Influence of Si Doping on Optical Properties of Cubic GaN Grown on GaAs (001) Substrates by Metalorganic Vapor Phase Epitaxy

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An advantage of cubic GaN grown on GaAs (001) substrates is that epitaxially grown layers can be cleaved easily along crystalline orientation to form the active cavities used for the fabrication of laser diodes (LD). Optically excited stimulated emission from such cleaved facets has been already observed [1]. Furthermore, blue LED based cubic GaN materials has been realized [2]. In order to fabricate practical optoelectronic devices, it is necessary to study doping characteristics of cubic GaN. There are many reports on Si-doping in hexagonal GaN. However, detailed studies of Si-doping in cubic GaN are deficient. In this paper, low temperature photoluminescence (PL) of the Si-doped cubic GaN films grown on GaAs (001) substrates by metalorganic vapor phase epitaxy (MOVPE) were described. The aim is to understand the effect of Si doping on PL of cubic GaN films.

The Si-doped cubic GaN films were grown on semi-insulating GaAs substrates with (001) orientation by LP-MOVPE. Trimethylgallium (TMG) and dimethylhydrazine (DMHy) were used as the precursors of Ga and N, respectively. The pressure in the reactor was maintained at 160 Torr during the growth. An about 100nm-thick GaAs buffer layer was firstly grown at 700℃, followed by 20-nm-thick GaN buffer layer at 575℃ with V/III ratio of 100. And then an about 1-μm-thick Si-doped GaN film was grown at 900℃ with a V/III ratio of 25. The detailed growth conditions were reported elsewhere [3]. Monomethylsilane (MMSi), CH_3SiH_3, diluted in ultra-pure H_2 (10 ppm) was adopted as the precursor of Si. The molar flux of MMSi was varied from 0.9 nmol/min to 18.4 nmol/min in this experiment. The samples were characterized by PL measurements excited by the 325 nm line of a He-Cd UV laser and scanning electron microscope (SEM). Luminescence is.

A series of low temperature (6 K) PL spectra obtained from cubic GaN grown on GaAs (001) substrates, doped with different molar flux of MMSi, are shown in Fig. 1. The PL spectrum of a nominally undoped GaN film grown in the same conditions is also included. The spectrum for undoped GaN film is dominated by the excitonic transition at 3.26 eV and the donor-acceptor (DA) pair transition at 3.14 eV. The detailed analysis for them was given before [3, 4]. With increasing Si flux, both the exciton and DA pair peaks shifted towards higher energy. The observed peak shift for exciton reaches approximately 38 meV. When the molar flux of MMSi is beyond 10.1 nmol/min, two peaks merge to one broad band. This behavior is similar to the case of GaAs heavily doped with Te [5] and can be well described by electron-impurity interactions (band tailing) and conduction band filling effects. Also the increase of the full width at half maximum (FWHM) and the increase of the absolute intensity for the two peaks are observed. Moreover, no deep level emissions are observed for our samples, showing that the high optical quality cubic GaN films Si-doped on GaAs (001) substrates have been obtained.

Surface morphology was observed by means of SEM. Fig. 2 shows the surface morphology of three samples, whose molar flux of MMSi are 0 nmol/min, 7.4 nmol/min, and 18.4 nmol/min, respectively. The slightly doped GaN (MMSi doped molar flux of 7.4 nmol/min) showed very smooth surface. However, the heavy dope of MMSi

resulted in rough surface. The Si concentration is estimated in the range of 10^{17}~10^{18}cm^{-3}, which will be calibrated in detail by electrical measurements.

In conclusion, high optical quality Si-doped cubic GaN films grown on GaAs (001) substrates have been obtained by LP-MOVPE. With increasing the molar flux of MMSi, the clear peaks shifts of excitonic and DA pair transition to higher energy are observed. The increase of the full width at half maximum (FWHM) and the increase of the absolute intensity for two peaks are also shown.

References

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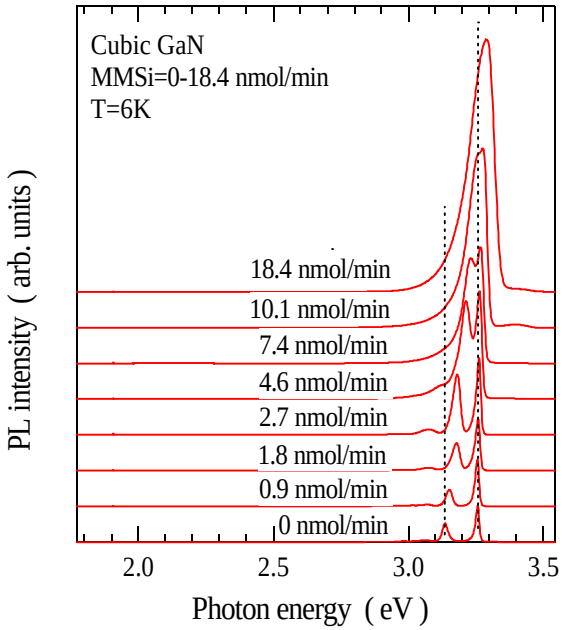
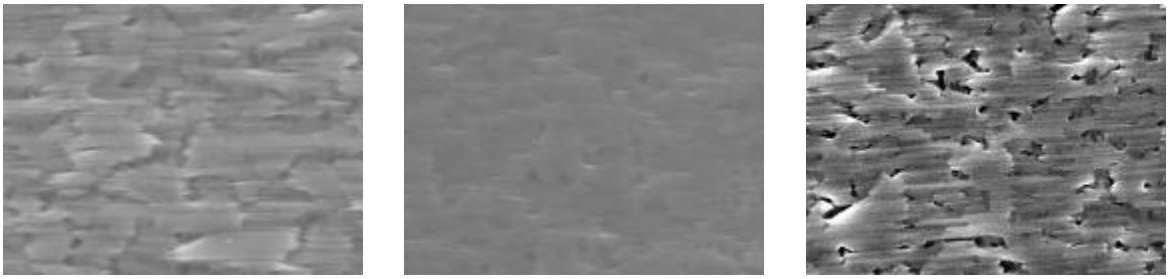


Fig. 1. 6 K photoluminescence spectra of Si-doped cubic GaN films Grown on GaAs substrates.



(a) (b) (c)

Fig. 2. Surface morphology of Si doped GaN films. The molar flux of MMSi were (a) 0, (b) 7.4 nmol/min, (c) 18.4 nmol/min, respectively.