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Editors:
Professor Dr. Zainuriah Hassan
Dr. Quah Hock Jin
Dr. Lim Way Foong
Dr. Ng Sha Shiong
Dr. Yam Fong Kwong

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Effects of Withdrawal Speed on the Synthesis of GaN Thin Films by Dip Coating Method

Maizatul Akmam Ab Hamid and Sha Shiong Ng

Institute of Nano Optoelectronics Research and Technology (INOR), Universiti Sains Malaysia, 11800 USM, Penang, Malaysia.

Keywords: Thin films, dip-coating, gallium nitride, sol-gel growth, wurtzite

*Corresponding author's: *maizatul33@yahoo.com, #shashiong@usm.my

ABSTRACT

In this research, hexagonal wurtzite structure gallium nitride (GaN) thin films were grown on aluminium nitride on silicon substrate [AlN/Si(111)] substrate by using sol-gel dip coating deposition method. The effects of the withdrawal speed on the strucutural and surface morphology of the synthesis GaN thin films were investigated. The withdrawal speeds were varied from 10-100 mm/min. High resolution X-ray diffraction results revealed that the deposited GaN thin films exhibit hexagonal wurtzite structure. The crystallite size increases with increase in withdrawal speed of substrate. Field-emission scanning electron microscopy results show that the grains were uniformly distribute over the film. While the grain size increases with increasing withdrawal speed. The results reveal that the best withdrawal speed is 100 mm/s.

1 Introduction

Wide and direct band gap gallium nitride (GaN) semiconductor has attracted remarkable interest due to its potential applications in optoelectronic devices. GaN has attained considerable importance for ultraviolet and blue emitters, spintronics, laser diode and radiation-resistant electronic devices [1]. Apart from that, GaN has also been used for the high temperature, high power and high frequency applications due to its properties of high electron drift saturation velocity, strong atomic bonding, good thermal conductivity, and good chemical and thermal stability [2, 3].

Nowadays, high quality GaN thin films can be mass-produced by manufacturing technology such as metal organic chemical vapour deposition [4], molecular beam epitaxy [5] and hydride vapour phase epitaxy [6]. Nevertheless, these methods involve sophisticated setup procedures that demand high production cost. Therefore, a cheaper and simpler technique is highly desirable. Sol-gel technique which has been widely to produce metal oxides can be an alternative for the growth of the GaN thin films.

In the present work, an effort has been carried out to synthesize GaN thin films on aluminium nitride on silicon substrate [AlN/Si (111)] substrates by sol-gel dip coating method. The attention is focused on the effects of the withdrawal speed on the structural and surface morphology properties of the deposited GaN thin films.

2 Experimental Details

2.1 Sample Preparation

In this work, gallium (III) nitrate hydrate ($Ga(NO_3)_3.xH_2O$) powder with purity of 99.7% was used as precursor. While, ethanol and diethanolamine (DEA) were used as solvent stabilizer respectively. Firstly, 2.5 g of ($Ga(NO_3)_3.xH_2O$) powder was dissolved in 10 ml ethanol under ultrasonic bath. Then, 0.7 ml of DEA was slowly added into the solution and ultrasonic bath was continued until a transparent solution was formed. Lastly, the sol-gel was left 24 hour at room temperature for stabilization before the deposition.

Prior to the deposition, the 1 cm × 1 cm AlN/Si (111) substrates were first ultrasonically cleaned in acetone, then dipped into hydrofluoric acid solution, lastly rinsed in deionized water. The dip coating process was carried out under various withdrawal speeds, i.e. 10, 25, 50, 75 and 100 mm/min. To obtain film with desired thickness, the dip coating