High-temperature Implantation of Mg ions in GaN

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Efficient and controllable p-type doping via Mg ion-implantation in GaN has been remained a major challenge in the development of GaN based devices for electronic and opto-electronic applications. This challenge is mainly attributed to formation of defects which depends upon concentrations of implanted Mg ions, post-implantation annealing and implantation temperature. [1-3] In this work, we explored the impact of high-temperature implantation of Mg ions into GaN layers using scanning transmission electron microscopy (STEM) and atom probe tomography (APT). The Mg ions with concentrations ~ 1×10^{19} cm^{-3} are implanted into GaN layers at room temperature and 1000 °C followed by rapid thermal annealing at 1300 °C in each case. The STEM and APT analysis revealed the presence of Mg-enriched clusters and loop-like dislocations in both the samples. However, number density of such Mg-enriched features was significantly reduced in sample where Mg ions were implanted at 1000 °C as shown in Figure 1. Such reduction leads to the increase in the Mg amount in the background GaN matrix. Moreover, Mg in the background matrix appeared to be randomly distributed as revealed by atomic-scale frequency distribution analysis. A significant reduction in the number of Mg-enriched features and increment in Mg amount in background matrix are likely to be beneficial for finding the appropriate conditions for implanting Mg ions into GaN, and thus enhancing device performance.

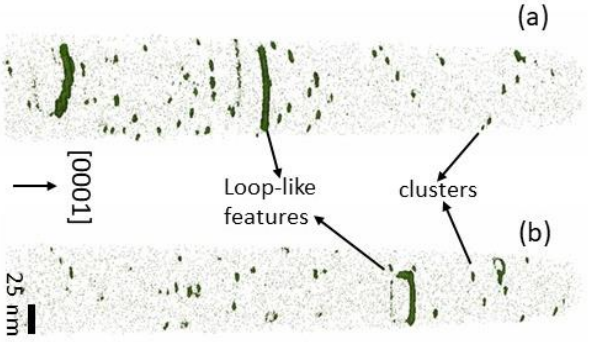

Figure 1. APT reconstructed Mg atomic maps showing the presence of Mg-enriched clusters and dislocation loops in GaN layers where Mg ions are implanted at (a) room temperature and (b) 1000 °C.

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