Interband cascade lasers emitting below 3 µm grown on GaAs substrate

M. Fagot,[1,*] D. A. Diaz-Thomas,[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: maeva.fagot@umontpellier.fr

Interband cascade lasers (ICLs) are mainly used in the 3 – 5 µm range, as diode lasers dominate below 3 µm due to their high efficiency and low threshold current. However, beyond 2.5 µm, diode laser performance begins to degrade, due to increased internal losses and non-radiative Auger recombination, causing an exponential increase in threshold current density [1]. GaSb-based laser diodes grown on Si have recently shown promising threshold currents, only three times higher than on native substrates [2], but suffer from rapid degradation, limiting their reliability. ICLs, on the other hand, are highly tolerant to dislocations within their operating window [3,4] and have demonstrated an extrapolated mean time of failure exceeding 35 years. While much efforts have been focused on extending ICL performance at longer wavelengths [5], little has been done to explore their potential at shorter wavelengths. Extending the operating range of ICLs below 3 µm could bridge the performance gap between 2.5 and 3 µm, leveraging the unique advantages of their design to improve laser technology in this spectral range.

This work presents our latest results on type-II ICLs designed to emit at 2.7 µm, grown on both GaSb and GaAs substrates. The laser structure includes a five-stage active region, situated between two 350 nm separate confinement heterostructures and two AlSb/InAs superlattice claddings. The ICL structure was first grown on GaSb to assess performance, then on GaAs substate for comparison. Laser ridges are fabricated using standard photolithography process, creating 8 µm-wide and 2 mm-long cavities with uncoated facets. The light-current-voltage (L-I-V) characteristics of the lasers, taken under pulsed operation (DC 1%, 10 kHz) at 20°C and presented Figure 1, show a slightly higher threshold current for GaAs (100 mA vs 80 mA for GaSb) while maintaining a similar slope efficiency (~ 130 mW/A for both GaSb and GaAs). The ICL on GaAs, however, has a higher series resistance (5.9 Ω vs 2.7 Ω for GaSb). Spectra (shown in insert) reveal emission between 2.8 and 2.9 µm for both structures, with a slight shift in the GaAs device likely caused by the higher As content in its active region. Aging tests will be conducted to evaluate the laser durability at this wavelength. These findings open the way for efficient devices on Si below 3 µm.

[1] K. S. Gadedjisso-Tossou *et al*, Semicond. Sci. Technol. **28**, 015015 (2012).

[2] A. Remis *et al*, J. Appl. Phys. **133**, 093103 (2023).

[3] L. Cerutti *et al*, Optica **8**, 1397 (2021).

[4] M. Fagot *et al*, in The 23rd International Conference on Molecular Beam Epitaxy, Matsue, Japan (2024).

[5] J. A. Massengale *et al*, Semicond. Sci. Technol. **38**, 025009 (2022).

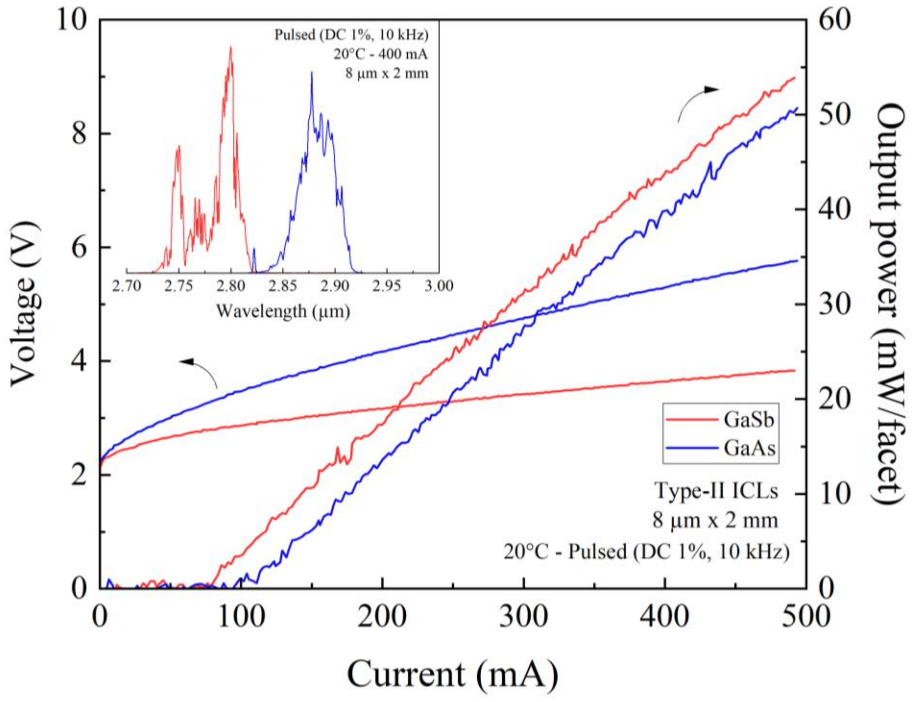

Figure 1: Pulsed L-I-V curves for 8 µm x 2 mm type-II ICLs grown on GaSb (red) and GaAs (blue) substrates. Insert: Emission spectra of ICLs measured under pulsed operation at 20°C with an injection current of 400 mA.

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).