



HAL
open science

Gallium Phosphide Platforms for Integrated Photonics

Lise Morice, Brieg Le Corre, Antoine Lemoine, Abdelmounaim Harouri,
Grégoire Beaudoin, Luc Le Gratiet, Tony Rohel, Julie Le Pouliquen, Rozenn
Bernard, Christian Grillet, et al.

► **To cite this version:**

Lise Morice, Brieg Le Corre, Antoine Lemoine, Abdelmounaim Harouri, Grégoire Beaudoin, et al..
Gallium Phosphide Platforms for Integrated Photonics. 36th International Conference on the Physics
of Semiconductors (ICPS 2024), Jul 2024, Ottawa, Canada. hal-04710080

HAL Id: hal-04710080

<https://hal.science/hal-04710080v1>

Submitted on 26 Sep 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Gallium Phosphide Platforms for Integrated Photonics

L. Morice^{1,2}, B. Le Corre^{1,3}, A. Lemoine¹, A. Harouri³, G. Beaudoin³, L. Le Gratiet³, T. Rohel¹, J. Le Pouliquen¹, R. Bernard¹, C. Grillet², C. Cornet¹, I. Sagnes³, K. Pantzas³, C. Monat², Y. Leger¹

¹Univ Rennes, INSA, CNRS, Institut FOTON, UMR 6082, F-35000 Rennes, France

²Institut des Nanotechnologies de Lyon, UMR CNRS 5270, Ecole Centrale de Lyon, Ecully, France

³Centre de Nanosciences et de Nanotechnologies, CNRS, Université de Paris-Saclay, Palaiseau, France

Lise.Morice@insa-rennes.fr

Gallium Phosphide (GaP) is a III-V semiconductor with many advantages for integrated non-linear photonics thanks to its wide transparency band (visible, NIR, MIR) pushing the absorption threshold to two photons below 1100 nm, its high refractive index ($n_0 > 3$), its indirect gap, its non-centrosymmetric geometry which results in a second-order non-linearity $\chi^{(2)}$ as well as a large order third-order non-linearity $\chi^{(3)}$ ($n_2 = 1.2 \times 10^{-17} \text{ m}^2/\text{W}$ [1]).

GaP photonic devices can be produced from the growth of GaP on different substrates like Gallium Arsenide (GaAs [2]), Silicon (Si [3]) or on native substrates [4]. The GaP/GaAs platform shows good crystal quality despite a high rate of dislocations due to the lattice mismatch between the two materials. The growth of GaP on Si induces fewer dislocations but shows structural defects specific to the use of a nonpolar substrate [5]. For photonic applications purpose, the refractive index of these substrates being larger than that of GaP ($n_0 = 3.27$ for GaAs and 3.5 for Si against 3.05 for GaP at 1.55 μm) the transfer of the GaP membranes to a material with a smaller refractive index is mandatory. In contrast, GaP/Al_{0.7}GaP/GaP epilayers can be straightforwardly used as a monolithic photonic platform ($n_0 = 2.88$ for AlGaP at 1.55 μm) but this advantage is mitigated by the fluctuating quality and high cost of GaP substrates.

In this work, we investigate the impact of the photonic platform used on the propagation losses of GaP nanowaveguides and evaluate their relevance in the development of advanced GaP photonic circuits. GaP waveguides on insulator (Fig.1 a) as well as monolithic structures (Fig.1.b) were realized following similar lithography/ etching process and propagation losses in the near infrared were measured on these structures by two distinct methods: vertical diffusion imaging and Fabry-Perot fringe contrast measurement [6]. We will discuss our results in terms of material structural quality, epilayer interface quality and process-induced roughness. The authors acknowledge RENATECH with nanoRennes for technological support. This research was supported by “France 2030” with the French National Research Agency OFCOC project (ANR-22-PEEL-005).



Fig.1. SEM image from a) a nanowaveguide of GaP on insulator. b) a nanowaveguide of GaP/AlGaP/GaP.

References

- [1] D. J. Wilson & al., Nat. Photonics, vol. 14, n°1, p. 57-62 (2020).
- [2] K. Pantzas & al., ACS Photonics, vol. 9, n°6, p. 2032-2039 (2022).
- [3] R. Saleem-Urothodi & al., Opt. Lett., vol. 45, n°16, p. 4646 (2020).
- [4] M. Mitchell & al., Appl. Phys. Lett., vol. 104, n°14, p. 141104 (2014).
- [5] Y. Ping Wang & al., J. Appl. Crystallogr., vol. 48, n°3, p. 702-710 (2015).
- [6] A. De Rossi & al., J. Appl. Phys., vol. 97, n°7, p. 073105 (2005).