Interfacial Misfit dislocation array assisted MBE growth of InSb quantum well on InAs using AlInSb buffer layer

F. F. Ince,[1] Alex T. Newell,[1] T. J. Rotter,[1] and G. Balakrishnan,[1] M. R. McCartney,[2] D. J. Smith [2]

[1] University of New Mexico, Albuquerque, NM 87108

[2] Department of Physics, Arizona State University, Tempe, AZ 85287

Mid-wave infrared (MWIR) detectors are commonly used in medical devices, remote sensing, and spectroscopy. InSb-based infrared focal plane arrays (FPAs) offer spatial uniformity, temporal stability, scalability, and affordability. Type-II superlattices and metamorphic buffers are used to cover the MWIR spectrum and reach the long-wave infrared (LWIR) region. We propose using interfacial misfit dislocations to grow fully relaxed InSb on InAs substrate, and direct growth of $Al_xIn_{1-x}Sb$ buffer layers on InAs, for developing tunable InAsSb absorbers for MWIR and LWIR applications [1], [2].

In this presentation will discuss the interfacial misfit dislocation growth mode to form instantly relaxed buffer layer on top of InAs substrates. We analyze both directly grown AlInSb and InSb epilayers on InAs substrates using HR-XRD ω-2θ scans as well as reciprocal space mapping. HR-XRD results indicate a relaxation of 99.4% for InSb directly grown on InAs, and a slightly reduced value for the $Al_{0.1}In_{0.9}Sb$ and $Al_{0.2}In_{0.8}Sb$ epilayers. Reciprocal space mapping allows us to estimate the screw and mixed dislocation density for the layers. Additionally, TEM analysis shows the formation of misfit dislocation arrays at the AlInSb/InAs interface. We investigate InSb quantum wells grown with different $Al_xIn_{1-x}Sb$ barrier layers using photoluminescence (PL). We will present a comprehensive analysis of the buffer layers with respect to threading dislocation density using XRD scans and TEM images. Furthermore, we will provide a detailed analysis of the InSb QWs based on PL and TRPL results.

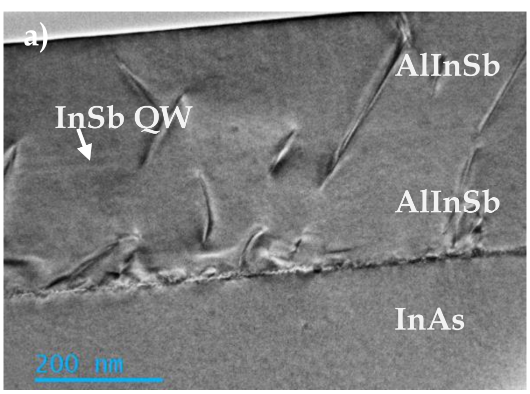

Figure 1 – TEM image of InSb QW using AlInSb buffer layer

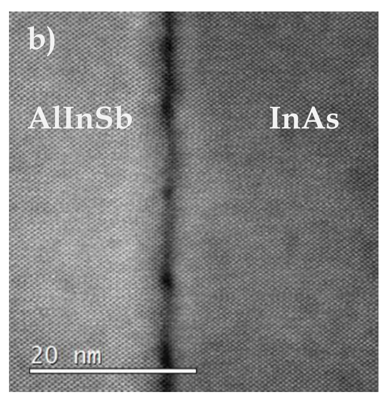

Figure 2 – HRTEM shows the formation of interfacial misfit dislocations

[1] W. L. Sarney, S. P. Svensson, Y. Xu, D. Donetsky, and G. Belenky, "Bulk InAsSb with 0.1 eV bandgap on GaAs," J. Appl. Phys., vol. 122, no. 2, p. 025705, Jul. 2017.

[2] A. Rogalski, "Next decade in infrared detectors," in Electro-Optical and Infrared Systems: Technology and Applications XIV, Warsaw, Poland, 2017.

+ Author for correspondence: incef@unm.edu

Supplementary Pages

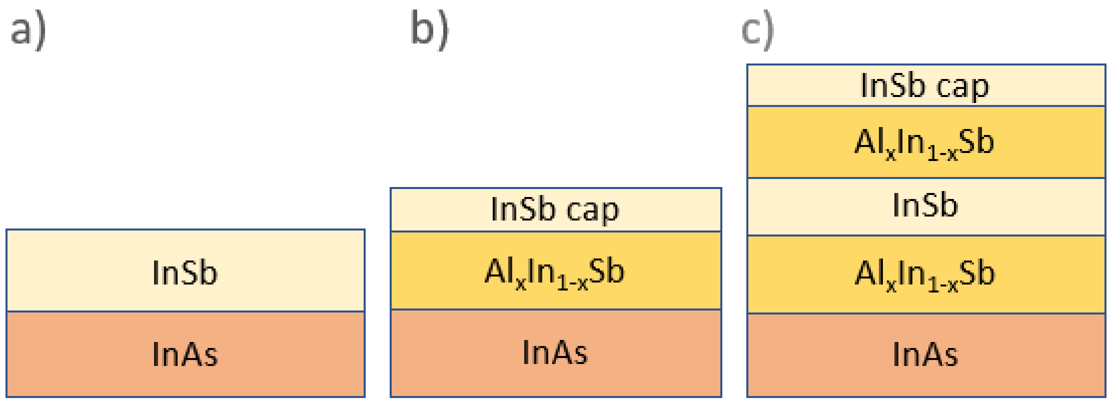

Figure 1: Schematic of different configurations of the IMF samples

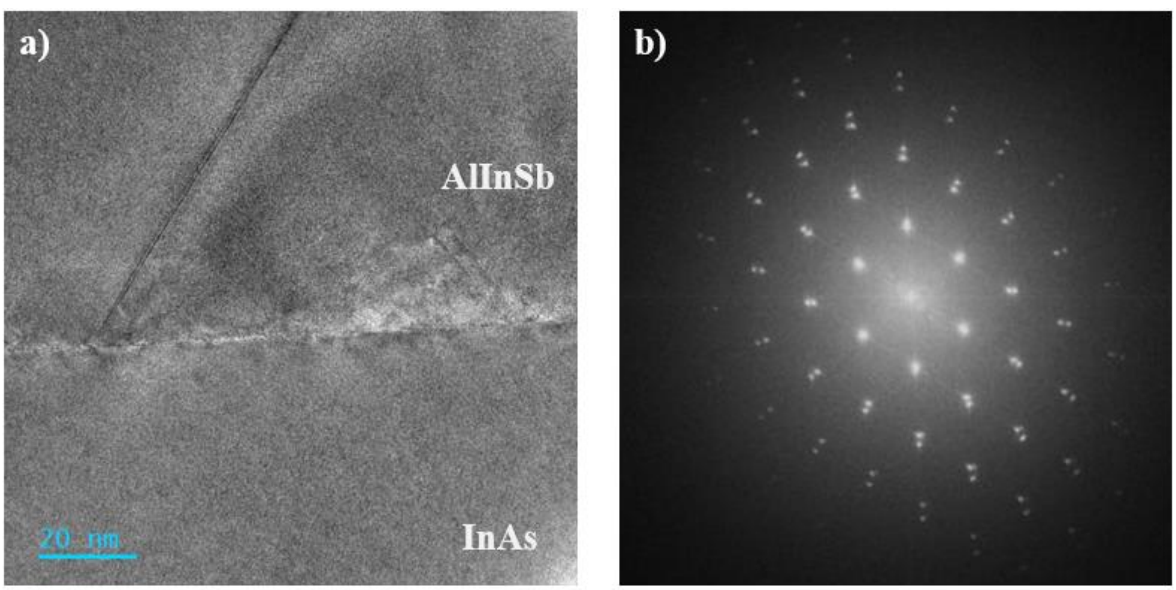

Figure 2: *TEM of the $Al_{0.2}In_{0.8}Sb$/InAs buffer layer interface showing a stacking fault formation and FFT of the image shows two distinct lattice parameters $Al_{0.2}In_{0.8}Sb$ and InAs*

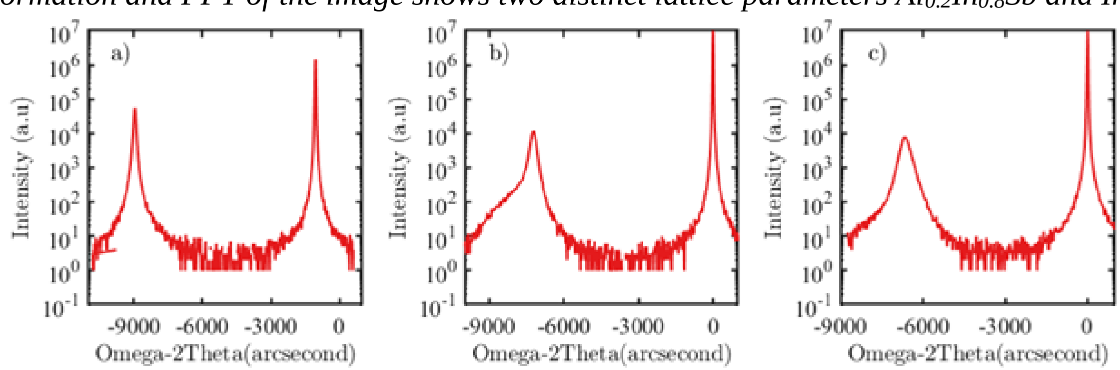

Figure 3 – *HR-XRD ω-2θ scans of a) InSb/InAs b) $Al_{0.1}In_{0.9}Sb$ and c) $Al_{0.2}In_{0.8}Sb$ buffer layers*