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Defect reduction of GaN growing on dome-shaped patterned sapphire substrates - Cheng Yen Chien - Graduate Institute of Electronics Engineering

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Defect reduction is usually a crucial 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 that they did reduce the density of defect considerably. So as 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 behaviour of defects during epitaxy 1. The results of etch pits density (EPD) had been included, too. All the measurements show a trend of rapidly decreasing rate initially, but become smooth after 20 minutes. The rationale might be found 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 show toward the interface to release the strain, because the red lines and yellow arrows indicate within the left a part. These lateral dislocations can block other up growing dislocations under them; therefore the defects reduce rapidly. When the expansion of GaN reaches the summit of domes (about 20 minutes), only few thread dislocations (TDs) are left. With the continual growing of GaN, these TDs could join other TDs because the yellow arrow indicated within the right a part of figure 3, and therefore the total TDs reduce gradually further. With knowing of the mechanism of defect reduction, further investigations are often designed.

The performance of devices with fairly low defect density are often improved greatly. Even defect free region even be expected. It'll improve the performance of device and optoelectronic device. And that we believe that not only feasible for GaN, but also for other III-V materials. The behavior of defect reduction in un-doped GaN (u-GaN) grown on a billboard dome-shaped patterned-sapphire substrate (CDPSS). Residual strain inside the u-GaN grown on the CDPSS are investigated also. As verified by the experimentally measured data, the limited rate of growth of the u-GaN on the sidewall of the CDPSS enhances the lateral growth of the GaN on the ditch region while increasing the expansion time. This subsequently contributes to enhance the crystalline quality of the GaN on the CDPSS. The more prominent dislocations occur within the u-GaN epilayers on the CDPSS after reaching the summit of the accumulated strain inside the epilayers. Such prominent bent dislocations improve their blocking abilities, followed by the achievement of the higher crystalline quality for the expansion of the u-GaN on the CDPSS. III-Nitride compound semiconductor have attracted much interest and achieved tremendous progress in recent years. GaN based materials are typically grown on foreign substrates made from sapphire because the native GaN substrate with larger size remains not commercially available at low cost.

Therefore, many defects are generated in GaN epilayers due to the massive mismatches within the lattice constants and within the thermal expansion coefficients between GaN and therefore the sapphire substrate. These defects can dramatically deteriorate the electrical and optical qualities of GaN-based devices. Currently, the only growth method of the pattern edsapphire substrate (PSS) can't only improve internal-quantum efficiency of devices by reducing defects but also enhance the light-extraction efficiency of optical devices [3e8]. Recently, a replacement popular sort of the PSS curving the sidewall surface of every pattern is suggests, well-known because the dome shaped PSS. Several pioneer works have investigated the consequences of complicated geometrical features of the dome-shaped PSS on the luminous efficiency of optical devices. However, few papers investigate the behavior of defect reduction inside GaN grown on the dome-shaped PSS. Nevertheless, additionally to defects, residual strains inside GaN grown on the dome-shaped PSS also impact the performance, reliability and stability of devices. Therefore, understanding in physical mechanisms of reducing defects and relaxing strain for the expansion of GaN on the dome-shaped PSS is an urgent and important work. additionally , there are still few papers reporting the experimental correlation among the measurements of high-resolution X-ray diffraction (HRXRD), Raman, transmission micro-scope (TEM) and etch pit density (EPD).

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