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Defect reduction of GaN growing on dome-shaped patterned - sapphire substrates

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Defect reduction is always an important topic for the researches of epitaxy improvement. Commercial dome-shaped patterned-sapphire substrates (CDPSS) had been designed to tackle this problem during the epitaxy of gallium nitride (GaN), and they did reduce the density of defect considerably. In order to reveal the veiled mechanism of defect reduction, we had executed Raman scattering and x-ray diffraction (XRD) measurements on various samples with different growth time to verify the behavior of defects during epitaxy 1. The results of etch pits density (EPD) had been included in figure 2, too. All the measurements show a trend of rapidly decreasing rate initially, but become smooth after 20 minutes. The reason could be figured out from the TEM cross section images. The empty spaces surrounding the sidewall of slope indicate that the growing rate here is so slow that the lateral growth takes place. When the accumulated strain reaches to a critical level, it forces dislocations to turn toward the interface to release the strain, as the red lines and yellow arrows indicate in the left part of figure 3. These lateral dislocations can block other up growing dislocations under them; therefore the defects reduce rapidly. When the growth of GaN reaches the summit of domes (about 20 minutes), only few thread dislocations (TDs) are left. With the continuous growing of GaN, these TDs could join other TDs as the yellow arrow indicated in the right part of figure 3, and the total TDs reduce gradually further. With knowing of the mechanism of defect reduction, further investigations can be designed. The performance of devices with fairly low defect density can be improved greatly. Even defect free region also be expected. It will improve the performance of electronic device and optoelectronic device. And we believe that not only feasible for GaN, but also for other III-V materials.

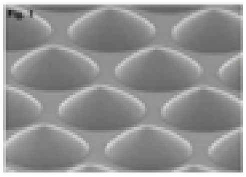

Figure 1: The surface profile of a CDPSS.

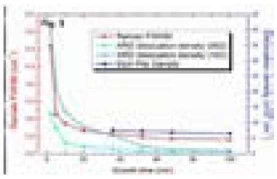

Figure 2: The results of defect density evaluated through Raman scattering(red line), XRD (cyan and Prussian blue line), and EPD (blue line)

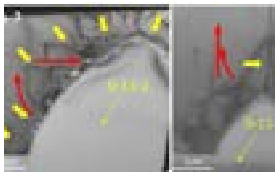

Figure 3: TEM cross section images of the samples with growth time of 36 minutes (left figure) and 68 minutes (right figure)

Recent Publication

1. Y J Liu, T Y Tsai, C H Yen, L Y Chen, T H Tsai, C C Huang, T Y Chen, C H Hsu and W C Liu (2010) Performance investigation of GaN-based light emitting diodes with tiny misorientation of sapphire substrates. Optics Express 18(3):2729-2742.

Biography

Cheng Yen Chien is PhD in Graduate Institute of Electronics Engineering, National Taiwan University. He has his expertise in electronic device, optoelectronics, nanotechnology, electron-beam lithography and application and III-V material. He demonstrated a new pattern design based on sapphire that effectively reduced dislocation density on surface GaN. The foundation is based on variety of GaN stress and strain which also modulates growth rate with GaN by MOCVD. This approach is responsive to all stakeholders and has a different way of focusing.

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