Narrow bandgap InAsSb detector on digital alloy AlInSb metamorphic buffer

V. Dahiya,[1] A. Kazemi,[1] E. D. Fraser,[2] J. I Deitz, [3] J. T. Boyer, [3] S. Lee, [1] P. R. Pinsukanjana, [2] T. J. Grassman, [1,3] S. Krishna[1+]

[1] *Department of Electrical and Computer Engineering, The Ohio State University, Columbus, OH, USA*

[2] *Intelligent Epitaxy Technology, Inc., Richardson, Texas, USA*

[3] *Department of Materials Science and Engineering, The Ohio State University, Columbus, OH, USA*

Recently, the $InAs_{1-y}Sb_y$ alloy system has emerged as a promising material in the long wave infrared (LWIR, 8-14 µm). However, to target LWIR wavelengths, Sb composition of more than 40% is required, which is relatively difficult to grow due to the non-availability of lattice-matched commercial substrates. This requires the growth of virtual substrates to target the desired lattice constant using, for example, step- or linear-graded metamorphic buffers. However, these structures typically suffer from various complexities, such as long growth interruptions and intricate cell temperature ramp profiles. In our previous work, we demonstrated the application of digital alloy (DA) defined compositions to produce step-graded $Al_{1-x}In_xSb$ metamorphic buffers, which helps eliminate the issues mentioned above. The buffer layers grown via the DA technique exhibited relaxation behavior similar to conventional bulk, random alloy compositions. In the present work, this effort was further extended to grow subsequent lattice-matched InAsSb absorber layers and nBn detectors.

To enable probing of the material and optical properties, 1.5 µm thick $InAs_{0.55}Sb_{0.45}$ absorber material was grown lattice-matched to an $Al_{0.68}In_{0.32}Sb$ terminal composition $Al_{1-x}In_xSb$ DA (1.85 nm period thickness) metamorphic buffer, as described previously [2]. Based on high resolution X-ray diffraction reciprocal space mapping measurements, the absorber layer $InAs_{0.55}Sb_{0.45}$ was found have residual strain of ~0.1%. Electron channeling contrast imaging characterization indicated a low threading dislocation density on the order of 5×10^6 cm^{-2} in the target $InAs_{0.55}Sb_{0.45}$ layer. A photoluminescence peak was observed at ~9 µm at 77K, close to the expected value based on the XRD-derived composition [1].

nBn detector structures were then grown with an undoped 1.5 µm thick $InAs_{0.55}Sb_{0.45}$ absorber and 100 nm thick $Al_{0.68}In_{0.32}Sb$ barrier (Be doped; 1×10^{16} cm^{-3}). Single pixel detectors of different sizes were fabricated via standard lithographic techniques. Preliminary spectral response of front side illuminated pixels revealed a 50% cutoff wavelength of 9 µm at 150K. Radiometric characterization of the devices including dark current and quantum efficiency are being undertaken and results will be presented later.

[1] W. L. Sarney et al. , J. Appl. Phys. **122**, 025705, (2017).
[2] V. Dahiya et al., J. Vac. Sci. Technol., B **36**, 02D111(2018).

+ Author for correspondence: krishna.53@osu.edu

Supplementary Pages

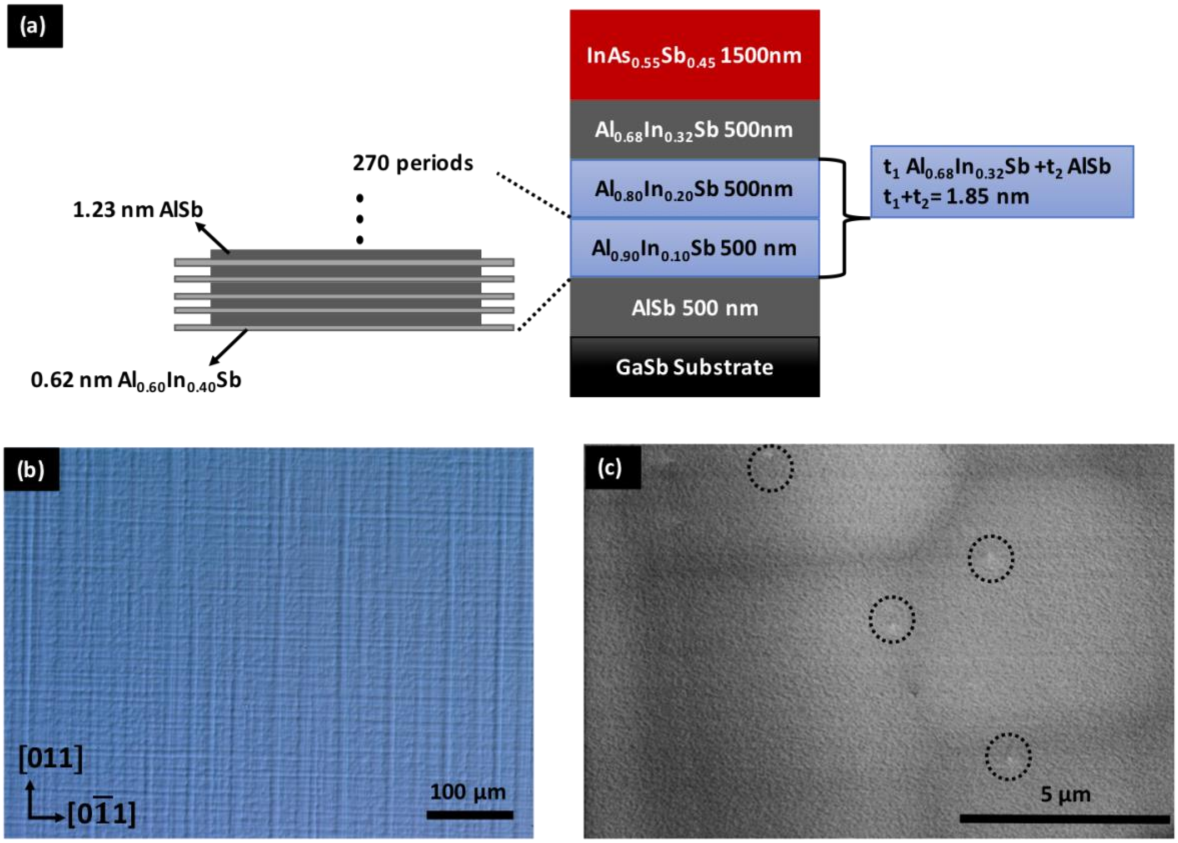

Fig.1 (a) Schematic of the $InAs_{0.55}Sb_{0.45}$ absorber grown on $Al_{1-x}In_xSb$ digital alloy (DA) metamorphic buffer with DA period thickness of 1.85 nm (b) optical nomarski micrograph for $InAs_{0.55}Sb_{0.45}$ absorber depicting cross hatch pattern indication of unhindered dislocation glide across the structure (c) Electron channel contrast imaging micrograph from the $InAs_{0.55}Sb_{0.45}$ absorber depicting threading dislocation density ~ 4×10^6 cm^{-2}. Examples of threading dislocations are indicated by the dotted circle.