

CW operation of a 1.55 μm VCSEL tunable over 20 nm integrating liquid crystals microcells

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Miniaturized tunable photonic devices can be of great interest for applications in wavelength division multiplexing systems or metrology applications. For a widespread deployment, compact sources and/or detectors dynamically reconfigurable in wavelength are highly desirable. To achieve such devices, many studies have been conducted in the past by using MEMS technologies. However, MEMS solutions may suffer from important power consumption, high driving voltage or mechanical steadiness of the MEMS structure itself. A promising alternative to MEMS approach is the use of the well-known and mature liquid crystals (LC) material within a monolithic microcavity structure. In this case a large refractive index variation is obtained by a moderate driving voltage leading to a low power consumption since leakage currents through LC layers are extremely low.

Recently, we have proposed and realized wavelength selective and tunable filter and photodiodes (PD) at 1.55 μm , by integrating liquid crystal (LC) micro-cells within a microcavity placed at the top of the PD [1]. A more than 100 nm wavelength tuning was demonstrated with a moderate applied voltage $< 10\text{V}$, and an average PD responsivity of 0.4 A/W, a first evidence of the efficiency of LC to act as a wavelength tuning media in this wavelength range. Going further, we have recently implemented these LC micro-cells process directly within the microcavity of an optically pumped InP based VCSEL to realize tunable laser devices. As presented on the Fig 1 inset, the VCSEL structure consists in 9 InGaAsP strained quantum wells distributed over three electrical field nodes, a bottom and a top dielectric DBRs, a diffraction free nano-grating imprinted in a SU-8 layer to insure the LC molecules uniform alignment, and finally a 2.5 μm thick LC layer defined by photoresist walls.

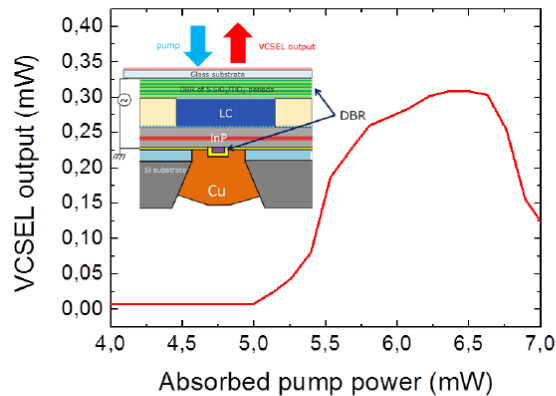


Figure 1 : L(L) in CW operation of the LC μ -cell VCSEL (inset is a sketch of the device)

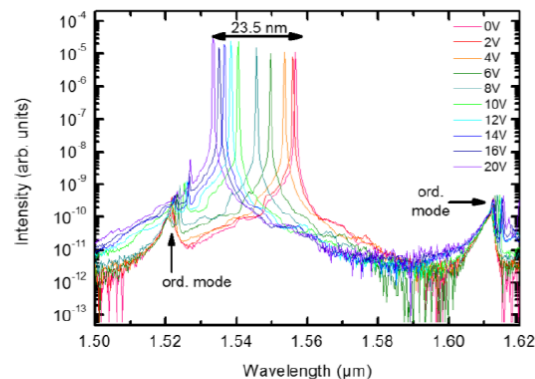


Figure 2 : VCSEL spectra as function of LC applied voltage

As shown by the Fig. 1, when no voltage is applied on the LC, CW operation is obtained at room temperature with a moderate output power (0.3 mW), and a threshold of 5 mW. This last value is among the typical threshold we already get with LC free VCSELs, showing the very low optical losses induced by the LC itself in the VCSEL cavity. When the AC voltage applied on the LC is increasing from 0 up to 20 V, the VCSEL wavelength is continuously blue-shifted from 1556.5 down to 1533 nm (Fig. 2), corresponding to a wavelength tuning of 23.5 nm. These very preliminary results, constituting the first demonstration of CW laser operation and wavelength tuning of a LC VCSEL at RT, is an important step for further development of tunable LC electrically-pumped VCSEL.

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[1] B. Sadani *et al.*, "Liquid-crystal alignment by a nanoimprinted grating for wafer-scale fabrication of tunable devices," IEEE Photonics Technol. Lett. 30(15), 1388 (2018).

[2] C. Levallois *et al.*, "Liquid crystal-based tunable photodetector operating in the telecom C-band", Optics Express 26(20) 25952 (2018)