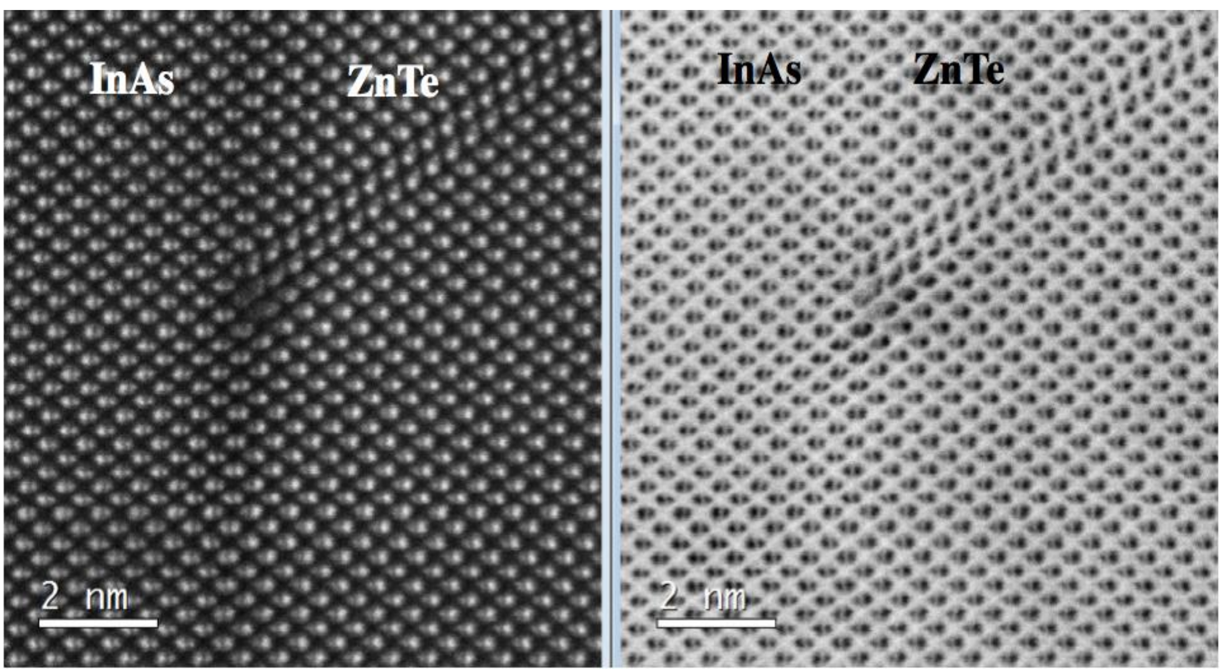
Compound semiconductors provide the basis for a broad range of optoelectronic devices based on their band-gap energies, which span from the far-infrared into the ultraviolet wavelengths. Epitaxial growth represents the preferred fabrication route but there are several practical factors that can seriously impact the final epilayer quality. Lattice mismatch will obviously lead to misfit strain and potential defect formation, but differences in thermal expansion as well as possible valence mismatch must also be taken into account when considering the fabrication of device heterostructures. The emergence of aberration correction has enabled electron microscope information limits to extend beyond the 1-Å resolution barrier, making it routine to achieve atomic-resolution imaging from many types of materials. For elemental and compound semiconductor heterostructures, it is possible to resolve the projections of individual atomic columns, often referred to as dumbbells, in the common <110> direction. This capability makes it possible to deduce bonding polarity and defect terminations directly from micrographs. Composition profiles across heterovalent interfaces, as well as bonding information at the atomic level, can also be extracted when using the probe-corrected configuration. his paper will describe our recent studies of isovalent (valence-matched) II-VI/II-VI and III-V/III-V structures such as ZnTe/CdTe and InSb/GaSb, and heterovalent (valence-mismatched) II-VI/III-V structures such as ZnSe/GaAs and CdTe/InSb, using aberration-corrected scanning transmission electron microscopy (AC-STEM). The effect of lattice mismatch across isovalent versus heterovalent interfaces in terms of defect creation and evolution with increasing epilayer thickness will also be compared. As an example, Figure 1 shows AC-STEM images of a ZnTe/ InAs(001) heterostructure where there is ~0.74% lattice mismatch between the two materials, with an interfacial stacking fault propagating upwards into the ZnTe epilayer.: (L) HAADF (90-150 mrad); (R) large-angle BF ()-22 mrad).



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