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Identification of dominant recombination mechanisms in narrow-bandgap InAs/InAsSb type-II superlattices and InAsSb alloys

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InAs/Ga(In)Sb type-II superlattices (T2SL) have been extensively studied for both advanced emitter and detector technologies associated with mid-wave (MWIR), long-wave (LWIR), and very-long-wave (VLWIR) infrared applications. The type-II band alignment, together with control of both the layer thicknesses and the alloy composition, provide a rich environment for band structure engineering, including band gap tuning and suppression of Auger recombination. Unfortunately, the InAs/Ga(In)Sb MWIR T2SLs have been found to have minority carrier lifetimes persistently below 100 ns, even at cryogenic temperatures. Such short lifetimes are problematic for detector applications and suggest that this material system will not compete with HgCdTe for IR detector applications. On the other hand, the report by Steenbergen, et al., [1] of much longer minority carrier recombination lifetimes (>412 ns at 77K) in a longwave (8.2 m) InAs/InAsSb T2SL suggests that the "Ga-free" superlattices could be competitive for IR detector applications. We will discuss all-optical measurements of carrier lifetimes as a function of temperature and injected carrier density in InAs/InAsSb T2SLs with a broad range of sample designs based on variations in alloy composition and/or layer thickness. Minority carrier lifetimes ranging from 4.5 s for a 9.2 m-band-gap T2SL to 18 s for a 4.2 m-band-gap T2SL have been measured at 77 K. This research was performed in collaboration with Y. Aytac, B.V. Olson, J.K. Kim, E.A. Shaner, J.F. Klem, S.D. Hawkins, and M.E. Flatté. [1] Steenbergen, et al., Appl. Phys. Lett. Vol. 99, 251110 (2011).