THE EFFECT OF SPIN COATING PARAMETERS ON GaN NANOSTRUCTURES THIN FILMS PROPERTIES DEPOSIT ON DIFFERENT SUBSTRATES

H. M. MAHMOOD[a], M. A. ABDULLAH[b], A. RAMIZY[c*],
A. S. MOHAMMED[a]
[a]*Department of Ramadi Education .General Di rectorate of Education in Anbar, Ministry of Education.*
[b]*Department of Physics, University of Tikrit, Tikrit, Iraq*
[c]*Department of Physics, University of Anbar, Anbar, Iraq*

GaN nanostructures with different layers were grown on quartz and silicon substrates, using the spin coating technique. The structural properties were studied by X-ray diffraction which indicated that the number and intensity of the peaks were changed as layers deposited changes. The cubic phase of GaN and the diffraction peaks of Ga_2O_3 were not observed; these results indicated that GaN output from the precursor was highly successful due to the complete transformation of all Ga_2O_3 layers into GaN ,.GaN morphological study was elaborated by field emission-scanning electron microscopy, the surface appears more homogeneous with more condensed particles, with particle size about 50 nm. Photoluminescence (PL) which revealed that the energy band gap ranged from (3.4 - 3.35) eV, for GaN/Si 3 and 7 layer, and (3.34 - 3.26) eV, for quartz 3 and 7 layer substrate respectively.

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1. Introduction

Gallium nitride GaN is one of the attractive semiconductor materials because it has unique properties such as thermal, chemical stability, and showed that the optical energy gap was to be (3.4 eV) at room temperature, so it also has direct band gap. All these properties are used in many applications such as LED diodes, LDS laser diodes with UV spectrum range, and gas sensor [1, 2]. GaN belongs to Group III such as GaN, AlN, InN and can be found in either a zinc blend or a wartzite structure. The wurtzite crystal structure for all binary, ternary and quaternary alloys is thermodynamically very stable. The III nitrides therefore have several properties, the easier to develop and the majority of these studies [3, 4].The interest in group-III Ns tends to be a quantum well structure induced by their electrical properties and spectacular optical making them suitable for electronic applications and various optoelectronics. Gallium nitride has many applications in electrical and optoelectronic devices for which it has been used successfully in detectors operating as (UV) ultraviolet and applied as light emitting, as well as high-powered electronic devices and high-temperature, high-frequency [5], and also used as a gas sensor [6]. Gallium nitride of a high crystalline uniformity may be obtained by depositing a low temperature buffer layer [7]. The Nanostructures GaN have been prepared by different techniques including, OMVPE method [9], pulsed laser deposition [8], DC sputtering magnetron [9], and thermal atomic layer deposition[10]. The goal of this work is to investigate the effect of various number of deposition layers on the structural, morphological and optical properties of GaN nanostructures prepared by the spin coating method on silicon and quartz substrates.

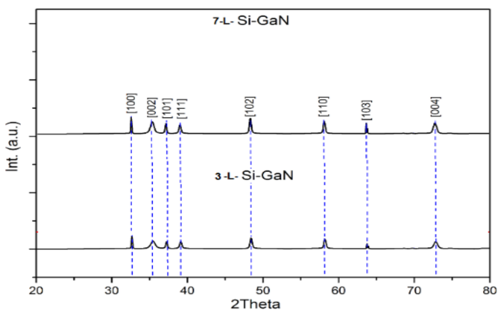
[*]Corresponding author: asmat_hadithi@uoanbar.edu.iq

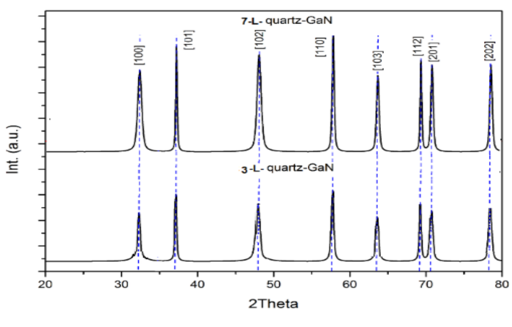
2. Experimental details

Spin coating technique is used to deposit thin film of the GaN nanostructures on silicon and quartz substrates with various layers of coatings. Gallium (111) nitrate hydrate ($Ga(NO_3)_3$•xH_2O) powder was dissolved under stirring in ethanol (CH_3CH_2OH) which was continued for 1 hour. To order to dissolve the metals completely during stirring, the precursor solution (0.3 M) was stirred at 50 ambient for 3 hours. The solution was then dropped onto a silicone and quartz substratum (20 mm x 20 mm x 1 mm) that rotated for 60s at 300 rpm. After the spin coating had been deposited, the thin film were dried on a hot plate for 1 hour at 100^{o}C. The processes of coating and drying were repeated several times to synthesize multilayer. The samples were annealing in furnace at 950^{o}C with NH_3 gas flow at ratio 6% for 1 h. X-ray diffraction (XRD) technique (Philips PW 1710 X-ray diffractometer, USA) with Cu Kα radiation was used to analyze crystal structures deposited on silicon and quartz substrate with different number of layer. The optical properties were measured at room temperature using a He – Cd laser (k = 325 nm), at room temperature using photoluminescence spectroscopy (JobinYvon model HR 800 UV method, JobinYvon, USA). Using the Field Emission Scanning Electron Microscope (FESEM) system (NOVA NANO SEM 450, USA) the surface morphologies of GaN thin film were characterized

3. Results and discussion

Fig. 1 showed the GaN thin film XRD pattern deposited on the 3-and7-layer silicon and quartz substratum. All the observed diffraction peaks agreed with the Joint Committee on Power diffraction standards data for bulk GaN (JCPDS-01-089-7522 and 01-088-2361) were deposited on Si (111) substrates using a spin coating deposition. These diffraction peaks correspond to the hexagonal GaN phase (100), (002), (101), (102), (110), (103), and (004), all these peaks and similar diffused background scattering in 3 and 7 strata. The 7-layer intensity is higher than the 3-layer ones. The cubic phase of GaN and the diffraction peaks of Ga_2O_3 were not observed; these results indicated that GaN output from the precursor was highly successful due to the complete transformation of all Ga_2O_3 layers into GaN [11]. On the other hand, XRD patterns for the GaN film prepared by deposition of 7 and 3 layers at quartz substrates with annealing with NH3 at 950^{o}C. The GaN demonstrated a greater relationship when treated at high temperatures with NH3. XRD patterns showed that peaks (101) and (110) of hexagonal GaN orientations have high sharp peaks in 7 layers compared to 3 layers, since the peak was found to be heavily dependent on transmission spectra for quartz-grown GaN films and this transmission decreases with the number of layers increasing corresponding reflection [12]. Other diffraction peaks correspond to the guidelines (100), (102), (103), (112), (201) and (202), all of these hexagonal GaN peaks were in compliance with the Joint Committee on bulk GaN Power Diffraction Standards (JCPDS fill No. 00-002-1078) this is agree with zhenxing zhang [13]. The pattern has modified insignificantly, but the thickness of the 3 layers decreases compared with 7 layers [14].





a) *b)*

Fig. 1. XRD pattern of GaN thin films deposited with different number of coatings layers onto (a) silicon 7 and 3 layers, (b) quartz 7 and 3 layers.

With aid Scherror's formula, the crystallite size (D) of the prepared thin films was calculated [15].

$$D = \frac{0.9\,\lambda}{\beta\ cos\theta} \qquad (1)$$

Where λ is the wavelength, and β is "the full width at half maximum (FWHM) of a diffraction peak in radians, and θ is the Bragg's angle. The crystallite size increased linearly with the increasing of the number of layers of GaN, which ranged between 38.25 nm to 46.15 nm for silicon substrate and 49.2 to 56.0 for quartz substrate.

FESEM of thin GaN nanostutcture films deposited on different substrate. Images of films from FESEM were shown in (Fig. 2). As can be seen from Fig. 2-a closer look at the deposition at room temperature with 3 layers of images does not show a solid structure, and it appears more blurred and scattered. Small cavities can be seen, in fact. Nevertheless, the morphologies are found to be enhanced with an increase for 7 layers, and coherent layers of grained structures can be observed. For silicon substrates the morphology of the surface increases dramatically compared to that deposited on quartz substrates as showed in figure (2-c and d), this is in line with predicted crystallite size from XRD patterns.

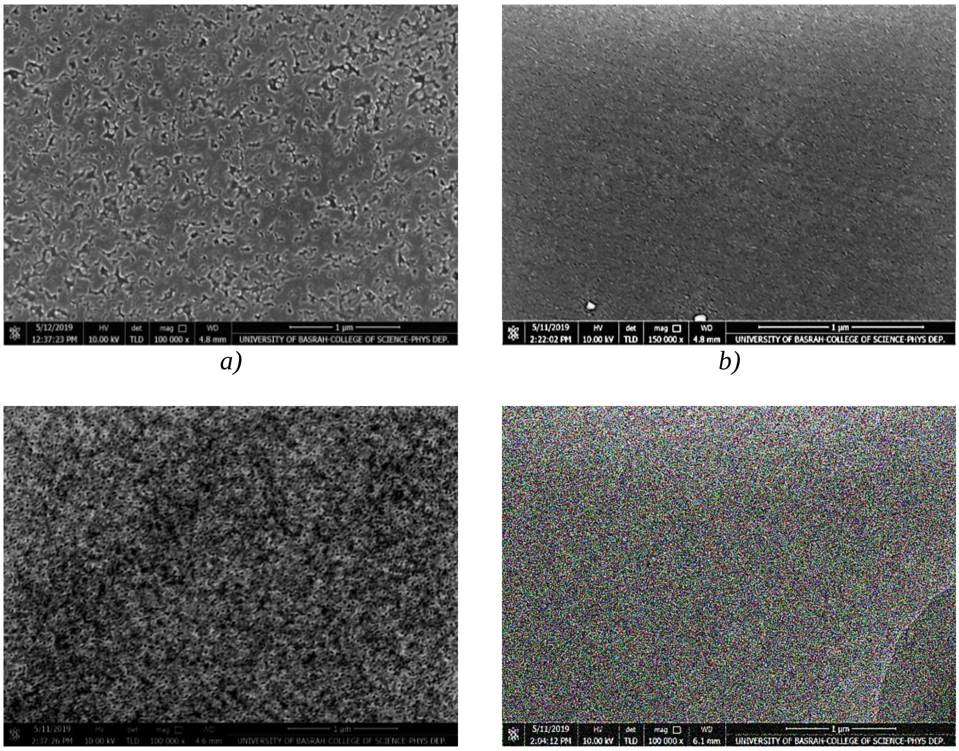
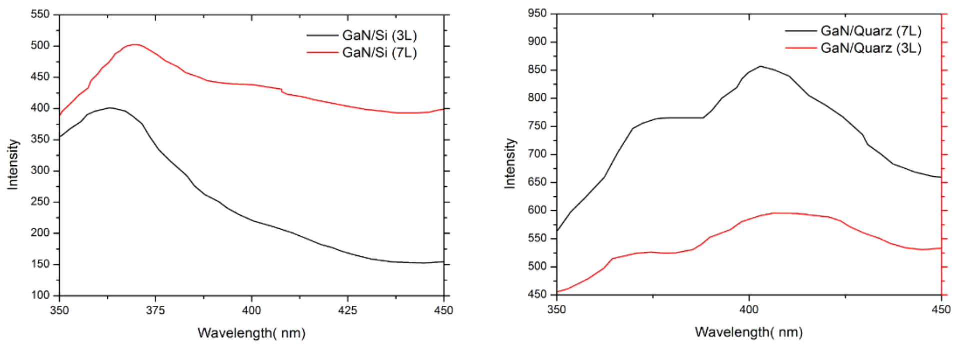


Fig. 2. FESEM image of GaN thin films deposited with different number of coatings onto (a) silicon3 layers, (b) quartz3layers,(c) silicon 7 layers, and (d) quartz 7layers.

The PL spectrum of GaN / Si (111) reported at room temperature was shown in figure 3-a. It could be observed that there are 369.1 nm and 364 nm respectively on the PL spectra with excitation wavelength up to 7and 3 layers. The peak locations in the 7 layers at 3.35 eV and 3.4 eV in the 3 layers, this is as a result of the reduction to nanosize, which supports charge carrier quantum confinement [16].

the peak in 7 layers larger than 3 layers, this is attributable to the presence of intrinsic defects or surface conditions [17], so there was a discrepancy in the band gap due to the different deposition layers, other minor peaks could be due to the donor acceptor (DA) transition [18]. The intensity of peak based at 3 layer GaN little compared with 7 layers due to gallium or nitrogen vacancy associated deep-level states [19]. The increase in the number of layers specifically contributes to a decrease in the energy gap. The number of unsaturated bonds is higher in amorphous thin film due to insufficient number of atoms. This results in an increase in the removed by the addition of more atoms and thus creates a homogeneous network with low defect density [12]. Thus, film thickness is an important parameter for modification of band structure.

Figure 3b showed the PL spectrum of GaN thin film deposition on quartz at room temperature It may be observed that 379.38 nm and 370.82 nm are PL spectra of excitation wavelength to 7 and 3 layers respectively. It can show high peak in the 7 layers with Eg = 3.268 eV and Eg=3.34eV at 3 layers, which is close to the GaN bond gap (Eg = 3.2 eV [20]. The wide peak in 7 layers indicated that surface state defects or intrinsic defects exist [17]. Heat treatment under NH3 at 950^{o}C has led to high crystal quality nanocrystalline and high stability can be managed during preparation, and has not altered peak position in 7 layers and 3 layers but has altered peak intensity [20]. A lot of small nano-sized particles appear on the film while deposition on 3 layers for low peak strength occurs because these small particles display huge defects and not enough for crystalline. As layers rise to 7 layers, small and large non-sized particles are present on the film due to the increase in the number of atoms for which high intensity would appear [21]. Absorption is dependent upon the number of deposited layers. The increase in the number of layers led to an increase in the number of atoms being transported, thus increasing the number of photons being absorbed. The increased number of layers is therefore well used for many applications, such as photo detectors, gas sensors and solar cells.



a) *b)*

Fig. 3. PL of GaN thin films deposited with different number of coatings onto (a) silicon 7 and 3 layers, (b) quartz 7 and 3 layers.

4. Conclusions

Spin coating technique was used to deposit GaN thin film nanostructures on a silicon and quartz substrate for two separate layers of coatings (3, 7). From XRD analysis, it was found that the size of crystallite increases due to an increase in film thickness with increasing number of coatings. With increased the number of layers on silicon and quartz substrates, peak intensity strength increases.

The optical band gap at 7 and 3 layers was estimated to be 3.35 eV, and 3.40 eV for GaN deposited on silicon substrate, and 3.268 eV, and 3.34 eV for quartz substrate respectively. FESEM images, reveals that the nanoparticles being dispersed evenly on the different substrates with 3 and 7 layers. The increase in the number of layers led to an increase in the number of atoms being transported, thus increasing the number of photons being absorbed and this feature be used for many applications, such as photodetectors, gas sensors and solar cells.

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