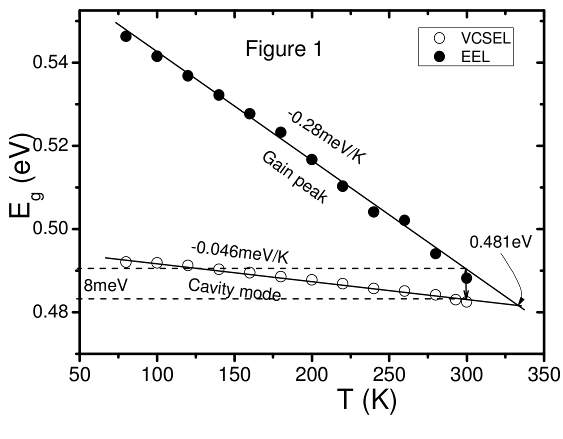
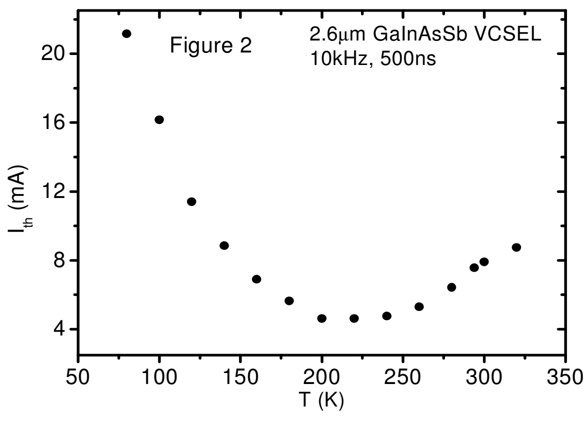
Gain-cavity tuning and non-radiative recombination in 2.6µm GaInAsSb VCSELs

<u>A. B. Ikyo</u>, I .P. Marko, K. Hild, A. R. Adams and S. J. Sweeney,
Advanced Technology Institute and Department of Physics, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom
S. Arafin and M.C. Amann
Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany
e-mail: a.ikyo@surrey.ac.uk

There is a growing interest in electrically pumped lasers that emit in the 2-3µm wavelength region for applications such as pollution monitoring, medical diagnosis and chemical process control. GaSb based type I quantum well edge-emitting lasers (EELs) provide room temperature CW operation although are limited by Auger recombination, inter-valence band absorption, etc. EELs typically have highly divergent beam quality and expensive fabrication processes, hence Vertical Cavity Surface-Emitting Lasers (VCSELs) are a preferred alternative [1]. However, a particular problem in VCSELs is related to temperature induced gain peak and cavity mode detuning [2]. For optimum VCSEL performance the gain peak and the cavity mode have to be aligned at the operating temperature. Gain-cavity de-tuning coupled with the intrinsic Auger recombination problem in low gap materials are the main limitations for efficient performance of Sb-based mid-infrared VCSELs [3] and hence it is important to understand the inter-play of these two effects when developing optimised devices. In this work we have studied electrically pumped GaInAsSb/GaSb VCSELs emitting at 2.6µm using hydrostatic pressure and temperature tuning techniques. For comparison we also studied an EEL with a nominally identical active region. The gain peak was estimated using the lasing photon energy of EEL while the cavity mode determines the lasing photon energy in the VCSEL. By changing the temperature from 80K-350K we estimate (fig 1) that the gain peak and cavity mode in the VCSEL are aligned at 330K. Interestingly, the threshold current goes through a minimum at a much lower temperature, close to 220K (fig. 2) due to the influence of Auger recombination. Further evidence for the interplay of gain peak-cavity mode alignment and Auger recombination will be shown from hydrostatic pressure and photo-reflectivity measurements from which design criteria for optimised mid-infrared VCSELs will be discussed.





[1] S. Arafin et al., Appl. Phys. Lett., **95**, 131120(2009).
[2] A. B. Ikyo et al.IET Optoelectron., **3**, 305–309 (2009)
[3] K. O'Brien et al., Appl. Phys. Lett., **89**, 051104 (2006).