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

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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.