Extended Abstracts of the 2007 International Conference on Solid State Devices and Materials, Tsukuba, 2007, pp. 578-579

P-8-10

Growth and Characterization of GaN Nano-column Grown on Gallium Coated Si by Molecular Beam Epitaxy

Kannappan Santhakumar[1], Dong-Wook Kim[1], Dong-Hun Kang[1], *D.W. Kim*[2] and Cheul-Ro Lee[1,*]
[1]School of Advanced Materials Engineering, Engineering College,
Chonbuk National University, Chonju 664-14, Chonbuk, South Korea
[2]*Department of Physics, Chungnam National University, 220 Gung-dong, Yuseong-gu, Daejeon, 305-764, Korea*
Phone: +82-63-270-3614, E-mail: crlee7@chonbuk.ac.kr

Introduction

GaN-based light emitters have been successfully commercialized in spite of that the large amount of dislocations is still a big threat to the lifetime and the yield of the devices. To reduce the dislocation density for higher quality, many methods have been proposed. High-quality nanocolumns with low dislocation density could be potential templates for high-performance nanodevices such as light-emitting diodes, laser diodes and photodetectors. Recently, the semiconductor columnar nanostructures ,i.e., nanocolumns, have aroused great attention because of their potential uses in both the mesoscopic research and the development of nanodevices. The photoluminescence intensity in the GaN nanocolumns was 20 ～30 times stronger than that in GaN continuous film grown by metalorganic chemical vapor deposition (MOCVD) because the former structures are almost dislocation free and the surface non-radiative recombination rate is very low.[1-3] We report an approach for the growth of one-dimensional GaN nanocolumns using self-organization on gallium -coated Si (111) substrates.

2. Experimental procedure

Vertically c-axis-aligned GaN nanocolumn in this work was grown on 1.5 cm x 1.5 cm Si (111) substrate by molecular beam epitaxy (MBE). The formation of nano-sized Ga droplets on Si substrate surface was formed by evaporating Ga from effusion cell. Ga alloy droplets were found to be uniformly distributed on silicon surface. The GaN nanocolumn growth was performed under the nitrogen rich conditions. The nanocolumn morphology and size distribution were analyzed with a field emission scanning electron microscope (FESEM). Optical and structural properties of the grown GaN nanocolumn were characterized by Photoluminescence (PL) and Raman spectroscopy.

3. Results and discussion

Figure 1 shows a high magnifying power image of a GaN nano-column grown after Ga droplet formation on substrate. Vertically aligned GaN nano-columns were grown uniform in diameter and length. The diameter and length of the nanocolumns ranged from 85 nm and 715 nm, respectively. The nanocolumns were densely distributed on the substrate surface.

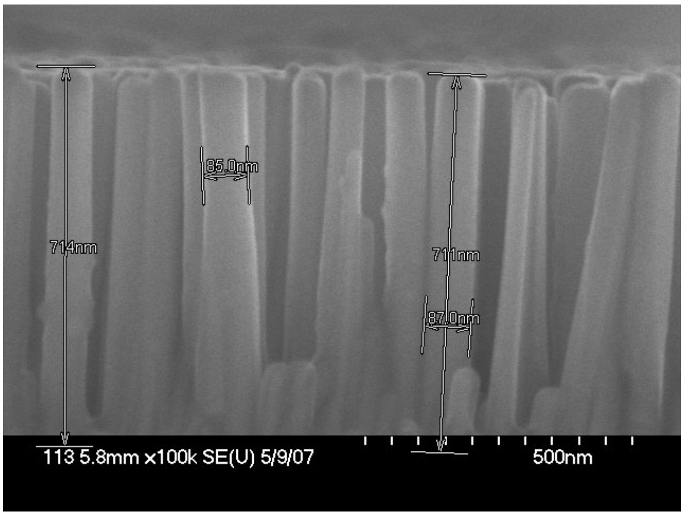

Fig.1 shows FE-SEM image of GaN nano-column vertically grown on Si substrate

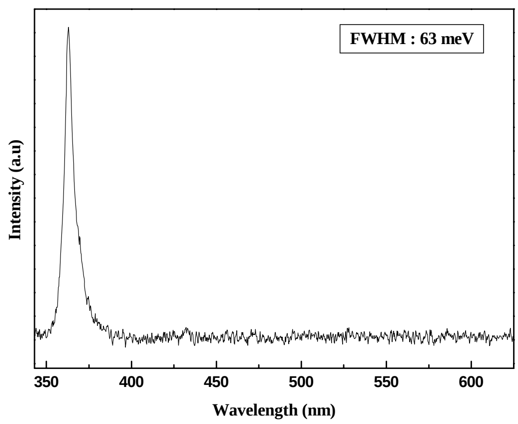

Fig. 2 Room temperature PL spectra of the GaN nano-column grown on Si

PL investigation indicates an improvement in the optical quality of the nano-column. Figure 2 shows the room temperature PL spectrum of the GaN nano-column. A strong band-edge emission is observed at 363 nm. The FWHM of the PL spectra at 363 nm peak was 68 meV which indicates the grown nano-columns are dislocation free with good crystalline quality. The data of PL intensity and FWHM at room temperature indicate a high optical quality of the GaN nano-column. This implies that the optical properties of GaN nano-column have high potential for GaN based opto-electronic devices.

Raman spectra of GaN nanocolumn were measured in the backscattering geometry. The light source of an Ar^+ laser operating at 514.5nm was focused through a microscope onto samples. Fig. 3 indicates Raman spectra of overgrown GaN on nano-columns by MBE method. The Raman signal of the GaN E_2 mode at 566.9 cm^{-1} and A_1(LO) were observed at 726cm^{-1} for GaN nano-columns.

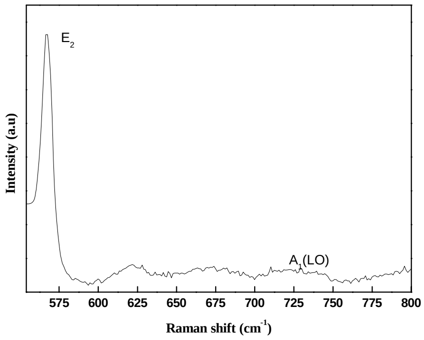

Fig. 3 Raman spectra of GaN nanocolumn grown on Si substrate

Conclusion

In summary, a novel technique was used to grow crystalline quality GaN nano-columns on Ga droplet coated on Si substrate using MBE system. The Ga droplet on Si substrate was annealed prior to GaN growth to obtain vertically well aligned nano-columns. The grown GaN nano-columns were vertical to the Si(111) growth plane are demonstrated and analysed with FE-SEM techniques. GaN nano-columns grown are single crystal in nature with good optical quality were confirmed by Raman spectroscopy and Pl measurements. This implies that the optical properties of GaN nano-column have high potential for GaN based opto-electronic devices.

Acknowledgements
This work was supported by Korea Science & Engineering Foundation (KOSEF) grant funded by the South Korea government (MOST) (No.R01-2006-10325-0)

References

[1] M. Yoshizawa, A. Kikuchi, M. Mori, N. Fujita, and K. Kishino, Inst. Phys. Conf. Ser. **155** (1997)187.
[2] M. Yoshizawa, A. Kikuchi, M. Mori, N. Fujita, and K. Kishino, Jpn. J. Appl. Phys. **36** (1997) L459.
[3] A. Kikuchi, K. Yamano, M. Tada, and K. Kishino, Phys.Stat. Sol. (b) **241** (2004) 2754.