# Design and Fabrication of GaAsBi/GaAs and InGaAs/GaAs VECSELs for NIR Emission

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Vertical cavity surface emitting lasers (VCSELs) are widely use in different applications in which a gain medium is in a cavity formed by two distributed Bragg reflectors (DBR). This design does not allow for easy optical pumping, due to this VCESLs are usually electrically pumped. This require doping of the DBRs and the presence of contacts reduces the effective surface from which is possible to get emission.

To overcome this limitation vertical external cavity surface emitting lasers (VECSELs) have been developed. In VECSELs the top DBR is substituted by an external coupler allowing access to the cavity, opening up the possibility to use efficient optical pumping, and the insertion of optical elements suited for different applications. Optical pumping combined with surface emission allow to increase the output power by increasing the emission area. The main limitation to output power becomes thermal management.

A VECSEL device designed for second harmonic generation has been demonstrated in literature [1]. In this case lasing could be obtained only while pumping a surface of diameter not larger than 50µm, because of inefficient heat transfer.

In the presented work a through the optimization of growth conditions and the use of a gain area design that uses couples of quantum wells, lasing from a VECSEL with a gain area comprised of InGaAs/GaAs multi quantum wells (MQWs) was demonstrated at 976nm from an area of diameter 500µm.

With bismuth incorporation in GaAs lattice the band gap of the material is significantly reduced. Also, the band gap of bismides is demonstrated to be less sensitive to temperature in comparison with InGaAs, allowing to increase the temperature working range of devices. Finally, even small Bi content influences an increase in the spin-orbit split-off energy of GaAsBi. If the content of bismuth is higher than 10%, the spin-orbit split-off energy even exceeds energy bandgap and thus reduces non-radiative Auger recombination [2].

Because of these favorable properties GaAsBi quantum structures are promising for optoelectronics devices. Using the same double quantum well design a VECSEL with gain area comprised of GaAsBi/GaAs MQWs was fabricated and lasing was obtained. The lasing wavelength was 1070nm and it was obtained by pumping a circular area of diameter 500µm. In literature no lasing is reported from VECSEL based on GaAsBi.

[1] Muszalski, Jan, et al. "VECSELs emitting at 976nm designed for second harmonic generation in the blue wavelength region." Laser Technology 2012: Progress in Lasers. Vol. 8702. SPIE, (2013).

[2] Fluegel, B., et al. "Giant spin-orbit bowing in $GaAs_{1-x}Bi_x$." Physical review letters 97.6 (2006).