Gallium Phosphide Platforms for Integrated Photonics

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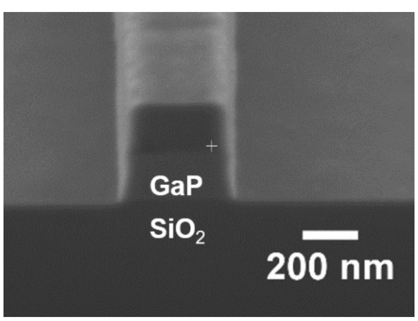
Gallium Phosphide (GaP) is a III-V semiconductor with many advantages for integrated non-linear photonics thanks to its wide transparency band (visible, NIR, MIR) pushing the absorption threshold to two photons below 1100 nm, its high refractive index (n_0 >3), its indirect gap, its non-centrosymmetric geometry which results in a second-order non-linearity $\chi^{(2)}$ as well as a large order third-order non-linearity $\chi^{(3)}$ ($n_2 = 1.2 \times 10^{-17}$ m^2/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 reasearch was supported by “France 2030” with the French National Research Agency OFCOC project (ANR-22-PEEL-005).



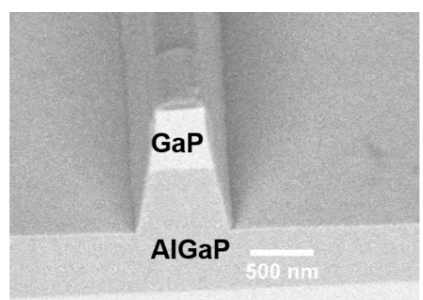


Fig.1. SEM image from a) a nanowaveguide of GaP on insulator. b) a nanowaveguide of GaP/AlGaP/GaP.

References

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