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► **To cite this version:**

Guy-Vano Tsamo Tagougue, Eugénie Martinez, Marc Veillerot, Vincent Thoreton, Thierry Baron, et al.. Study of $\text{In}_{0,53}\text{Ga}_{0,47}\text{As}/\text{InP}/\text{InAlAs}/\text{InP}$ heterostructures by TOF-SIMS and HAXPES. SIMS 24, Jun 2024, Rochelle, France. cea-04862165

HAL Id: cea-04862165

<https://cea.hal.science/cea-04862165v1>

Submitted on 2 Jan 2025

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Study of $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{InP}/\text{InAlAs}/\text{InP}$ heterostructures by TOF-SIMS and HAXPES

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Abstract

The advantages of III-V semiconductors such as their direct gap and high charge carrier mobility make them interesting for optoelectronics applications, high-frequency transistors (HBTs) and high electron mobility transistors (HEMTs) [1]. Although the growth of heterostructures such as $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}$ on InP has a tuned lattice parameter, interdiffusion of the main elements and dopants can reduce device performance. Time-of-flight secondary ion mass spectrometry (TOF-SIMS) has proved ideal for studying buried interfaces [2]. For III-V semiconductors, the choice of abrasion gun and analyzer polarity is a key factor in achieving good ionization efficiency of the elements to be monitored [3]. For such materials, for example, it has been shown that using a dioxygen gun (O_2^+) for sputtering results in depth resolution degradation due to the formation of an oxide layer at the bottom of the crater [4].

In this presentation, we'll show how the use of two analyzer polarities and the choice of abrasion and analysis guns (Cs^+ and Bi_3^+) enable complete monitoring of the main elements, dopants and impurities in heterostructures such as $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{InP}/\text{InAlAs}/\text{InP}$. We'll compare TOF-SIMS analyses using Cs^+ and O_2^+ sputtering sources. From AFM images of the crater formed, we obtain roughness values around 2 and 6 nm using the Cs^+ and O_2^+ sources respectively. This difference is due to the formation of an oxide layer at the bottom of the crater in the case of the O_2^+ source, which destroys depth resolution. High-energy photoelectron spectroscopy (HAXPES) with a chromium source Cr $K\alpha$ ($h\nu=5415$ eV) [5] will be used to quantify the elemental composition and investigate chemical environments at the buried InGaAs/InP interface, showing for instance the absence of interfacial oxidation.

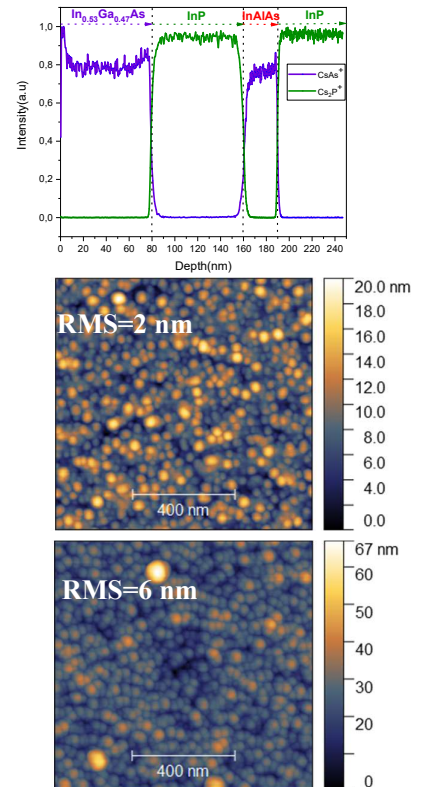


Figure 1: TOF-SIMS profiles and AFM images of the crater formed for Cs^+ and O_2^+ abrasion respectively for $\text{In}_{0.53}\text{Ga}_{0.47}\text{As}/\text{InP}/\text{InAlAs}/\text{InP}$ heterostructures.

- [1] J. W. Lambrechts *et al.*, *IEEE Access*, vol. 12, no. January, pp. 21402–21419, 2024.
- [2] T. Spelta *et al.*, *Solid. State. Electron.*, vol. 208, no. August, pp. 2–4, 2023.
- [3] B. Gong and C. E. Marjo, *Surf. Interface Anal.*, vol. 48, no. 7, pp. 422–427, 2016.
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- [5] O. Renault *et al.*, *Faraday Discuss.*, vol. 236, pp. 288–310, 2022.

Acknowledgements

This work, carried out (in part) on the Plate-Forme de Nano-Characterisation (PFNC), benefited from government funding managed by the Agence Nationale de la Recherche under the "Recherche Technologique de Base" and France 2030 programs (ANR-22-PEEL-0014). We would also like to thank Labex Minos for funding this project.