

## Anti-phase boundaries annihilation in the growth of GaSb on Silicon(001)

J.-B. Rodriguez<sup>1\*</sup>, M. Rio Calvo<sup>1</sup>, C. Cornet<sup>2</sup>, L. Cerutti<sup>1</sup>, M. Ramonda<sup>3</sup>, A. Trampert<sup>4</sup>, G. Patriarche<sup>5</sup>  
and E. Tournié<sup>1</sup>

<sup>1</sup>*IES, University of Montpellier, CNRS, F- 34000 Montpellier, France*

<sup>2</sup>*Univ Rennes, INSA Rennes, CNRS, Institut FOTON – UMR 6082, F-35000 Rennes, France*

<sup>3</sup>*CTM-UM, University of Montpellier, F- 34000 Montpellier, France*

<sup>4</sup>*Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V.,  
Hausvogteiplatz 5-7, 10117, Berlin, Germany*

<sup>5</sup>*Université Paris-Saclay, CNRS, Centre de Nanosciences et de Nanotechnologies, 91120, Palaiseau,  
France.*

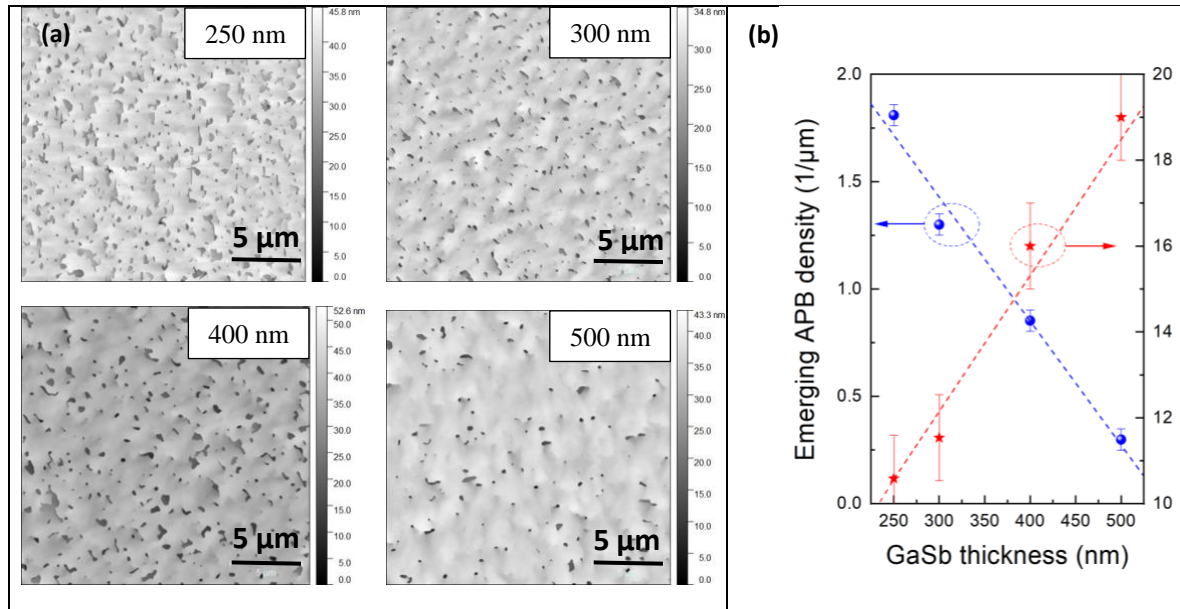
\*Corresponding author: [rodriguez@ies.univ-montp2.fr](mailto:rodriguez@ies.univ-montp2.fr)

**ABSTRACT.** We present a study of the APB annihilation mechanism during the growth of GaSb on “on-axis” Si (001) substrates. We demonstrate for the first time that the APDs are buried by the main-phase domain due to the growth rate difference existing between the two domains. We experimentally quantified the growth rate difference and explored the various parameters influencing this mechanism, using an original approach based on AFM analysis of several series of samples.

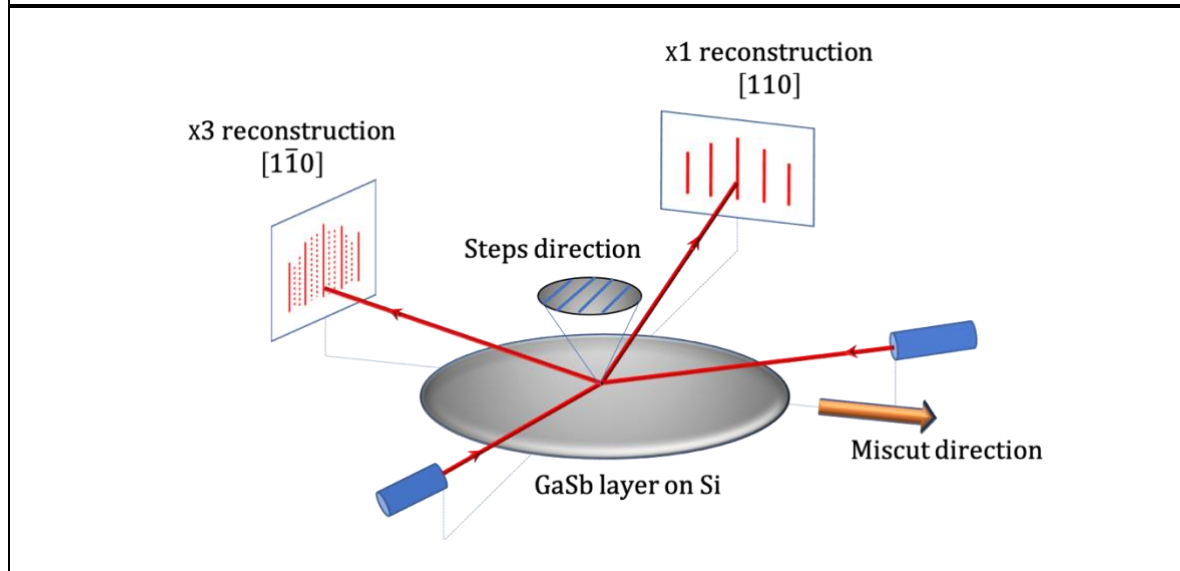
**Keywords:** III-V/Si heteroepitaxy, monolithic integration, miscut, antiphase domains.

In this presentation, we review our recent results and effort aimed at understanding the growth of III-V semiconductors on Silicon (001) substrates. In particular, we clarify the mechanism and the conditions allowing for the annihilation of anti-phase boundaries (APBs) during the growth of GaSb pseudo-substrates, on “on-axis” Si(001). We demonstrate for the first time that the anti-phase domains (APDs) are buried by the main-phase domain thanks to a larger growth rate due to the fact that the type of steps populating the surface of each domain is different in properly prepared samples (Figure 1). Analyzing series of samples having different nominal GaSb layer thicknesses by Atomic Force Microscopy (AFM), we were able to accurately quantify the growth rate difference between the domains. For our optimized substrate preparation and growth conditions, APBs could be completely removed from the GaSb surface after a layer of about 500 nm was grown on a Si substrate having a residual controlled offcut towards the [110] direction as low as 0.5°, which can be considered as “on-axis”. We then explore how the substrate preparation influence the burying mechanism, and clarify the interplay between the transfer of the offcut direction and the efficacy of the burying. We also show that the temperature is the main parameter influencing the process. Using RHEED (Figure 2), we have been able to identify which of the two initial phases becomes the main phase domain (MPD) in the case explored here (GaSb grown on Si by MBE in standard growth conditions). The better comprehension of these mechanisms will be the key towards a reduction of the APB density that will enable the hybridization of high-performance III-V devices with industry-compatible Si substrates.

Part of the work has been supported by the French program on Investment for the Future (ANR-11-EQPX-0016) and the H2020 program of the European Union (GA 780240). This work received support from the Renatech network for part of the transmission electron microscopy studies.



**Figure 1.** (a) 20 μm x 20 μm AFM topographic images of GaSb/Si layers with a thickness varying between 250 and 500 nm. (b) Emerging-APB density (blue line and dots) and GaSb thickness difference between the MPD and the APD (red line and stars) as a function of the deposited GaSb layer nominal thickness.



**Figure 2.** : RHEED analysis on the surface of samples with APB-free surface. The x1 and x3 reconstruction directions (corresponding to [110] and [1-10] respectively in the case of GaSb) are compared to the miscut (and therefore to the step edges) direction in order to infer the type (V- or III-) of the steps populating the MPD surface.