

Integration of Electro-Absorption Modulator in a Vertical-Cavity Surface-Emitting Laser

Ludovic Marigo-Lombart, Stéphane Calvez, Alexandre Arnoult, Alexandre Rumeau, Christophe Viallon, Hugo Thienpont, Krassimir Panajotov, Guilhem Almuneau

► **To cite this version:**

Ludovic Marigo-Lombart, Stéphane Calvez, Alexandre Arnoult, Alexandre Rumeau, Christophe Viallon, et al.. Integration of Electro-Absorption Modulator in a Vertical-Cavity Surface-Emitting Laser. SPIE Photonics West, SPIE, Jan 2018, San Francisco, United States. 10.1117/12.2287465 . hal-01614811

HAL Id: hal-01614811

<https://hal.laas.fr/hal-01614811>

Submitted on 23 Oct 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Integration of Electro-Absorption Modulator in a Vertical-Cavity Surface-Emitting Laser

L. Marigo-Lombart^{1,2}, S. Calvez¹, A. Arnoult¹, A. Rumeau¹, C. Viallon¹, H. Thienpont², K. Panajotov², G. Almuneau¹

1. LAAS - CNRS, Université de Toulouse, CNRS, F-31400, France

2 Department of Applied Physics and Photonics (TW-TONA), Vrije Universiteit Brussel, Pleinlaan 2, B-1050 Brussels, Belgium

VCSELs became dominant laser sources in many short optical link applications such as datacenter, active cables, etc. Actual standards and commercialized VCSEL are providing 25 Gb/s data rates, but new solutions are expected to settle the next device generation enabling 100 Gb/s. Directly modulated VCSEL have been extensively studied and improved to reach bandwidths in the range of 26-32 GHz [Chalmers, TU Berlin], however at the price of increased applied current and thus reduced device lifetime. Furthermore, the relaxation oscillation limit still subsists with this solution. Thus, splitting the emission and the modulation functions as done with DFB lasers is a very promising alternative [TI-Tech, TU Berlin]. Here, we study the vertical integration of an Electro-Absorption Modulator (EAM) within a VCSEL, where the output light of the VCSEL is modulated through the EAM section. In our original design, we finely optimized the EAM design to maximize the modulation depth by implementing perturbative Quantum Confined Stark Effect (QCSE) calculations, while designing the vertical integration of the EAM without penalty on the VCSEL static performances.

We will present the different fabricated vertical structures, as well as the experimental electrical and optical static measurements for those configurations demonstrating a very good agreement with the reflectivity and absorption simulations obtained for both the VCSEL and the EAM-VCSEL structures. Finally, to reach very high frequency modulation we studied the BCB electrical properties up to 110 GHz and investigated coplanar and microstrip lines access to decrease both the parasitic capacitance and the influence of the substrate.

100 words:

In this presentation, we describe the operation of Multiple-Quantum-Wells Asymmetric Fabry-Perot modulator, vertically integrated into a VCSEL structure for high-speed modulation. First we optimize the Electro-Absorptive Modulator (EAM) and the EAM-VCSEL structures by utilizing a perturbative quantum-confined Stark-effect and transfer matrix calculations. Then we present experimental reflectivity, LIV curves and photocurrent measurements and demonstrate very good agreement with our modelling results. High frequency measurements of BCB electrical response up to 110 GHz are carried out to estimate the parasitic effects due to the pad configuration and the impact of the substrate.