Optically-Addressed Monolithically-Integrated Triple-Band Photodetectors Using Type-II Superlattice Materials

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Multiband photodetectors are desired in various applications, including thermal imaging, environmental resources surveying, and chemical sensing. When implementing multiband photodetectors into an FPA, reducing the number of terminals on the photodetector is necessary since an increase in terminal count reduces the detector's active area and complicates ROIC and FPA layout and device processing [1]. This talk reports the demonstration of two-terminal multiband monolithically integrated optically addressed photodetectors using InAs/InAsSb type-II superlattice (T2SL) to cover SWIR, MWIR, and LWIR, as shown by the device structure in Figure 1.

The operating principle of the optical-addressing design is to use multiple optical biases on a stack of photodiodes (PDs) connected in series to switch detection bands, as shown in Figure 1 schematically. The detecting PD becomes the current-limiting device and determines the spectral response. Our preliminary results show that the MBE-grown InAs/InAsSb T2SLs as MWIR and LWIR photodetectors are nearly perfectly strain-balanced onto GaSb, showing distinct satellite peaks and a perfect overlap of the 0 order SL peak with the substrate peak, as plotted in Figure 2. Additionally, an analytical model has been established to analyze the noise characteristics and cross-talk between bands of the optically-addressed multiband detectors.

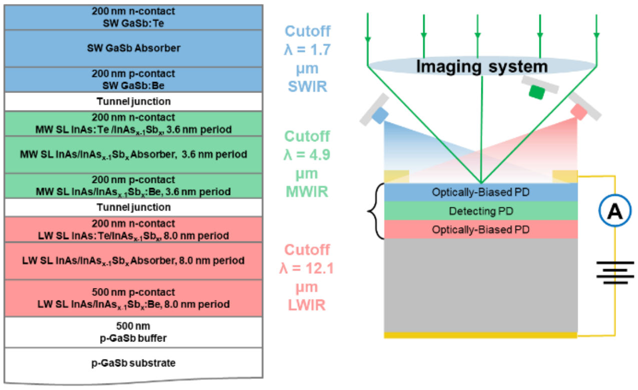

Figure 1: (Left) Triple-band PD layer structure, (right) and its operating principle under optical addressing.

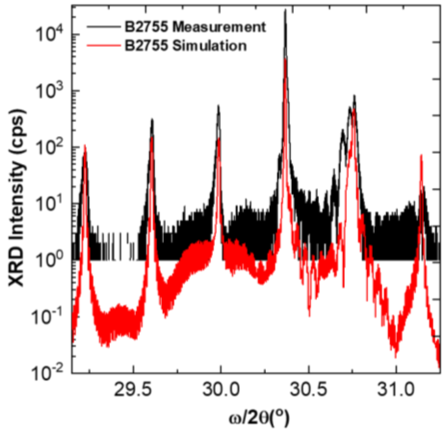

Figure 2: ω/2θ scan of a strain-balanced T2SL on a GaSb substrate.

[1] E. H. Steenbergen, Appl. Phys. Lett. **97**, 161111-161114 (2010).

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Supplementary Pages (Optional)

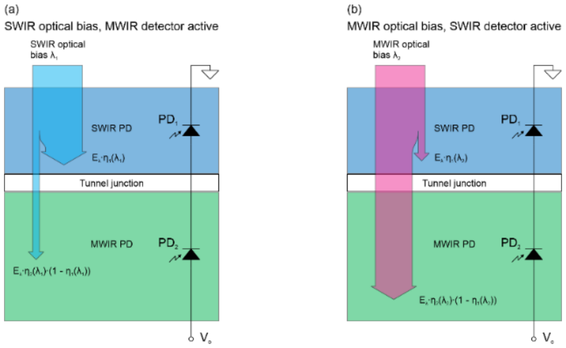

Figure 3: Schematics illustrating (a) incomplete absorption in the SWIR optically biased PD, whereas (b) parasitic absorption occurs in the SWIR PD while under MWIR optical bias. Incomplete absorption in the SWIR PD creates spectral cross-talk, directly contributing to the shot noise current in the MWIR device.

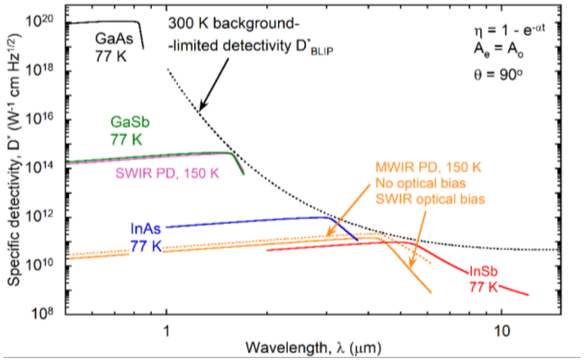

Figure 4: Specific detectivity D* as a function of wavelength at zero output current for optically-addressed SW/MWIR multiband photodetector showing the degradation in the MWIR detectivity under SWIR optical bias.

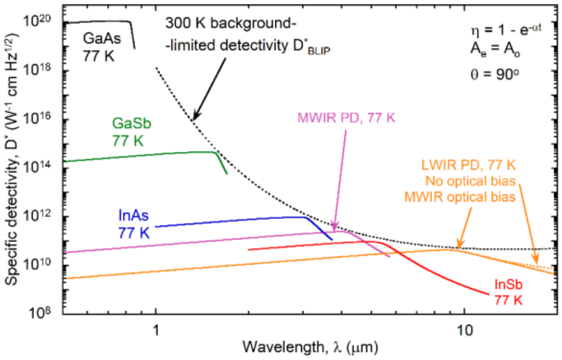

Figure 5: Specific detectivity D* as a function of wavelength at zero output current for optically-addressed MW/LWIR multiband photodetector showing minimal degradation in the LWIR detectivity under MWIR optical bias.

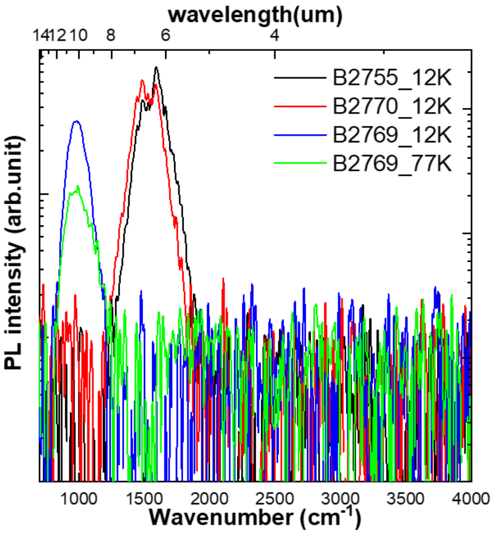

Figure 6: PL spectra of MWIR and LWIR T2SL measured by FTIR showed peaks at 6 μm for the MWIR sample and 10 μm for the LWIR sample.