

# A Three-Color Quantum Well Infrared Photodetector for MWIR/LWIR/VLWIR Detection

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In this paper, we report a 3-stack, 3-color quantum well infrared photodetector (QWIP) for mid wavelength infrared (MWIR), long wavelength infrared (LWIR), and very long wavelength infrared (VLWIR) applications. Infrared focal plane array (FPA) technology is essential for many IR applications, such as exo-atmospheric seekers, space-based surveillance sensors, and satellite mapping. With the advent of QWIP technology, large format and high uniformity single- and two-color QWIP FPAs have been developed for IR imaging applications [1-2]. There is an increasing need to develop multi-color FPAs, which can detect three- and four- colors simultaneously. For example, in a 3-color temperature estimation with earthshine in exo-atmosphere, the accuracy of the earthshine ratio terms is maximized if one of the detector colors is chosen in a band where the earth's atmosphere partially blocks the earthshine. There are three blocking bands in the MWIR to VLWIR region that can be used: the water band (5.5-7.5  $\mu\text{m}$ ), the ozone band (9.4-9.9 $\mu\text{m}$ ) and the CO<sub>2</sub> band (14-16  $\mu\text{m}$ ), none of these bands blocks earthshine totally. We have designed a 3-stack, 3-color QWIP with the bandwidth of full-width at half-maximum (FWHM) covering above blocking bands. Figure 1 shows the energy band diagram of this 3-color QWIP. The structure for each stack is designed for the desirable peak wavelengths and bandwidth at the three blocking bands. Figure 2 shows the responsivity, and figure 3 shows the dark current characteristics of the VLWIR stack. Specific issues concerning the device design and performance of this 3-color QWIP will be depicted in this paper.

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## References:

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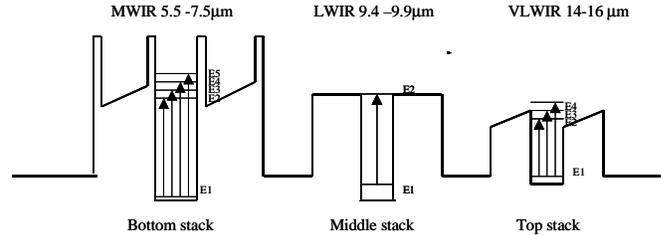
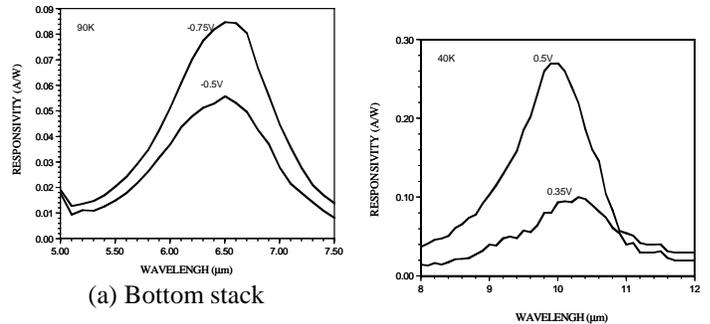
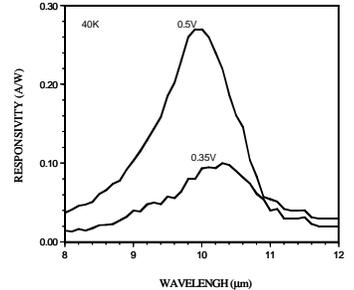


Figure 1 Energy band diagram of a 3-color 3-stack QWIP. Bottom-stack:  $\text{In}_{0.15}\text{Ga}_{0.85}\text{As}(64\text{\AA})/\text{Al}_{0.5}\text{Ga}_{0.5}\text{As}(20\text{\AA})/\text{Al}_x\text{Ga}_{1-x}\text{As}(460\text{\AA})/\text{Al}_{0.5}\text{Ga}_{0.5}\text{As}(20\text{\AA})$ ,  $x=0.13\sim 0.17$ ; middle- stack:  $\text{In}_{0.1}\text{Ga}_{0.9}\text{As}(63\text{\AA})/\text{Al}_{0.1}\text{Ga}_{0.9}\text{As}(500\text{\AA})$ ; top-stack:  $\text{In}_{0.05}\text{Ga}_{0.95}\text{As}(60\text{\AA})/\text{Al}_x\text{Ga}_{1-x}\text{As}(500\text{\AA})$ ,  $x=0.06\sim 0.08$ .



(a) Bottom stack



(b) Middle stack

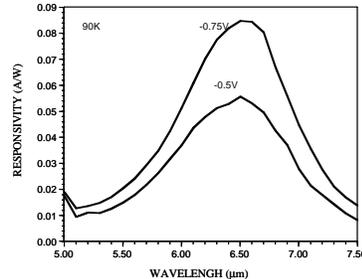


Figure 2 Responsivity vs. wavelength for the 3-color QWIP: (a) bottom stack, (b) middle stack, and (c) top stack.

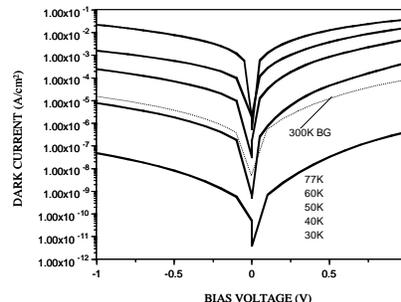


Figure 3 Dark current density versus bias for the top stack of the 3-color QWIP.