MIR Sb-based Interband cascade lasers on metamorphic substrates

Maeva Fagot, Daniel Andres Diaz-Thomas, Audrey Gilbert, Michel Ramonda, Gad Kombila, Yves Rouillard, Jean-Baptiste Rodriguez, Eric Tournié, Laurent Cerutti

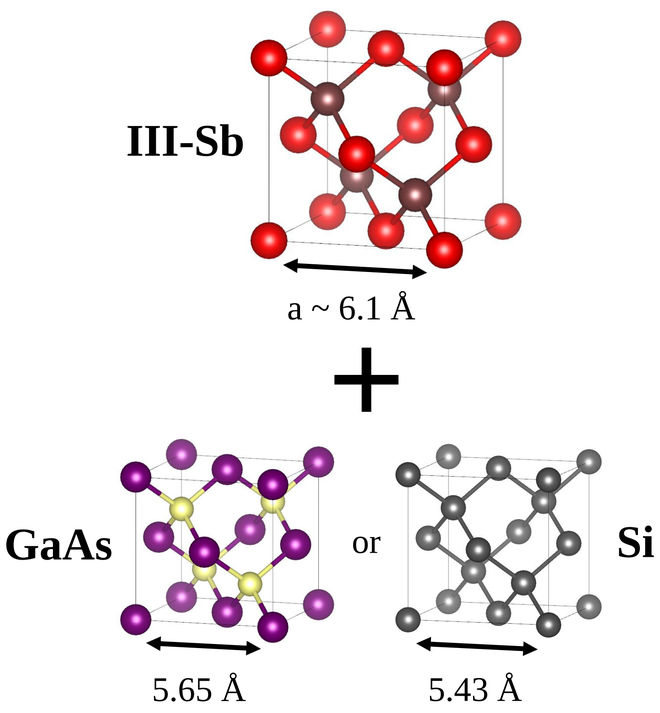
MIR Sb-based Interband cascade lasers on metamorphic substrates

M. Fagot, D. Diaz Thomas, A. Gilbert, M. Ramonda, G. Kombila, Y. Rouillard, J.B. Rodriguez, E. Tournié and L. Cerutti

IES, Univ. Montpellier, CNRS, 34000 Montpellier, France

Introduction:

The production of **MIR gas sensors** on PICs requires **Sb-based light sources**. The growth on inexpensive and large-sized **mismatched substrates** introduces dislocations. They create **deep level**s in the gap and act as trap defects, impacting laser performances. It's crucial to have an active zone **tolerant to dislocations**, which is achievable with interband cascade lasers (ICL).



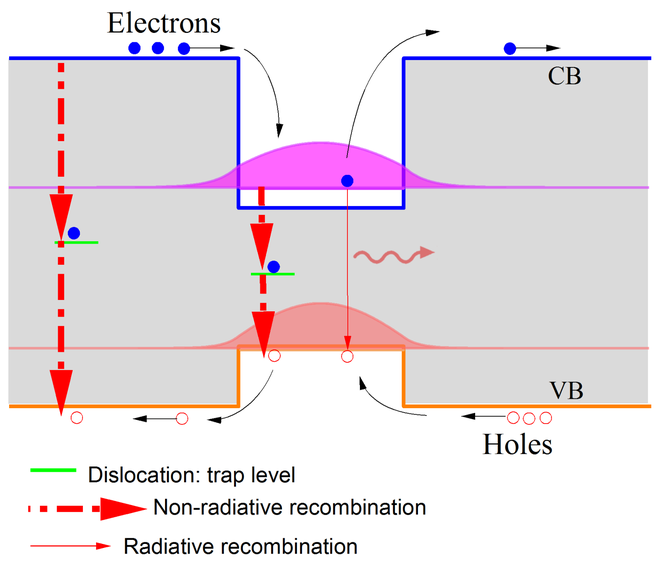


Fig. 1. Impact of dislocations in a type-I QW [1]

[1] L. Cerutti et al., Optica, vol. 8, no 11, p. 1397, nov. 2021

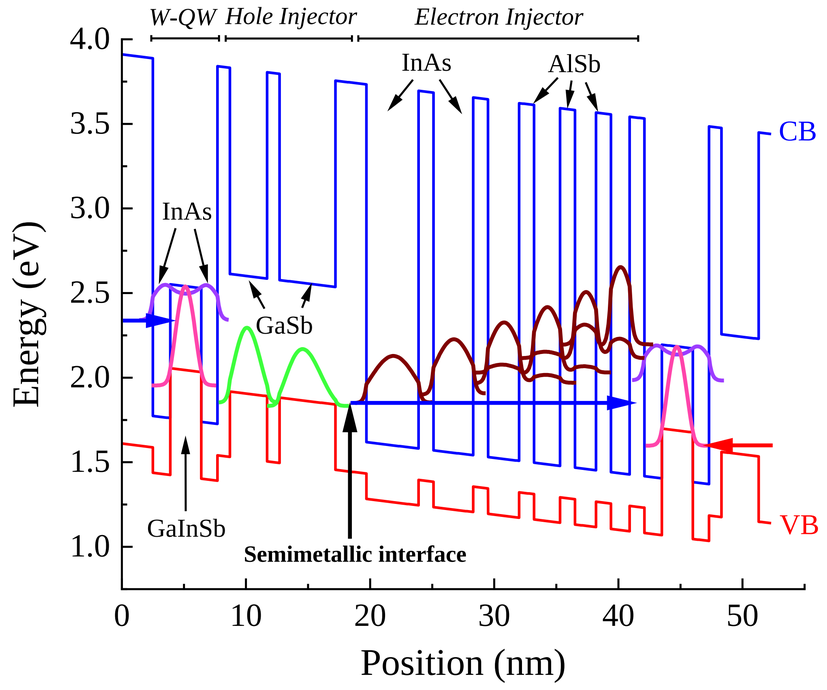


Fig. 2. Band structure of 1 stage of the ICL active zone

Structural characterizations:

Cap – 20 nm InAs

Top cladding – 1.8 µm AlSb / InAs SLs

SCH – 500 nm GaSb:Te

Active zone – x5 or x7

SCH – 500 nm GaSb:Te

Bottom cladding – 3 µm AlSb / InAs SLs

Substrate

Fig. 3. ICL structure

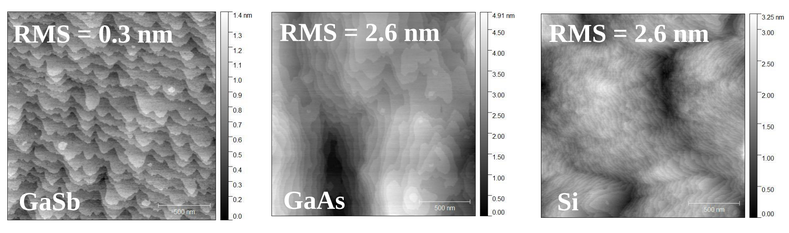


Fig. 4. 2 µm x 2 µm AFM images for ICLs emitting at 4.2 µm

Higher RMS on GaAs and Si

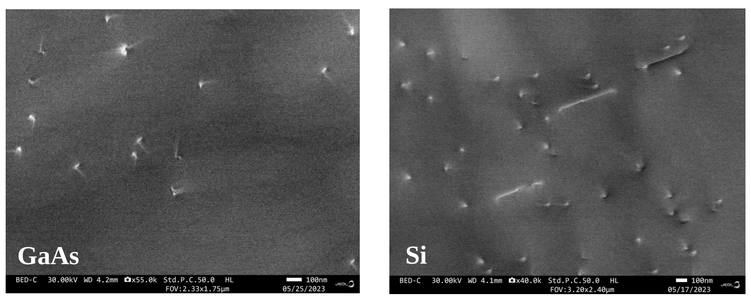


Fig. 5. ECCI for ICLs at 3.3 µm on GaAs and Si

TDD ~ **5.10^8** cm^{-2}

Growth on **mismatched** substrates → **High** dislocation density ($>10^8$ cm^{-2})

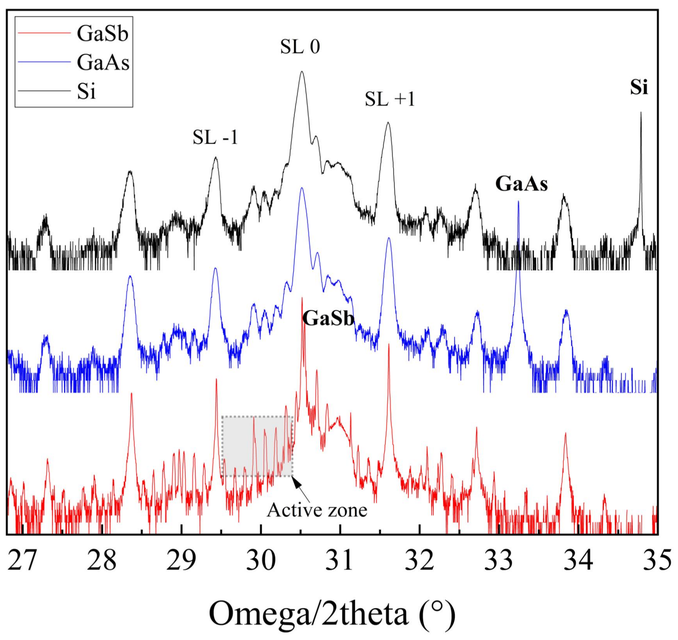


Fig. 6. Comparison of XRD patterns for ICLs grown on different substrates

Dislocations

↓

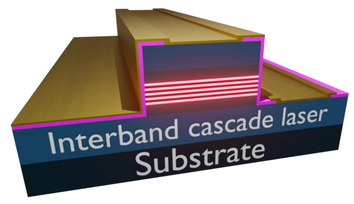
Lattice distortion

⇩

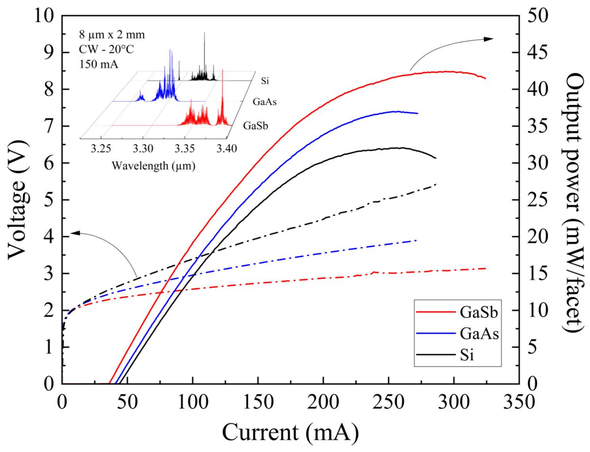
Broad satellite peaks on GaAs and Si

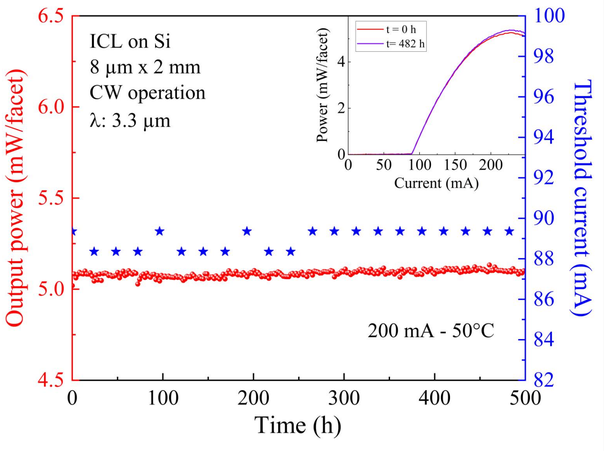
Results:

ICLs **episide-up** with **uncoated** facets and both contacts taken on the epitaxial side



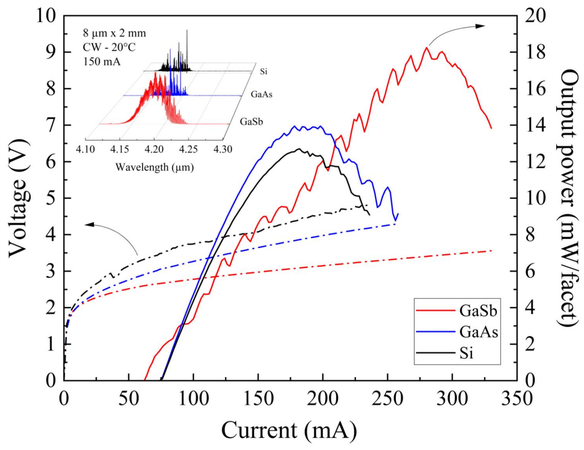
➢ *Lasers at 3.3 µm*

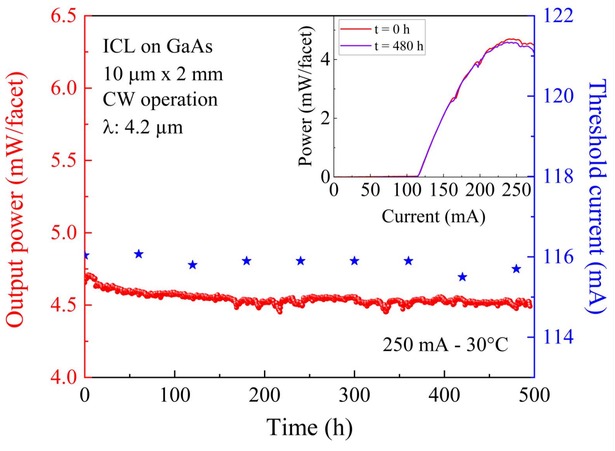




Similar I_{th}: 40 mA • CW operation up to ~ **65°C** • **Same T_0**: 39K

➢ *Lasers at 4.2 µm*





$I_{th(GaSb)}$ ~ $I_{th(GaAs/Si)}$ • CW operation up to **40°C** • **Same T_0**: 32K

Conclusion:

No degradation during the aging

↓

ICLs tolerant to dislocations between 3.3 and 4.2 µm

⬇

Towards integration on PICs

Funding sources:

This work was partially supported by the French program "Investments for the Future" (EquipEx EXTRA and HYBAT, ANR-11-EQPX0016, ANR-21-ESRE-0026), the French Occitanie Region (LASIDO project), the French Agency for Defense and Innovation (AID-DGA) and the BPI (HyQuality project DOS0188007/00).