GaN/AlInO Waveguides for Visible Light Communications

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Introduction

Gallium Nitride (GaN) is most commonly and successfully used for light-emitters, high-speed transistors, and power devices. A more nascent application is III-nitride waveguides which have potential for various applications such as nonlinear optics, quantum photonics [1], and visible light communications (VLC) [2] [3]. VLC can be accomplished using either light-emitting diodes (LEDs) or laser diodes (LDs), the latter offering faster modulation speeds. These speeds can be enhanced further, as shown in other material systems, by using waveguides and modulators to form photonic integrated circuits (PIC). PICs require routing of the photonic signals which is, for example, accomplished in Si-based PICs using a Silicon-on-insulator waveguiding structure [4]. Here we are able to accomplish this same structure in GaN using Aluminum Indium Oxide (AlInO) as a guiding layer. AlInO is formed by oxidizing Aluminum Indium Nitride (AlInN) through a new method discovered by the Photonics and Nanoelectronics Center at Lehigh University.

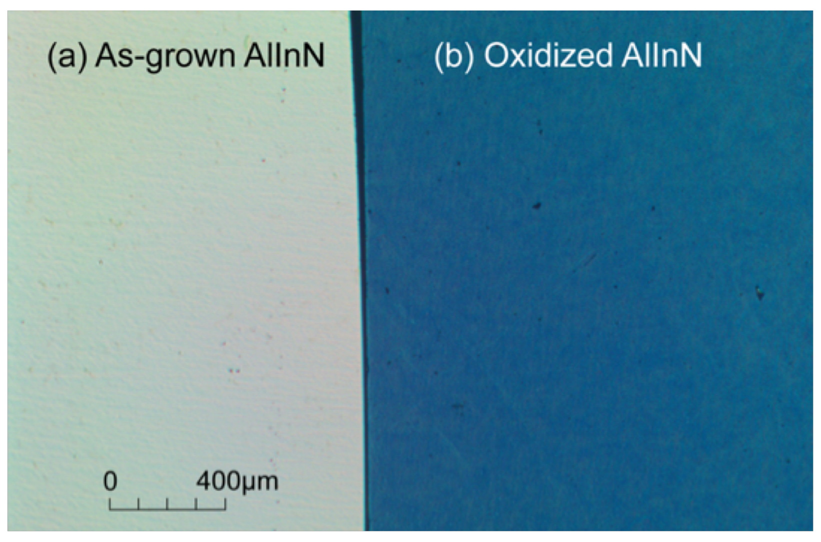
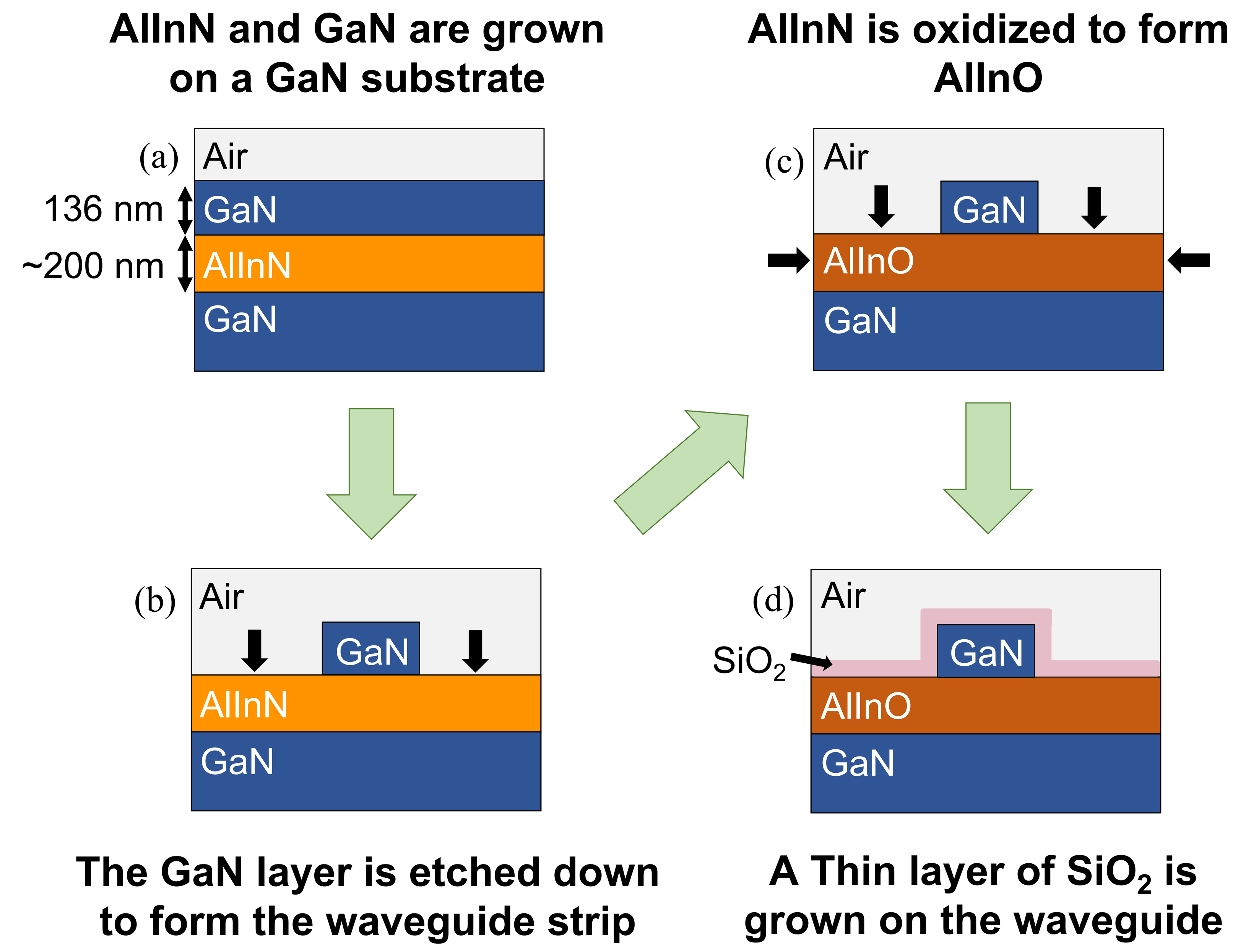


Figure 1. Top-view microscope image of an as-grown AlInN layer (left) and an oxidized AlInN layer (right).

Fabrication



Simulation

This air/GaN/AlInO waveguide is simulated using COMSOL Multiphysics modeling software to determine mode characteristics and dimensional requirements. The structure is designed for single-mode propagation of blue laser light ($\lambda = 405\,nm$), but could potentially guide light in the infrared spectrum, if designed with the proper dimensions. Infrared light is most often used for telecommunications.

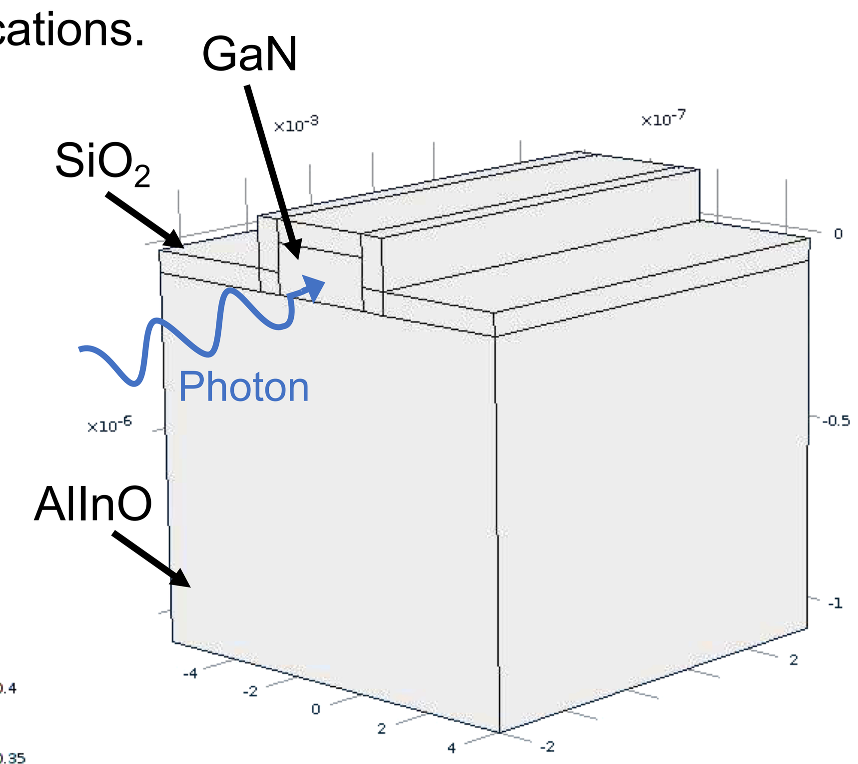


Figure 2. This figure shows a 3D depiction of a GaN (n~2.4) waveguiding strip on AlInO (n~1.7) with a thin cladding layer of SiO_2 (n~1.5). A photon will be incident on the GaN strip and be guided to exit from the other end.

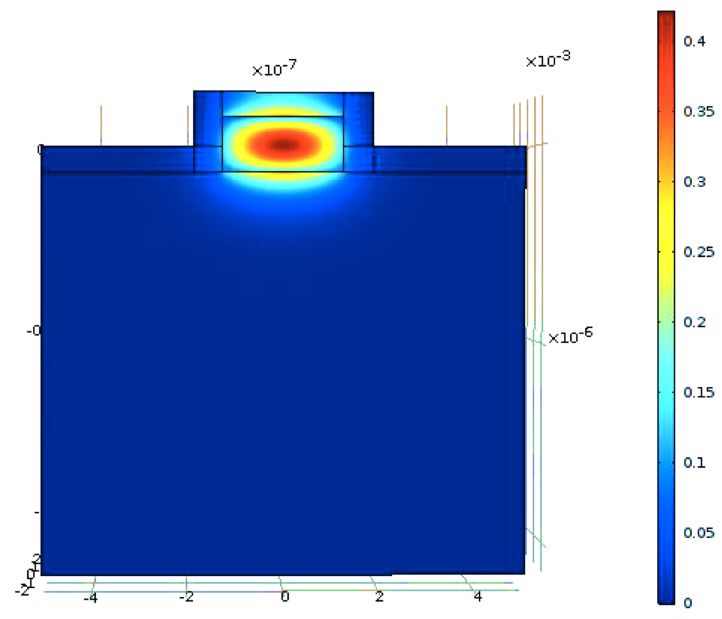


Figure 3. COMSOL simulation of waveguide and electric field intensities as a function of position. This figure shows the cross-section of the waveguiding structure. The electric field intensity peaks within the GaN, exhibiting an effective guiding structure.

Characterization

In order to determine the effectiveness of this new waveguide, the loss factor, γ cm^{-1}, must be determined. A high loss factor indicates high internal and scattering losses.

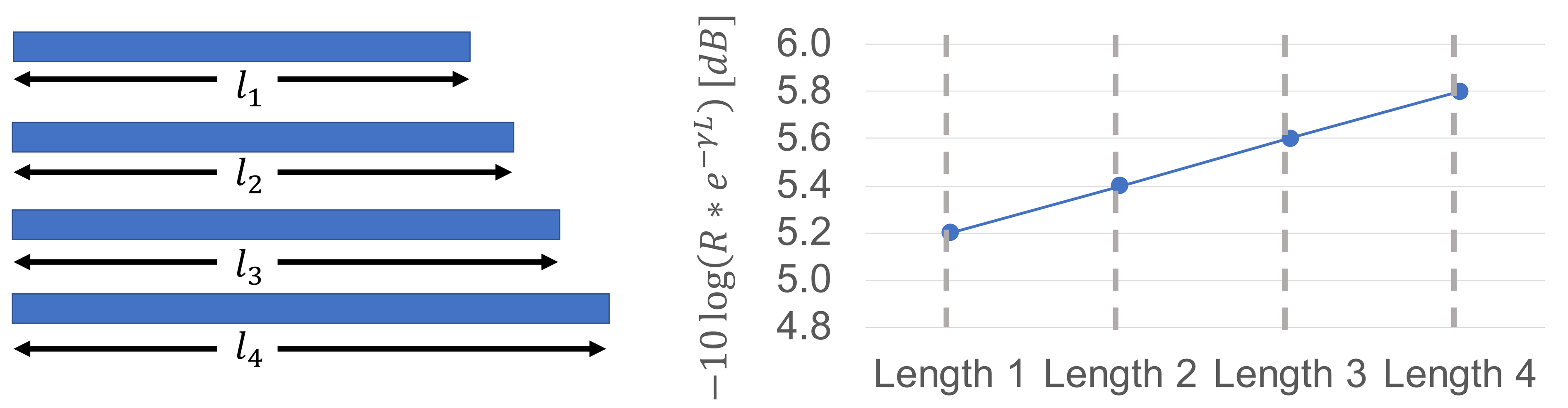


Figure 4. Waveguide strips are cleaved into four different lengths. Reflectivity values are determined at each length by sending light into one end and measuring transmission and reflection. The intercept and slope of the resulting line are used to determine the loss factor, γ.

Future Work

The GaN layer can also be etched to create a Mach-Zehnder Modulator. This modulator uses the constructive and destructive interference of light waves to modulate a light source. The existence of a GaN-based modulator would revolutionize the future of VLC devices.

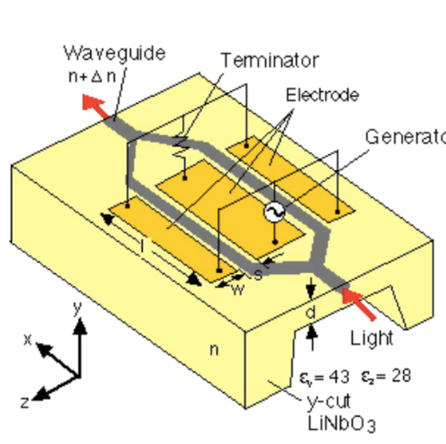


Figure 5. Example of Mach-Zehnder Modulator using $LiNbO_3$. Reprint from [6].

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Reference:

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