Research
Journal of
Physics
RJPHY

OPEN ACCESS

Executive Summary

Introducing Ions into Unusual GaN Structures

Kosai Srewi

GaN, AlN, InN, and their ternary and quaternary compounds, which make up Group III nitride semiconductors, gained notoriety outside of the research community when they were used in light-emitting diodes (LEDs) and laser diodes for data storage and lighting. Isamu Akasaki, Hiroshi Amano, and Shuji Nakamura received the Nobel Prize in Physics in 2014 for developing the blue light-emitting diode (LED) in the 1990s, which was the pinnacle of their renown. Many of these new applications rely on unconventional structures, such as those that use nanowires or non-polar nitrides (i.e., surfaces having an a- or m-plane surface rather than the typical c-plane surface) (NWs).

The potential of these broad bandgap semiconductors for the creation of high-temperature, high-power, and high-frequency electronic devices is less well recognized but equally exciting. III-nitrides are anticipated to surpass silicon power devices in terms of breakdown voltage and on-resistance, respectively, thanks to their broad bandgap and high electron mobility, creating the possibility of significant energy savings. Regimes I and II, which deal with the impact of various surface orientations, are comparable for the three orientations that were tested, and defect profiles match up well with ballistic models like Monte Carlo SRIM (stopping and ranges of ions in the matter) simulations. The three samples with noticeably reduced defect levels in a-plane GaN exhibit diverse behaviours for higher fluences (regimes III and IV) (note the logarithmic scale).

On the one hand, the same flaws could emerge, but the effectiveness with which they are discovered depends on the chosen channelling directions. On the other hand, a-plane GaN has a significantly lower defect count than c- and m-plane GaN and/or various defect types are present, which could explain why the low backscattering yield is true. To distinguish between these two possibilities, TEM was used in samples belonging to regime IV and implanted with a fluence of 8 1015 at/cm2. Doping with optically active rare earth (RE) ions is the most researched use of ion implantation in GaN at LATR, Instituto Superior Técnico (Lisbon, Portugal).

GaN is often regarded as a semiconductor that resists radiation quite well. Strong dynamic annealing and high amorphization thresholds found in the study mentioned above and, in several publications, serve as confirmation of this. The latter has lower quantities of atoms that are dispersed randomly, indicating more effective dynamic annealing. Intriguingly, GaN NWs reduce protracted defect development after ion implantation and exhibit lower defect-induced strain levels.

Particularly at the high temperatures required for dopant activation in GaN during annealing, more defect transformation and dopant diffusion may take place. On the other hand, the creation of thermally stable flaws is a requirement for implant isolation to guarantee stable characteristics, even after additional device processing stages at high temperatures.

Journal Reference

Lorenz, K., 2022. Ion Implantation into Nonconventional GaN Structures. Physics 2022, 4, 548–564.

KEYWORDS
group III nitrides; non-polar GaN; nanowires; ion implantation; doping