Optically pumped type-II antimonide mid-IR lasers with integrated absorber layers

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We report on optically-pumped mid-infrared (3.8-4.8 μm) lasers based on (InAs / $In_xGa_{1-x}Sb$ / InAs) type-II active layers that are periodically inserted into the InGaAsSb waveguide designed to absorb the ~1.85 μm pump radiation. These type-II "integrated absorber" lasers exhibit high quantum efficiency and high characteristic temperature, T_o, associated with lasing threshold. The effects of many of the design parameters, however, are not yet well understood. We have systematically varied the indium content in the hole-bearing $In_xGa_{1-x}Sb$ layers, (0 [x^{In} [0.35), to determine its effect on lasing characteristics.

Varying the $In_xGa_{1-x}Sb$ alloy composition without affecting compositional changes elsewhere in the heterostructure was achieved by modulating the incident In-flux during the growth of that layer in molecular beam epitaxy. In each active region, a nominally eight-monolayer thick $In_xGa_{1-x}Sb$ layer with a prescribed composition was surrounded by two InAs layers which were nominally seven-monolayers thick. Heterostructures in which x^{In} ~ 0, 0.15, 0.20, 0.25, 0.30 and 0.35 were grown. Each of these samples produced gain-guided lasers with a power output more than 400 mW/facet when operated epi-side up and uncoated at quasi continuous-wave conditions near 80K.

A clear improvement in T_o was observed as x^{In} was increased. For example, T_o ~ 33 K for x^{In} = 0 , while T_o ~ 67 K for x^{In} ~ 0.35. In addition, the characteristic temperature associated with quantum efficiency, T_1, also increased substantially with increasing x^{In}. Thus the maximum operating temperature also increased with increasing x^{In}. We attribute these significant improvements in lasing characteristics to improved hole confinement as well as increased compressive strain in the hole-bearing layers.

An additional notable feature of these lasers is an extremely small linewidth enhancement factor, α~1, measured using the Hakki-Paoli methodology in our laboratory.

We also report on optically pumped integrated absorber lasers that can simultaneously emit at two different wavelengths.