MBE growth of mid-IR interband cascade lasers

M. Fagot,[1] D. A. Diaz-Thomas,[1] A. Gilbert,[1] Y. Rouillard,[1] J.-B. Rodriguez,[1] E. Tournié[1,2] and L. Cerutti[1,*]

[1]IES, University of Montpellier, CNRS, F-34000 Montpellier, France

[2]Institut Universitaire de France (IUF), F-75005 Paris, France

*E-mail: laurent.cerutti@umontpellier.fr

Interband cascade lasers (ICLs) were first proposed 30 years ago [1] and have since become essential for a wide range of applications within the 3–6 µm wavelength range [2,3] thanks to their operation in continuous wave above room temperature and a power consumption below 0.5 W. However, the active region of ICLs is particularly complex and relies on the alternance of few-monolayers thin layers of binary antimonides and alloys with non-common atoms. Therefore, the molecular beam epitaxy (MBE) growth of ICLs remains challenging. In fact, the extensive group-V intermixing at the interfaces, the different optimal growth temperatures required for the various layers, and the sensitivity to thermal annealing can affect the properties such as threshold current and emission wavelength [4, 5].

However, despite the high sensitivity of ICL to their growth conditions, these structures are surprisingly very tolerant to high crystalline defect densities such as dislocations. In contrast to interband diode lasers, which are very sensitive to dislocations with a rapid degradation of their performance [6], ICL grown on highly mismatched substrates such as GaAs and Si exhibit very similar performances without degradation during ageing [7]. These properties open the way for the direct integration of mid-infrared lasers on GaAs or Si photonic integrated circuits for the development of compact and low-power consumption optical sensors.

In this talk, we will first detail the influence of the growth conditions on the properties of the QWs constituting the ICL active region and then review the growth and performance of ICLs on different substrates emitting between 3.3 and 4.7 µm.

[1] R.Q. Yang *et al,* Superlattices and Microstructures, **17**, 77 (1995)

[2] H. Wu *et al,* Sensors and Actuators B: Chemical, **297**, 126753 (2019)

[3] P. Didier *et al,* Photonics Research, **11**, 582 (2023)

[4] C. Canedy *et al,* Journal of Vacuum Science and Technology B, **28**, C3G8 (2010)

[5] D.A. Díaz-Thomas *et al,* Optics Express, **27**, 31425 (2019)

[6] J. li *et al*, Advanced Photonics Research, **5**, 2300348 (2024)

[7] M. Fagot *et al,* Optics Express, **32**, 11057 (2024)

This work was partially funded by France 2030 program (EquipEx EXTRA and HYBAT, ANR-11-EQPX-0016, ANR-21-ESRE-0026), the French Occitanie Region (LASIDO project), the French Agency for Defense and Innovation (AID-DGA) and the Banque Publique d'Investissement (Hyquality Project DOS0188007/00).