Antimonide based heterostructures: MBE growth strategies for infrared applications

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The 6.1 Å materials family, which includes InAs, GaSb, and AlSb, along with their ternary and quaternary alloys and corresponding type-II superlattices (T2SLs), allows for extensive wavelength tuning across the infrared (IR) spectrum. This versatility in detector design enables the creation of advanced device concepts and high-performance, bandgap-engineered IR technologies suitable for a range of applications. By growing these materials lattice-matched on GaSb substrates through molecular beam epitaxy (MBE), we can effectively combine them to fulfill specific requirements. At Fraunhofer IAF, we harness these materials to design and develop IR detectors and arrays for the extended shortwave infrared (eSWIR), mid-wavelength infrared (MWIR), long-wavelength infrared (LWIR), and various combinations thereof.

Alternatively to extended InGaAs on InP substrate, which suffers from a high dislocation density resulting in limited performance, we have recently developed lattice matched InGaAsSb heterojunction photodiodes on GaSb substrate for the extended short-wavelength infrared (eSWIR) spectral range from 1.7 up to 3.0 µm. Initial results demonstrate first-rate performance with low dark current and high detectivity, which will be presented.

For the thermal infrared in the range from 3 up to 12 µm covering MWIR to LWIR, T2SLs based on InAs/InAsSb and InAs/GaSb are developed. The activities range from basic studies up to pilot line production with detectors at TRL 8. In the latter case reproducibility and process-accompanying quality control are of great importance and will be addressed in this talk.

Recent developments on large-format, Ga-free type-II superlattice (T2SL) detectors are focused on achieving high operating temperatures (HOT) in the mid-wavelength infrared (MWIR) range. Epitaxial growth studies have been conducted to enhance material quality, supported by extensive structural and electro-optical characterization. We are currently involved in several collaborative European projects to demonstrate a non-dependent supply chain for antimony based high quality infrared detectors. With its material expertise, Fraunhofer IAF is a reliable partner for industrial customers without a suitable MBE facility of their own.