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Study on mechanism of gallium nitride growth employing a plasma-enhanced metal-organic chemical vapor deposition

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Introduction: In order to realize ammonia-less and relatively low temperature growth of high quality GaN with high growth rate, plasma-enhanced metal-organic chemical vapor deposition (PE-MOCVD) is one of the most promising techniques [1]. However, there was few research reported on it previously, and its reaction mechanism requires a sufficient clarification. In this study, the effect of N_2/H_2 plasma was investigated on growth rate and crystallization quality of GaN film grown by PE-MOCVD.

Experiment: GaN film was grown on α-Al_2O_3 c-plane (0001) substrate by a PE-MOCVD system with a capacitively coupled plasma (CCP) source. After chemical cleaning, the substrates were subjected to in-situ pre-treatments, including thermal cleaning and buffer layer growth. Then, nitrogen plasma was generated and trimethylgallium (TMG) precursor was introduced into the chamber. At the procedure of PE-MOCVD, the sample susceptor was 800°C. The GaN films were deposited with varying power at 400, 600 and 800 W for 1 hour, and then Scanning electron microscope (SEM) and X-ray diffraction (XRD) measurement was performed to confirm growth and crystallinity of the sample films.

Results and discussion: During the N_2/H_2 plasma-enhanced MOCVD, excited species was monitored by in-situ optical emission spectra (OES) as shown in Fig.1. The 1st and 2nd positive lines from N were apparently observed, corresponding to the two transitions between excited states as $C^3\Pi_u \rightarrow B^3\Pi_g$ and $B^3\Pi_g \rightarrow A^3\Sigma_u^+$. Their intensities rose with increasing the power from 400 to 800 W. Although the small peaks attributed to neutral Ga atom transition $5^2S_{1/2} \rightarrow 4^2P^0_{3/2}$ was also observed at about 418 nm, their intensities hardly changed by increasing the power. Results about films' properties from SEM and XRD were summarized in the Fig.2. It was found that the GaN films' thickness rose by increasing the power. Moreover, the peak positions of GaN002 plane in the 2θ/ω analyses shifted closer to the theoretical value of the bulk GaN (34.70°), with increasing the power. This suggests the effect of N radical density on the surficial competing with Ga. Our preliminary results indicate that the GaN film growth can be realized with the N_2/H_2 PE-MOCVD method and its crystallization reaction is affected by N radical supply.

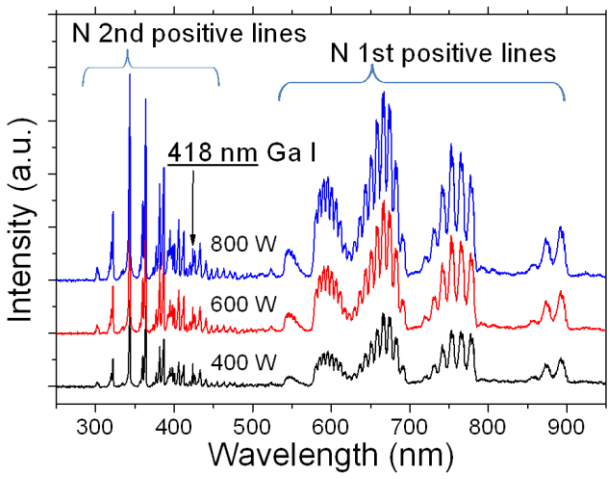

Fig.1. Optical emission spectra of N_2/H_2 plasma during PE-MOCVD at 400, 600 and 800 W

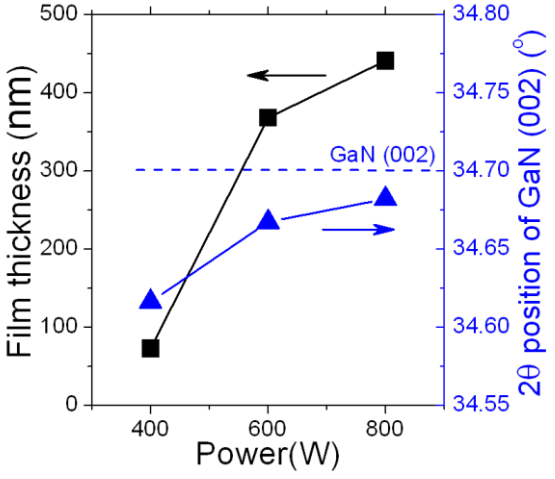

Fig.2. Film thickness and 2θ/ω peak position of GaN(002) as a function of power from 400 to 800 W

References:

[1] R. P. Campion, et al., Phys. Stat. Sol. (A) **188**, No. 2, 663-666 (2001)