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Atomic Mixing at Interfaces in Nano-Structures

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Short-period superlattices, based on semiconductor or oxide layers, have wide range of applications from infrared imaging to giant magneto-resistance devices. Some of them require deposition of a nm-thick sub-layers. In these systems, the interface quality becomes crucial for device functioning. Most common imperfections are related to atomic intermixing during growth that is difficult to probe on such short length scales. We use for this purpose advanced characterization techniques, which include high-resolution transmission electron microscopy (HRTEM) for lattice imaging and, especially, high-angle annular dark field (HAADF) in scanning transmission electron microscopy (STEM) for Z-contrast imaging, scanning tunneling microscopy (STM) for direct counting of atomic substitutions on freshly fractured surfaces, local electrode atom probe (LEAP) tomography for three-dimensional chemical analysis with a sub-nm-resolution, and high-resolution X-ray diffraction (HRXRD) for spatial profiling of inter-planar spacings. In the current work, we apply all these methods to study atomic intermixing in short-period GaSb/InSb/InAs/InSb superlattices for infrared detectors. We discuss the suitability, complementarity, uniqueness, and limitations of the above mentioned characterization techniques.