Structural and optical properties of bulk nBn InAsSb metamorphic detector

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With the availability of GaSb substrates, 6.1Å family based III-antimonide material system has shown enormous potential in the infrared detectors due to high design flexibility of various heterostructures. However, to compete with the incumbent HgCdTe technology, fabrication of large format focal plane arrays (FPAs) is required for higher throughput and yield. One promising path to larger FPAs and higher volumes includes the epitaxial growth on mismatch large area substrates, which includes the drawback of the generation of deleterious threading dislocations (TDs). The TDs impedes the minority carrier lifetime which in turn increases the dark current, hence noisy photodetector. Thus, it is important to minimize the TD density (TDD) and study its effect on the minority carrier lifetime.

For this purpose, InAsSb nBn photodetectors with a room temperature 50% cut-off wavelength of 4.2 µm are grown on three substrates, including GaSb itself, semi-insulating GaAs, and Ge/Si substrates using appropriate metamorphic buffer layers. To study the correlation between TDD and the minority carrier lifetime, τ techniques including electron channel contrast imaging (for TDD measurement) and time resolved microwave reflectance (for minority carrier lifetime measurement) are employed.

The preliminary results indicated that the sample with lowest TDD (grown on GaSb substrate) has the highest minority carrier lifetime and the magnitude of minority carrier lifetime is reduced to half when grown on Ge/Si. Although, the nBn detector on Ge/Si has higher lifetime compared to the GaAs substrate. Interestingly, the difference in lifetime does not have a direct correlation with the diode performance measured on large-area devices, as the quantum efficiency measured ~60% on all three samples. Thus, Ge/Si can be used as an alternative approach to grow virtual substrates, enabling large format FPA processing with direct integration of the III-V devices with Si microelectronics read-out and processing architectures.

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Supplementary Pages

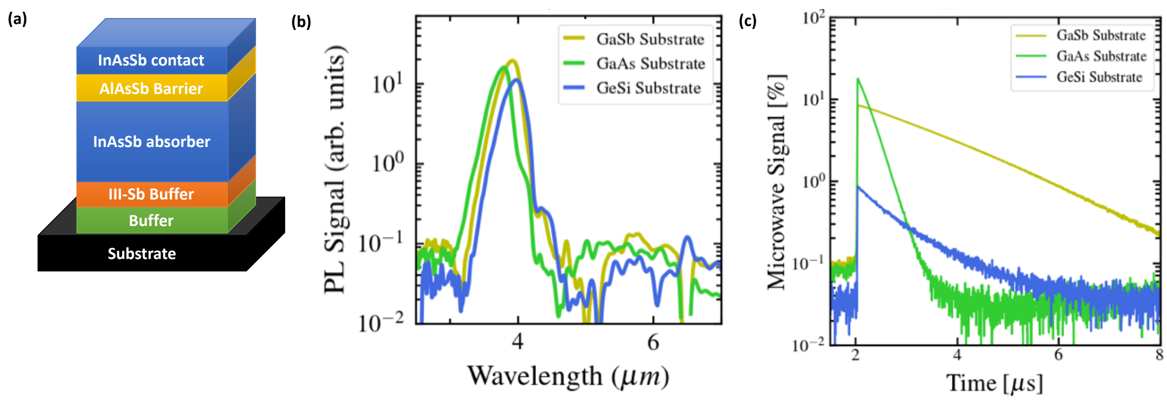

Fig.1 (a) Schematic of the nBn InAsSb detector grown on different substrates (b) Photoluminescence and (c) minority carrier lifetime at 80 K for InAsSb absorber grown on substrates