APPLICATION NOTE

COMPACT 21 DELIVERS STATE-OF-THE-ART VCSEL STRUCTURE

Introduction

In recent years, there has been great interest in gas detection for environmental pollution monitoring applications. The mid-infrared (2-2.5µm) spectral range contains the strong fundamental absorption bands of a number of these pollutants such as: CH_4 (2.3µm), CO_2 (2.04 µm), NH_3 (2.1 µm). Antimony based semiconductors have been succesfully applied to this area of study . GaSb edge emitting laser diodes showed very good results in the 2-2.5µm range. Alternatively, Vertical Cavity Surface Emitting Lasers, VCSEL's, offer several advantages such as excellent wavelength characteristics, but they typically exhibit very low output power. From these observations, "Le Centre d'Electronique et de Micro-optoélectronique de Montpellier" (CEM2), UMR Université Montpellier 2/CNRS n°5507, France, developed a new category of semiconductor laser: Optically Pumped Vertical External Cavity Surface Emitting Laser, OP-VECSEL.

These lasers offer the advantage of being optically pumped, allowing low cost source but they also provide high output power. The VECSEL is composed of a monolithic ½ VCSEL grown by MBE (high reflectivity Bragg bottom mirror and multi-quantum well) and of an external spherical dielectric mirror, as shown in figure 1.

This application note reports the structural and optical properties of this complex device structure, highlighting the excellent control of the growth conditions and the purity of the layer. The study was carried out using Riber's market leading Compact 21 MBE system and clearly illustrates how well – suited the machine is for the stringent demands imposed on epitaxy in this type of work .

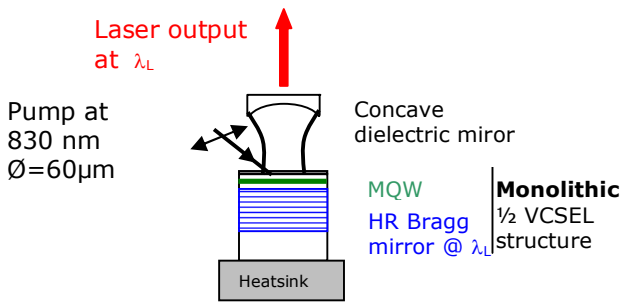

Figure 1 : Optically Pumped Vertical External Surface Emitting Laser structure

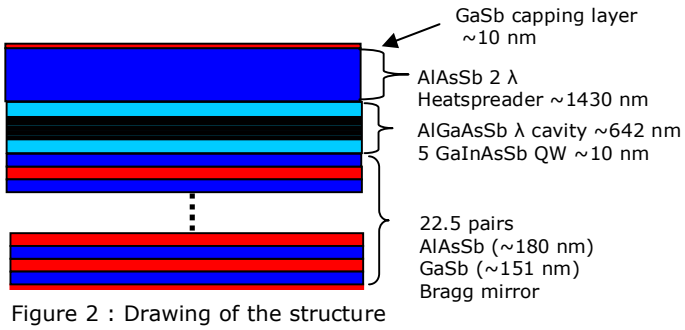

Figure 2 : Drawing of the structure

Results

Growth process

Structures were grown in the RIBER Compact 21 MBE system. Growths were carried out in two steps: first a 22.5 period of GaSb/ AlGaSb Bragg mirrors, followed by the multi-quantum well active region composed of five compressively strained 10 nm thick GaInAsSb type I quantum wells separated by 20 nm AlGaAsSb barriers. To allow continuous wave operation at room temperature, and to prevent surface overheating an AlAsSb heatspreader layer was grown on top as shown in figure2.

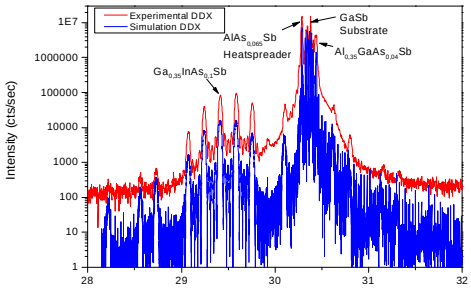

Figure 3 : X-ray diffraction spectra of the half VCSEL

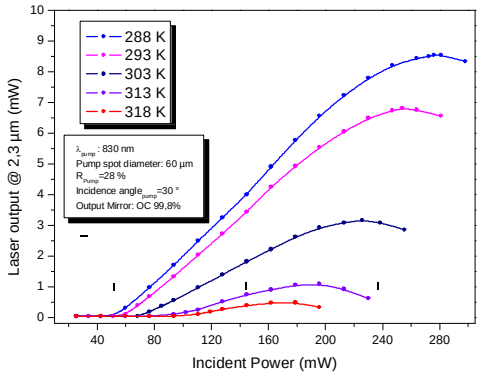

Figure 4 : VECSEL ouptut power function of the input power for different temperatures

Compact 21 MBE research system

Excellent structural quality

Samples characterized by X-ray diffraction, figure 3, showed very narrow and sharp satellite peaks from the multi-quantum well due to very abrupt interfaces and the excellent crystalline quality of the active layer.

Optical properties

The structure was optically pump using a commercial GaAs laser emitting at 830 nm and with a spot light diameter of 60 µm. Laser effect has been achieved from 15°C to 45°C as shown on figure 4. A maximum output power of 8.3mW was obtained at 15°C for an input power of 280 mW.

Conclusion

CEM2 laboratory realized a half VCSEL operating in continuous mode at room temperature around 2.3µm in the Compact 21 MBE system. Structural and optical results demonstrated the high quality of the layers grown in our MBE Compact 21.

System configuration

All epitaxial structures were grown in the compact 21 T MBE research system equipped with ABN 60cc effusion cells for group III elements and of a VAC500 for the Arsenic source.

About CEM2

The "Composants à Nanostructures pour Moyen Infrarouge" (NanoMIR) group lead by Professor Tournié from "Le Centre d'Electronique et de Micro-optoélectronique de Montpellier" (CEM2) is involved in the development of laser sources and photo-detectors operating in the mid infra-red spectral range. Studies include the realisation of InAs/AlSb quantum cascade laser, VCSELs and VECSELs, laser diodes, detectors …

References:

[1] L. Cerutti, A. Garnache, A. Ouvrard, and F.Genty *High temperature continuous wave operation of Sb-based vertical cavity surface emitting laser near 2.3 µm* Journal of Crystal Growth, 268 (2004) 128-134

[2] A. Ouvrard, A. Garnache, L. Cerutti, F. Genty and D. Romanini, *"Single Frequency Tunable Sb–based VCSELs emitting at 2.3 µm",* IEEE Photon. Techn. Lett., 17 (2005), 2020