Direct MBE Growth of Metamorphic nBn Infrared Photodetectors on 150 mm Ge-Si Substrates for Heterogeneous Integration

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GaSb-based infrared (IR) photodetectors continue to progress and improve, and the transition from pure development to a manufacturing phase is underway. The rich bandgap engineering possibilities of the GaSb materials system, with typical type-II broken-gap alignments, result in myriad device architectures, frequently based on the unipolar barrier design concepts commonly noted as nBn or XBn [1, 2]. To compete with HgCdTe in both performance and cost requires manufacturing processes based on larger-format focal plane array (FPA) detectors, leading to a requirement for larger diameter wafers for improved throughput, volumes, and yield. IQE has demonstrated a nBn production molecular beam epitaxy (MBE) growth process in multi-wafer configurations on 4-inch and 5-inch diameter GaSb substrates as well as via a metamorphic process on 4-inch and 6-inch GaAs substrates [3-5].

A next step in the progression of this IR photodetector technology is its heterogeneous integration with silicon. Such integration can provide the combined advantages of high-level volume production of Si-based electronic circuitry with superior high speed and optical performance of III-V components. In this work, we report the growth of GaSb-based metamorphic nBn (M-nBn) photodetector structures on large diameter (150 mm) Si substrates. Multiple growth steps are required to transition from the Si to the GaSb lattice constant, beginning with a Ge layer deposited by CVD at IQE-Silicon. This provides a Ge-Si substrate for the growth of the remaining III-V layers, from GaAs and GaSb buffer layers up to the M-nBn device layers, via MBE at IQE Inc. Standard epiwafer characteristics, including morphology, x-ray, and optical properties, will be presented. Large-area mesa diode characteristics from these M-nBn epiwafers compare favorably to those grown on lattice-matched substrates. The results represent an important technological path toward next-generation large-format IR detector array applications.

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