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Auger and optical loss suppression in near- and mid-IR emitters based upon Bismide alloys

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Abstract: III-Bismides are a relatively underexplored set of III-V alloys yet offer the possibility to engineer many aspects of the band structure and band alignment which are of significant potential benefit to photonic devices. For example, the incorporation of Bismuth into binary compounds such as GaAs leads to a band anti-crossing effect. However, unlike the dilute nitrides, this occurs in the valence band and leads to a reduced temperature dependence of the band gap which has potential applications in devices such as lasers, optical amplifiers and optical modulators operating in the telecoms window (1.3-1.6um) This offers the potential to operate cooler-free bringing along substantial energy savings.

Perhaps most interestingly, due to the large size of the Bismuth atoms, alloys incorporating Bismuth exhibit a very large spin-orbit splitting. We will show that exploiting this property may substantially increase the operating efficiency of near-infrared lasers by suppressing Auger recombination processes and inter-valence band absorption. For Bi fractions ~10% in GaAsBi/GaAs we show that a preferential band structure may be formed offering lasing in the telecoms band (and beyond) on a GaAs substrate whilst suppressing the losses which dominate conventional InP and GaAs based lasers. Furthermore, we will describe that incorporating both nitrogen and Bismuth into GaAs to form the quaternary GaAsNBi/GaAs offers the possibility to widely engineer III-Vs to operate in the near- and mid-IR, suppressing non-radiative recombination processes, increasing thermal stability and developing both type-I and type-II band alignments. Theoretical data will be presented and supplemented by initial experimental results.