Results in Physics 12 (2019) 1177–1181

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

Structural and optical properties of AlN/GaN and AlN/AlGaN/GaN thin films on silicon substrate prepared by plasma assisted molecular beam epitaxy (MBE)

Ho Xin Jing[a], Che Azurahanim Che Abdullah[a,b,*], Mohd Zaki Mohd Yusoff[c], Azzafeerah Mahyuddin[d], Zainuriah Hassan[e]

[a] Department of Physics, Faculty of Science, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia
[b] Materials Synthesis and Characterization Laboratory, Institute of Advanced Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[c] Department of Applied Sciences, Universiti Teknologi MARA (UiTM), 13500 Permatang Pauh, Penang, Malaysia
[d] Universiti Kuala Lumpur, Malaysian Institute of Industrial Technology (MITEC), Persiaran Sinaran Ilmu, Bandar Seri Alam 81750, Johor, Malaysia
[e] Nano-Optoelectronics Research and Technology Laboratory, School of Physics, Universiti Sains Malaysia, 11800 Penang, Malaysia

ARTICLE INFO

Keywords:
Aluminium Nitride
Aluminium Gallium Nitride
Gallium Nitride
Thin film
MBE
Silicon

ABSTRACT

In this study, the Aluminium Nitride/Gallium Nitride (AlN/GaN) layers and Aluminium Nitride/Aluminium Gallium Nitride/Gallium Nitride (AlN/AlGaN/GaN) layer heterostructures were successfully created using technique known as plasma-assisted molecular beam epitaxy (MBE) on silicon substrate. Gallium (7 N) and Aluminium (6 N5) of high purity were used to grow GaN, AlN and AlGaN respectively. The structural and optical properties of the prepared AlN/GaN and AlN/AlGaN/GaN layer heterostructures were investigated by means of atomic force microscope (AFM), X-ray diffraction (XRD), photoluminescence spectroscopy (PL) and Raman spectroscopy. AFM measurement demonstrated that the root mean square of surface roughness for AlN/GaN and AlN/AlGaN/GaN heterostructures are 3.677 nm and 10.333 nm respectively. XRD data indicated that the samples have typical diffraction pattern of hexagonal structure. Raman spectra revealed all four Raman-active modes present inside both samples. PL spectra data showed the yellow luminescence which corresponds to the deep energy levels due to imperfections of AlN did not appear. Thus, PL observation indicated that the thin film of AlN/GaN and AlN/AlGaN/GaN layers have good optical quality and looks promising for various target applications in optoelectronics, photovoltaic and radiofrequency applications.

Introduction

III-nitride group have attracted world attention rapidly in the last few years as a new promising material for electronic devices in the blue-ultraviolet range owing to its superior properties in electrical and optical. GaN and its associated III-nitrides for example, have attracted worldwide researcher to further investigate in detail due to the promising application in light-emitting diodes (LEDs), liquid crystal display back-lighting, general lighting, as well as for the outdoor commercial display [3,5,42]. Furthermore, III-nitrides family of semiconductors materials also revealed excellent characteristics not limited to physical and chemical inertness, thermal and mechanical stable, superior electron saturation velocity and peak velocity, high breakdown voltage and thermal conductivity, as well as excellent radiation hardness [25–26,49]. In addition, it also has a wurtzite crystal structure and direct extensive energy band gap. The energy band gap values are 6.2 eV, 3.4 eV and 0.7–1.9 eV for AlN, GaN, and InN, respectively [43,44]. InN and AlN can be alloyed with GaN to form alloys which allows tuning of band gap and emission of wavelength [40–41].

Previously, GaN is grown typically on substrates like sapphire and silicon carbide (SiC) [19,45]. However, due to the high cost of sapphire and SiC, another alternative suggested by material scientists is by utilizing the usage of silicon as substrate as it also offers promising properties for the GaN based semiconductor nanostructure devices. Silicon substrates are low cost, available in large diameters and the most important it is thermal characteristic and electrical properties. Herein we grown AlN/GaN and AlN/AlGaN/GaN thin films on silicon substrate via plasma assisted molecular beam epitaxy (MBE).

Silicon substrate is chosen as the substrate material for this research due to its good conductivity, low-cost materials, and the most important

* Corresponding author at: Department of Physics, Faculty of Science, Universiti Putra Malaysia (UPM), 43400 Serdang, Selangor, Malaysia.
E-mail address: azurahanim@upm.edu.my (C.A. Che Abdullah).

https://doi.org/10.1016/j.rinp.2018.12.095
Received 17 May 2018; Received in revised form 29 December 2018; Accepted 29 December 2018
Available online 31 December 2018