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# GOOD OPTICAL QUALITY $In_xGa_{1-x}N$ THIN FILMS GROWN ON Si(111) BY PLASMA-ASSISTED MOLECULAR BEAM EPITAXY

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$In_xGa_{1-x}N$/GaN/AlN heterostructure epitaxial layer on silicon utilizing plasma-assisted molecular beam epitaxy (PA-MBE) sample. X-ray diffraction (XRD) estimations uncover that the InGaN thin film was epitaxially developed on silicon substrates. high In- fraction of InGaN sample with an estimation of 0.30 has been acquired. Scanning electron microscopy (SEM) show, many depressions, V-shapes, and breaks were detectable on that surface; this may most presumably be because of moderately low sidelong development rate of the InGaN films. We trust that this imperfection in our sample might be used to upgrade the etching mechanism if these specimens utilized as porous layer, which realized that the vast majority of this deformity is metal and may prompt to make a new charging carrier density resulting in increasing the electron-hole pairs which create extraordinary plasmon resonance in the surface during the etching procedure then accelerate the etching rate and may reduce the defect inside the surface. Micro-photoluminescence (PL) spectra showed sharp and extreme crests at 364 nm with the generally low yellow emanation band, demonstrating great optical quality.

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*Keywords:* InGaN, MBE, Optical Quality

## 1. Introduction

III–V nitride materials get incredible consideration in view of the optoelectronic applications. InGaN with a wurtzite structure is a direct band semiconductor and its broad spectrum is thought to be a potential factor from IR to UV region. This property create from InGaN a standout amongst the most encouraging materials for optical applications [1, 2].

In this manner, the development of nitride nanomaterials is etched in gigantic consideration. Late research exercises are not just concentrating on the manufacture of nanostructured materials, yet comprehension of the crucial properties of nano-scale structures, and along these lines creating nanotechnologies. Porous semiconductors have additionally been considered seriously as of late. The reviews are principally spurred by the potential utilizations of porous semiconductors show in optoelectronics gadgets [3-5]. Porous semiconductors are additionally under review as conceivable mold for epitaxial development [6,7], in which the pores could go about as sinks for mismatch dislocations and to accommodate elastic strain in heterostructures, this in the long run, prompts to the creation of great epitaxial films that has low strain and low auxiliary imperfection density.

An extraordinary enthusiasm for grown GaN-construct materials on Si substrates as contrasted with sapphire ($A1_2O_3$) or (SiC) are normally utilized for development excellent GaN films; which offer low generation cost as well as an alluring chance to join GaN-based gadgets into Si-based innovation. The significant difficulties in grown GaN-construct materials with respect to silicon is the large lattice mismatch amongst Si and GaN-construct materials, which repress the

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development of excellent GaN-construct materials. Hence, a support layer, for the sample, AlN applying to limit this issue. [8]

In this study, InGaN thin film features developed by (PA-MBE) growth are examined. High-determination (XRD), scanning electron microscopy (SEM), and Micro-photoluminescence (PL) are utilized to examine Indium division , crystalline quality and surface morphology of the heterostructure, respectively.

## 2. Experimental procedure

InGaN/Si (111) was performed utilizing Veeco display Gen II MBE framework. Dynamic N2 was provided by RF plasma source working at 300 W. The growth compressing was 1.2×10-5 Torr. Influx cells were utilized for In, Ga and Si. Developable surfaces of employers were checked by reflection high energy electron diffraction (RHEED). Taking after outgassing in the load lack and cushion chamber, the Si (111) substrate was exchanged to the development chamber, then thermally cleaned of substrate at temperature of 860 oC was occurred . A perfect Si surface was gotten when RHEED images demonstrated noticeable Kikuchi lines for its surface.

A high Al flux were used for depositing of couple of Al monolayers before AlN buffer layer growing. The quality of the thin film crystalline is highly dependent on AlN buffer layer[7]. The cushion layer of AlN was developed at 760 oC (Al cell at 1,120 oC , both N and Al cell screens at the same time opened for 15 min) and after that GaN epilayer was developed at 810 oC for 15 minutes then, the substrate temperature was sloped down to 710 oC to get ready to the development InGaN epilayer. As a result, the In is extremely sensitive to the growth temperature, in order to control the measure of In joined along these lines, low substrate temperature was utilized. To develop n-type InGaN, the influx cells of In and Ga were warmed up to 900and 910 $^{o}$C.

The grown sample was described by an assortment of instruments. PANalytical X'Pert Pro MRD XRD framework. SEM (JSM-6460 LV model) was utilized to study the structural properties of the specimen. For PL estimation, a 325nm Helium -Cadmium laser was utilized.

## 3. Results and discussion

Fig. 1 demonstrates the RHEED images of the development of thin films of InGaN on Si (111) substrates. Fig. 1(a) presents the GaN surface reproduction pattern with appearance of streaky and Kikuchi lines, which transform into clean Si (111) utilizing a 7 x7 surfaces [9,10]. At the point when the AlN grew, the RHEED pattern got to be distinctly streaky and the Kikuchi lines vanished, as shown in Fig. 1(b).

Fig. 1(c and d) indicates RHEED pattern changes amid the development of GaN and InGaN. In view of this, RHEED intensity to be distinctly sharpened which indicates that the crystalline nature of InGaN was improvement compared with GaN layer.

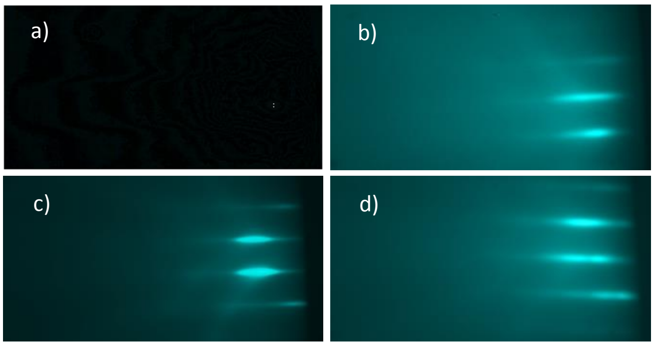


*Fig. 1. The patterns of RHEED during the growth of (a) Si substrate, (b) AlN pattern buffer layer, (c) GaN pattern confinement layer and (d) InGaN pattern layer*

Fig. 2 demonstrated the SEM image of the developed layers which grown on Si (1) substrates. The lnGaN samples display, many furrows, V-shapes, and breaks were perceptible on that surface; this may most presumably be because of generally low sidelong growth rate of the InGaN films. We trust that this imperfection in our sample might be used to upgrade the etching mechanism if these specimens utilized as porous layer, which realized that the vast majority of this deformity is metal and may prompt to make a new charging carrier density resulting in expanding the electron-hole pairs which create extraordinary plasmon resonance in the surface during the etching procedure then accelerate the etching rate and may reduce the defect inside the surface.

Fig.3 shows the EDX range of the specimen components. The peak intensity alludes sample components. The outcomes demonstrated that film is of good quality, without the being of impurity elements.

Fig. 4 exhibits the cross segment of the InGaN thin films developed on Si (111) substrates. AlN ,GaN and lnGaN epilayers thickness are 0.065μm, 0.120 μm and 0.105μm as appeared in Fig.3. The growth rates of the AlN, GaN, lnGaN were assessed at 0.38 μm/hr, 0.48 μm/hr and 0.315 μm/hr, respectively.

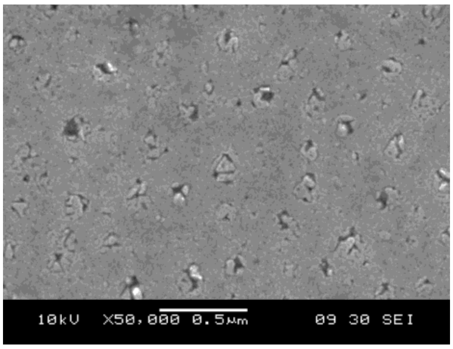
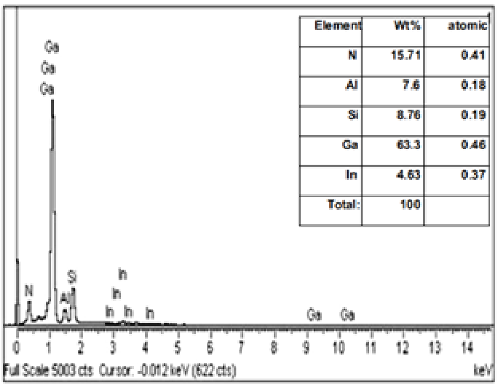


*Fig. 2. Morphology of SEM surface of the InGaN/GaN/AlN layers that grown on Si (111) substrate*



| Element | Wt% | atomic |
|---|---|---|
| N | 15.71 | 0.41 |
| Al | 7.6 | 0.18 |
| Si | 8.76 | 0.19 |
| Ga | 63.3 | 0.46 |
| In | 4.63 | 0.37 |
| Total: | 100 | |

*Fig. 3. Energy Dispersive X-ray Analysis (EDX) spectrum of "InGa1N/GaN/AlN layers grown on Si(111) substrate".*

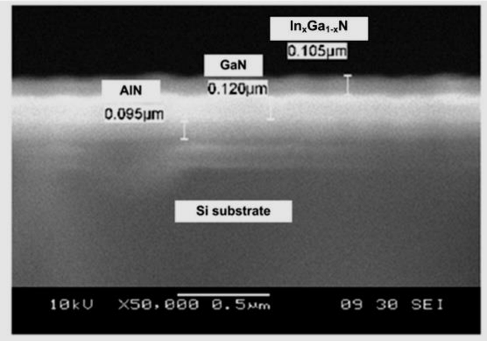


*Fig. 4. SEM cross section of the InGaN/GaN/AlN layers grown on Si (111) substrate*

Fig. 5 demonstrates the XRD scan of InGaN thin films developed on Si (111) substrates . The XRD results affirmed that the InGaN thin films was epitaxially developed on Si (111). This can be noted at 33.61◦, 34.54◦ and 36.02◦peaks appearance for a sample which relates to {lnGaN (0002), GaN(0002) , AlN(0002)} diffraction crests, respectively. The constant of lattice (C) for both AlN and GaN layers were calculated utilizing the law of Bragg diffraction is around 4.982 and 5.190 Å. These qualities are in great concurrence with the literature review [11]. The In fraction (x) can be determined utilizing the XRD symmetric ω/2θ scan of (0002) plane as in Eq. (1) [12] and the law of Vegard as in Eq. (2) [13] as shown below:

$$C = \frac{\lambda l}{2\sin\theta} \tag{1}$$

where λ is the X-ray wavelength (0.15406 nm), θ is the Bragg's angle, and l is the Miller's index.

$$x = \frac{c_{(InGaN)} - c_{(GaN)}}{c_{(InN)} - c_{(GaN)}} \tag{2}$$

$c_{(InGaN)}$, $c_{(GaN)}$, $c_{(InN)}$ are the actual c-plane lattice constants of InGaN, -GaN, and InN, respectively. In fraction (x) was found to be equal to 0.30.

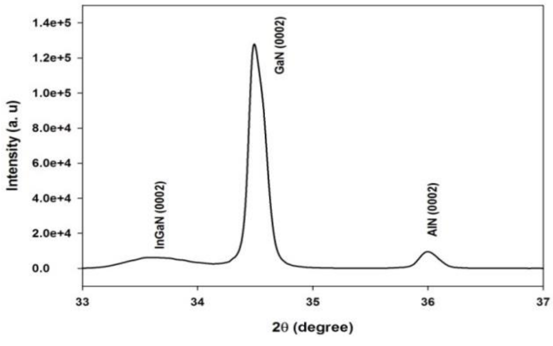


*Fig. 5. XRD scan of InxGa1-xN/GaN/AlN grown on Si(111) substrate*

Fig. 6 showed the PL spectra of InGaN thin films developed on Si (111), a sharp peak at 364 nm that is ascribed to the absorption of GaN edge and the peak at 535.38 nm was related to emission of InGaN.

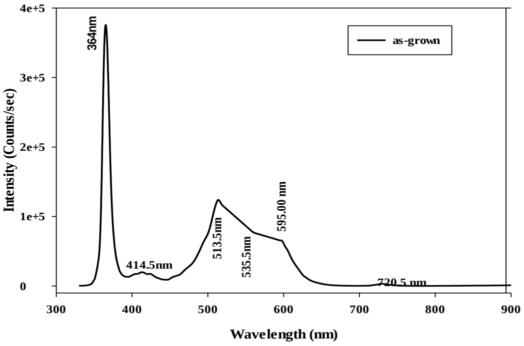


*Fig. 6. PL spectra of InGaN/GaN/AlN layers grown on Si (111) substrate.*

Other than this, there is a peak focused at 513 nm identified with the green band emission. Little crest at 720.2 nm might be from the contaminations or deformities, (for the sample, N vacancy or N vacancy) [14,15]. Generally, the low yellow band is observed ; demonstrated that the quality of the film is good.

## 4. Conclusions

The effective development of $\mathrm{ln_xGa_{1-x}N}$/GaN/AlN thin film layers has been acquired by PA-MBE. The structural and optical properties of the grown film have been examined by EDX range, X-ray diffraction, scanning electron microscopy and Micro-photoluminescence spectra. EDX spectrum demonstrated that film is of good quality, without presence of contamination elements . The fraction of indium in InGaN epilayer was ascertained to be equivalent to 0.30 Micro-photoluminescence sharply displayed and extreme crests at 364 nm with the generally low yellow emanation band demonstrating great optical quality.

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