

Gallium nitride (GaN) is a material with the potential to revolutionize power electronics due to its unique properties, including a wide bandgap and high critical electric field. Vertical GaN-based devices, such as diodes and transistors, have already demonstrated remarkable performance, but their fabrication still presents significant technical challenges. One key issue is developing efficient selective doping methods to precisely introduce electrons (n-type) and holes (p-type) into the material's structure.

One promising solution involves ion implantation, a technique well-established in the silicon industry but still under development for GaN. To achieve stable and efficient n-type and p-type layers, ultra-high-pressure annealing is essential. This process enables the formation of layers with properties comparable to those created using epitaxial growth techniques.

This project investigates how the structural quality of GaN, measured by defect density, influences the diffusion of dopants introduced via ion implantation. Samples will be prepared using GaN grown on substrates of varying quality, such as:

- native GaN substrates (highest structural quality, lowest defect density),
- thick GaN layers on sapphire (moderate structural quality),
- thin GaN layers on sapphire (lower structural quality),
- GaN on silicon (lowest structural quality, highest defect density).

These samples will undergo ion implantation with key dopants (e.g., magnesium, silicon) and ultra-high-pressure annealing. Advanced analytical techniques, such as electron microscopy, Raman spectroscopy, and Hall effect measurements, will be used to characterize the material's properties and diffusion behavior. The data will guide the design of more efficient devices in the future, such as Schottky diodes and field-effect transistors.