기판의 이온빔 전처리에 의한 GaN 에피층의 특성연구

(Study of Ion Beam Pre-treated Substrate on Characteristics of GaN Epilayers)

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1. Introduction

Despite of the high dislocation density in GaN-based optoelectric devices grown on sapphire substrates, high brightness green/blue light emitting diodes, and the blue laser diode with a lifetime of more than 10,000 hr for continuous operation at room temperature (RT) have been reported. Since the lattice mismatch between GaN and sapphire is 16 %, GaN epilayer is usually grown using a thin, low-temperature polycrystalline AlN or GaN buffer layer, and nitridation of sapphire. In both cases, the nucleation behavior of GaN is controlled to favor the two-dimensional growth mode. We focus our attention on the different chemical alteration of substrate surface using ion beam pre-treatment with low energy reactive (N_2^+) ion beam (RIB) and high energy N^+-implantation, which may be used to improve properties of GaN epilayer growth on sapphire (0001) substrate.

2. Experimental

Prior to the growth of GaN epilayer, ion beam pre-treatment was carried out. One case we employed the N^+-implantation on substrates as a pre-treatment technique. And the other case, the sapphire substrate was irradiated by reactive N_2^+ ions, which were not tilted at room temperature with a dose of 1×10^{16} cm ^{2} using a 5 cm gridded cold-hollow ion source. The growth of GaN was carried out in a horizontal MOCVD reactor (Hanvac: HVR-1010S) maintained at a pressure of 300 Torr. X-ray photoelectron spectroscopy (XPS) was performed to analyze the chemical status of the ion beam pre-treated sapphire (0001) substrate surface. The stress of GaN epilayer was analyzed by Raman spectroscopy. And cross-sectional transmission electron microscopy (TEM) was used to measure the dislocation density in the GaN epilayer.

3. Summary

Ion beam pre-treatment on the sapphire (0001) substrate resulted in chemical and physical modification of the surface layer. The amorphous AlN phase was formed by N^+-implantation with high energy, and the amorphous AlON phase was formed by RIB treatment with low energy on sapphire substrate. In addition, relaxation of the misfit strain at high temperature was decreased and internal free energies mainly controlled by the amorphous AlN or AlON phase. These facts indicate that amorphous AlN or AlON phase decreased the elastic strain energies by lattice mismatch with the sapphire substrate.