

Epitaxial Growth, Materials Characterization, and Detector Assessments of Quinary GaInAsSbBi

**R. A. Carrasco,¹ A. T. Newell,¹ Z. M. Alsaad,¹ J. V. Logan,¹ C. P. Morath,¹
D. Maestas,¹ C. P. Hains², and P. T. Webster,¹**

¹ Air Force Research Laboratory, Space Warfare Directorate, Kirtland AFB, NM, USA

² Aerovironment Inc., Albuquerque, NM, USA

Alloying Bi in group III-V material systems has been the subject of extensive study due to the large bandgap reduction behavior per percent of Bi incorporated, and the high degree of device optimization flexibility this property affords. When alloyed with infrared materials, such as InAsSb to create InAsSbBi, a wide design space is unlocked where lattice constant and bandgap may be tuned to desired wavelengths, while maintaining a lattice-matched condition to a commercially available substrate. However, achieving proper Bi compositions in this alloy to the desired wavelength extension while maintaining smooth surface morphologies, and device-ready optoelectronic quality proved to be difficult. [1]

Adding Ga to the mix may offer a path to mitigate these difficulties. Here, infrared quinary GaInAsSbBi alloys are grown lattice matched on GaSb by molecular beam epitaxy. Essential and rapid growth feedback by Normarski interference contrast imaging is used to determine the ideal Bi flux condition to attain smooth surface morphologies (Fig. 1a-f). Fortunately, with only 0.3% Bi, ~14% Ga and corresponding As and Sb compositions that allow for a lattice-matched condition, photoluminescence extending beyond 5 μm emission, and minority carrier lifetimes >1 μs were realized. [2] This motivated $n\text{Bn}$ device structures to be grown and fabricated into variable area single pixel device arrays. Detector dark current, and quantum efficiency are determined as a function of bias, temperature and displacement damage due to 63 MeV proton irradiation. [3, 4] The $n\text{Bns}$ are also fabricated into small format 350 $\times$ 256 focal plane arrays and hybridized to an analog read-out integrated circuit. This allows for direct evaluations of sensitivity, noise spectra, uniformity, operability, and radiation tolerance. A discussion on the growth feedback strategy, materials characterization results and device performance will be provided, followed by current efforts and progress.

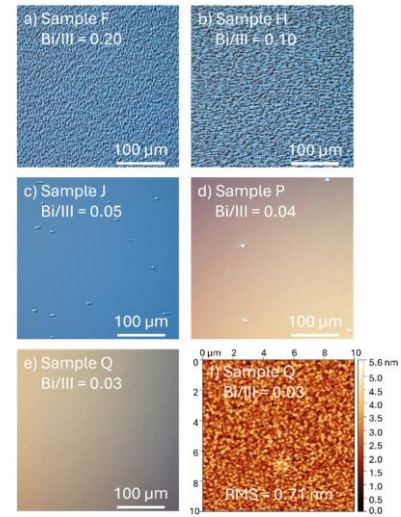


Figure 1: (a)-(e) Normarski interference contrast micrographs of the surfaces of 1 μm thick GaInAsSbBi samples grown with varying Bi/III flux ratios. (f) Atomic force microscopy of sample Q.

[1] P. Petluru, P. C. Grant, A. J. Muhowski, I. M. Obermeier, M. S. Milosavljevic, S. R. Johnson, D. Wasserman, E. H. Steenbergen and P. T. Webster, *Appl. Phys. Lett.*, vol. 117, p. 061103, (2020).

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