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AlGaAsSb/AlAsSb distributed Bragg reflectors

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We report 77K operation of an optically pumped vertical cavity surface emitting laser with an Sb- based cavity. The structure consists of 15 and 20 pair AlGaAsSb/AlAsSb top and bottom reflectors and a bulk InGaAs active region.

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Vertical cavity surface emitting laser emitting at 1.56 microns with AlGaAsSb/AlAsSb distributed Bragg reflectors

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Long-wavelength vertical cavity surface emitting lasers (VCSELs) are attractive for a variety of application, such as low cost sources for optical communications and optical interconnects. One of the major obstacles to implementing these structures has been the lack of sufficiently large refractive index contrast (Δn) in the mirror layer pairs that can be lattice matched to InP. There are a variety of epitaxial approaches to this problem, from wafer bonding GaAs/AlAs DBRs ($\Delta n \sim 0.44$) to growing very thick InP/InGaAsP DBRs ($\Delta n \sim 0.31$). In order to realize a monolithic device, we have utilized a AlGaAsSb/AlAsSb material system ($\Delta n \sim 0.52$) lattice matched to InP as a means of forming highly reflecting distributed Bragg reflectors (DBRs) with relatively few mirror pairs. The structure was grown by molecular beam epitaxy. The active region consists of 2λ thick bulk InGaAs, whereas top and bottom DBR are made up of 15 and 20 periods of AlGaAsSb/AlAsSb mirror pairs, respectively. This corresponds to an active region of 878 nm with 135 nm and 117 nm thick low and high refractive index layers, respectively. The device structure is shown in Fig. 1. The high refractive index layers, AlGaAsSb contain 12% Al, in order to make them transparent at the emission wavelength. We found that at 77K their absorption edge occurs at $1.3\mu\text{m}$. In a separate structure, 77K reflectivity of the 15 pair DBR was measured to be $>99\%$ in good agreement with a calculated value of 99.2%. Calculations indicate that the 20 pair DBR reflects 99.8% of incident light. Fig. 2 shows the below and above threshold spectra of the VCSEL. Lasing peak occurs at 1564 nm with 0.2 nm linewidth. Below threshold, linewidth is measured to be approximately 2.5 nm and occurs at 1568 nm. This agrees well with the calculated width of the Fabry-Perot resonance. The structure was pumped CW by a $1.32\mu\text{m}$ diode pumped Nd:YAG through a single mode fiber. Power was coupled through one of the input legs of a 2X2 10/90 fiber splitter, with one output leg of the splitter in physical contact with the sample, which was submerged in liquid nitrogen. The other output leg was used to monitor the incident power, whereas the second input leg was connected to the optical spectrum analyzer for spectral measurements or a power meter for L-L measurements. Spot size on the sample was taken to be equal to the core of the single mode fiber, $9\mu\text{m}$. Results of the light in-light out (L-L) measurement are shown in Fig. 3. Threshold occurs at 44 mw. This corresponds to incident power density of 69 kW/cm^2 and equivalent current density of 32 kA/cm^2 . Since the pump wavelength falls outside of the Fabry-Perot stop band we assume single pass configuration of the pump with 75% of the incident power transmitted through the top mirror. Absorption coefficient of the active region is taken to be $1\mu\text{m}^{-1}$. Such equivalent current densities are comparable to results obtained with optically pumped InP/InGaAsP DBRs or GaAs/AlAs bonded DBR results. This represents the first report of stimulated emission in a Sb-based cavity, lattice matched to InP. The results are comparable to other approaches involving optical pumping and similar active regions, in spite of a CW pump source

Fig. 1 Schematic diagram of the VCSEL with AlGaAsSb/AlAsSb DBRs.

Fig. 2 Below and above threshold spectra

Fig. 3 Output power versus input pump power