

Reducing defect density in the epitaxy of III-Vs on Silicon substrates

A. Gilbert¹, E. Tournié^{1,2}, G. Patriarche³, C. Cornet⁴, M. Ramonda⁵, L. Cerutti¹, M. Fagot¹, A. Trampert⁶, K. Graser⁶, and J.-B. Rodriguez^{1*}

¹ IES, Univ. Montpellier, CNRS, F-34000 Montpellier, France

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

³ C2N, CNRS- Univ. Paris-Saclay, F-91120 Palaiseau, France

⁴ Univ. Rennes, INSA Rennes, CNRS, Institut FOTON – UMR 6082, F-35000 Rennes, France

⁵ CTM, Univ. Montpellier, F-34000 Montpellier, France

⁶ Paul-Drude-Institut für Festkörperphysik, Leibniz-Institut im Forschungsverbund Berlin e.V., Hausvogteiplatz 5-7, 10117 Berlin, Germany

*e-mail : jean-baptiste.rodriguez@cnrs.fr

Molecular Beam Epitaxy of III-V semiconductors on foreign substrates and in particular on Silicon has been an important topic since the 80's. From an application point of view, this monolithic approach would open a wide range of structure engineering possibilities by combining the advantages of the two type of materials. From a more fundamental perspective however, the epitaxy of III-V on group-IV substrates is considered to be very challenging due to the crystal structure differences. Indeed, III-Vs have a zinc blende structure and are grown on a diamond group-IV substrate, which leads to the formation of a high density of the so-called antiphase boundaries, due to the symmetry difference of the two crystals [1]. In addition, in most cases, there is a large lattice-mismatch between the two crystals, resulting in a very large dislocation density upon relaxation of the III-V layers. For this reason, the structural quality of the III-V layers was so poor for a long time that it was not possible to produce any high-performance device.

Much progress has been made in the last two decades, especially in the growth of GaAs and GaSb pseudo-buffers on silicon. Antiphase boundaries have been successfully buried even on very low miscut substrates, and the mechanism governing this process has been elucidated [2-3]. The dislocation density has been reduced but remains quite high. However, new ideas about the active region of the devices have made it possible to fabricate devices with performance as high as their counterparts grown on native substrates [4].

In this talk, we will review the latest developments in this field and present some future prospects for further integration with optical circuits towards the realization of complete photonic chips.

References:

[1] H. Kroemer, Journal of Crystal Growth **81**, 193 (1987).

[2] A. Gilbert, M. Ramonda, L. Cerutti, C. Cornet, G. Patriarche, É. Tournié, and J. Rodriguez, Advanced Optical Materials **11**, 2203050 (2023).

[3] M. Rio Calvo, J.-B. Rodriguez, C. Cornet, L. Cerutti, M. Ramonda, A. Trampert, G. Patriarche, and É. Tournié, *Advanced Electronic Materials* **8**, 2100777 (2022).

[4] L. Cerutti, D.A. Díaz Thomas, J.-B. Rodriguez, M. Rio-Calvo, G. Patriarche, A.N. Baranov, and E. Tournié, *Optica*, **8** (11), 2021.

Acknowledgments: Part of this work was supported by the France 2030 program (Equipex EXTRA, ANR11-EQPX-0016, the Equipex+ HYBAT (ANR-21-ESRE-0026), BPI France (project HYQUALITY-DOS0188007/00), the ANR-DFG FILTER (ANR-20-CE92-0045), the ANR PIANIST (ANR-21-CE09-0020), the ANR NUAGES (ANR-21-CE24-0006) projects and the French Renatech network.