Progress on MBE Grown Type-II Superlattice Photodiodes

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Abstract

The closely lattice-matched material system of InAs, GaSb, and AlSb, commonly referred to as the 6.1Å material system, has emerged as a fertile ground for the development of new solid-state devices. The flexibility of the system in simultaneously permitting type-I, type-II staggered, and type-II broken-gap band alignments has been the basis for many novel, high-performance heterostructure devices in recent years, including the GaInSb/InAs type-II strained layer superlattice infrared detectors proposed by Smith and Mailhot [1] in 1987. The type-II superlattice design promises optical properties comparable to HgCdTe, better uniformity, reduced tunneling currents, suppressed Auger recombination, and normal incidence operation [2, 3]. In 1990, Chow and co-workers first reported Ga_{1-x}In_xSb/InAs superlattice materials with high structural quality, LWIR photoresponse, and LWIR photoluminescence [4]. Later, researchers demonstrated excellent detectivity (approaching HgCdTe, 8-μm cutoff, 77K) on individual superlattice devices [5]. Currently, superlattice detector technology is undergoing the transition from single element detectors into high-performance focal plane imaging arrays[6].

Here we report on the status of superlattice diodes grown and fabricated at the Jet Propulsion Laboratory designed for infrared absorption in the mid (2-5μm) and long wavelength (8-12 μm) infrared ranges. Our mid-wavelength infrared devices display a zero bias differential resistance-area product as high as 1e6 Ohmcm² at 80K with a 5μm cutoff, with a corresponding detectivity of nearly 1e13 Jones. These detectors continue to function at room temperature with a detectivity of nearly 1e9 Jones. In the long wavelength region, we have produced devices with detectivities as high as 8x10¹⁰ Jones with a differential resistance-area product greater than 6 Ohmcm² at 80K with a long wavelength cutoff of approximately 12μm. A typical IV curve a 12μm cutoff device is shown in Figure 1. Responsivity, detectivity and quantum efficiency for a typical 12μm cutoff device is shown in Figure 2. In addition to detector performance results, recent progress in epitaxial regrowth as a passivation method and progress on long-wavelength imaging array fabrication will be presented.

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Figure 1. Dark current vs. applied bias for a typical 250x250 μm test device at 80K (12 μm cutoff devices).

Figure 2. D^* , responsivity, and QE (dotted, right axis) for the 12 μm cutoff, large-area superlattice photodiodes.

¹ D.L.Smith and C.Mailhiot, *J. Appl. Phys.* **62**, 2545 (1987).

² C.Mailhiot, and D.L.Smith, *J. Vac. Sci. Technol. A* **7**, 445 (1989).

³ R. H. Miles and D. H. Chow, in “*Long Wavelength Infrared Detectors*”, edited by M. Razeghi, Chapter 7 (Gordon and Breach, Singapore, 1996); and references therein.

⁴ R. H. Miles, D. H. Chow, J. N. Schulman, and T. C. McGill, *Appl. Phys. Lett.* **57**, 801 (1990).

⁵ F. Fuchs, U. Weimar, W. Pletschen, J. Schmitz, E. Ahlswede, M. Walther, J. Wagner, and P. Koidl, *Appl. Phys. Lett.* **71**, 3251 (1997).

⁶ M.Walther, R.Rehm, F.Fuchs, J. Schwitz, J.Fleissner, W.Cabanski, D.Eich, M.Finck, W.Rode, J.Wendler, R.Wollrab, and J.Ziegler, *J. of Elect. Mater.* **34** (6): p. 722-725 (2005)