

Analysis on Photo Emission and Absorbing Spectrum on GaN Sample by Finite Difference Time Domain Method

Phyoe Sandar Win¹, Kathy Kyaw Min¹, Hla Myo Tun², Zaw Min Naing², Win Khaing Moe²

¹Department of Electronic Engineering, Mandalay Technological University, Mandalay, Myanmar

²Department of Electronic Engineering, Yangon Technological University, Yangon, Myanmar

Email address:

phyoesandarwin.mtu@gmail.com (P. S. Win), makathykyawmin.mtu@gmail.com (K. K. Min), hlamyotun.ytu@gmail.com (H. M. Tun), drzaw290615@gmail.com (Z. M. Naing), winkmoe@gmail.com (W. K. Moe)

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Abstract: III-Nitride semiconductors are especially capable for both electronics and optical devices. The capability of the III-Nitride semiconductors as light emitters to extent the electromagnetic spectrum from deep ultraviolet light, throughout the whole visible region, and into the infrared part of the spectrum, is a significant characteristic, making this material indispensable for the areas of light emitting devices. The near and far field characteristics of the GaN samples are studied by affecting the finite-difference time domain (FDTD) technique. The far region spreading characteristics at diverse incident angles are also conferred. In addition, the spreading field would be concentrated and the transmission efficiency could be enhanced by the phase shift caused by the dielectric substrate. The intended of optoelectronic devices fictitious from III-Nitride materials is supported by acquaintance of refractive index and absorption coefficient of these materials.

Keywords: Photo Emission, Absorption Spectrum, GaN Sample, Finite Difference Time Domain Method

1. Introduction

Gallium nitride (GaN) is one of the majority talented wide-band-gap semiconductors for such prospective purposes as blue light-emitting diodes (LED) and laser diodes [1, 2]. GaN-based LEDs have revealed better-quality lifetimes and gave off power than have conformist light sources [3]. In recent times, numerous research groups have lucratively amalgamated GaN nanowires using a variety of practices [4–6]. Those one dimensional nanostructures are accepted to reveal electronic and optical properties that strappingly be certain of size and geometry. Additionally, the surface effect grows to be significant in thinner nanowires. Surface obedience nanostructure semiconductors reveal improved luminescent efficiency [7]. Nevertheless, the optical properties of one-dimensional GaN have been petite investigated in anticipation of now.

The accomplishment of those optoelectronic devices is principally the consequence of latest developments in material excellence. This analysis was enthused by the comparatively

huge discrepancy in addressed values of the absorption coefficient, refractive index, energy band gap, and thickness by using the practices of transmission and reflection spectroscopy. Optical experiments offer a superior approach of investigative the properties of semiconductors. Predominantly assessing the absorption coefficient for an assortment of energies provides information about the band gaps of the material. Acquaintance of those band gaps is tremendously significant for thoughtful the electrical properties of a semiconductor, and is consequently of enormous practical attention. This study depicts experiments of this kind using the practices of transmission to study the properties of GaN thin semiconductor films.

For light underneath the band gap of the semiconductor, the intrusion within the thin film amends both the reflection and transmission spectrum. On top of the band gap, the elevated absorption coefficient reasons the film to soak up any numerous reflections of the light. For those materials, if not the film is less than ~ 1 mm thick, there are rarely adequate signals for commercial spectrophotometers to acquire an exact ratio measurement. Due to the petite penetration depth of the

light on top of the band gap, reflection measurements develop into more dependent relative on the surface circumstance of the semiconductor, but have been used with enormous achievement to meet information concerning band structure. In the spectral region approximately the band gap the circumstances is intricate, for besides disappearing from a transparent to an absorbing Fabry-Perot cavity, the excitonic structure develops into significant. This is particularly correct in the case of nitride materials, where the binding energy of the exciton is physically powerful ($> \sim 20$ meV). The three intimately spaced valence bands lead to three strapping absorption features, the A, B, and C exciton. The assortment regulations also formulate the transmission and reflection divergence dependent. The birefringence of the hexagonal material and the spreading from the columnar grain arrangement originate in the majority nitride materials extra confused matters. In semiconductor alloys, fluctuations in work of art become wider the exciton creation the absorption descriptions not as much of distinctive. On the other hand, the gamut absorption of the exciton still manipulates the absorption spectra, even when the excitonic features are no longer evidently perceptible. On the whole, all nitride epitaxial films are also exceedingly stressed, with strain being dependent relative on substrate material and on buffer layer.

In most cases, the long-established incident plane wave analysis to thin film transmission and reflection exertions presumes that the films are of homogeneous thickness and have a smooth surface morphology. In reality, this is confront particularly when the crystal grower would like to have a realistic growth rate and also has to dope the film for electrical properties. In the case of thin films with the purpose of have surface roughness, some of the light is spread and fails to spot the detector. This lowers the investigational values of transmittance and reflectance with the effect being supplementary obvious at shorter wavelengths. Even a miniature error in the investigational values can escort to huge errors in the formative the index of refraction [13]. The spreading also upsets the period of the plane wave primary to a thrashing of consistency in the thin film and a dampening of the intonation of the transmission and reflection spectra. Swanepoel [14, 15], Szczyrbowski [16], and Nowak [17] have measured the effects of surface roughness and thickness variations on the optical spectrum of thin films and their models were included into the at hand replica. A different issue to think about in those thin film models is that the explanation encloses an index thickness product (nd). Accordingly, the index of refraction and the thin film thickness are confidentially interrelated. In very thin films such as those used in this work, even though the order quantity of the intrusion peaks is recognized, only a few data points can be got hold of for the Swanepoel procedure for influential the thickness. With the film thickness identified experimentally to $\sim 7\%$ from SEM measurements, the index of refraction of the films was strong-minded using the identical process as Ambacher [18]. The absorption coefficient was originated using the reflectance data and the confused multilayer representation by Wemple [19]. The exciton theory of Elliott [20] was used to robust the absorption coefficient data to come across the optical band gap. Even with the exciton detached, it has a

physically powerful manipulate ahead the absorption spectra that non-excitonic models can not robust [21, 22]. In view of the fact that the entity excitons could not be experiential for alloy compositions above 5 % due to alloy broadening, for level-headedness the three excitons were assemblaged into one restriction and dispersed a single binding energy.

In this paper, we theoretical study the excitation condition, then the finite-difference time-domain (FDTD) [8] numerical method for the optical simulation is conversed; the far region data calculation process and the time domain iterative invent for metal are expressed. In the discussion sections, the transmission properties of the slit array plate are premeditated by utilizing the FDTD method at the start. After that the effects of GaN substrate to the transmission and scattering properties are developed [24-25].

2. Background Theory

A great deal of the information about the properties of materials is achieved when they interrelate with electromagnetic radiation. When a beam of light (photons) is incident on a material, the intensity is expressed by the Lambert-Beer-Bouguer law [9-11]:

$$I = I_0 \exp(-\alpha d)$$

If this circumstance for absorption is convened, it appears that the optical intensity of the light wave, (I), is exponentially reduced while travelling through the film. If the power that is attached into the film is designated by I_0 , gives the transmitted intensity that leaves the film of thickness d . α is called "absorption coefficient". From (1) it follows that

$$\alpha = -\frac{1}{d} \ln \left(\frac{I}{I_0} \right)$$

It is comprehensible that α must be a strapping function of the energy $h\nu$ of the photons. For $h\nu < E_g$ (direct), no electron hole pairs can be fashioned, the material is transparent and α is small. For $h\nu \geq E_g$ (direct), absorption should be strapping. All mechanisms other than the elementary absorption may append difficulties, but usually are not very obvious.

Optical transmission measurements were performed to establish the film thickness, the wavelength dependence of the refractive index and optical absorption coefficient. The optical constants were single-minded from the optical transmission measurements using the method depicted by Swanepoel [12].

The transparent substrate contains a thickness several orders of magnitude larger than (d) and encompasses index of refraction (n) and absorption coefficient ($\alpha = 0$). The index of refraction for air is occupied to be $n_0 = 1$.

The transmission spectrum can approximately be separated into four regions. In the transparent region ($\alpha = 0$) the transmission is considered by n and s through multiple reflections. In the region of weak absorption α is small and the transmission embarks on to decrease. In the medium absorption region α is large and the transmission decreases primarily caused by the effect of α . In the region of sturdy absorption the transmission

decreases considerably owed approximately completely to the influence of α . If the thickness d is uniform, interference effects provide goes up to the spectrum, revealed by the full curve. These interference fringes can be used to estimate the optical constants of the film.

3. Implementation

To analyze the optical characterization of GaN in depth, the transmission and reflection spectra are contrasted in the subsequent indicates. The wavelength positions of interference peaks are approximately the identical but the maxima and minima positions are immediately the contradictory. This is presumed from the half-wave loss at air/GaN interface in the reflection spectrum. When light is incident from a film with minor refractive index to a film with greater refractive index, the reflected beam has an supplementary half-wave loss, whilst the transmitted beam does not. The refractive indexes of each layer in decreasing succession are n_{GaN} and n_{air} , so the direct reflected light has a supplementary half-wave loss at air/GaN interface, whereas others do not. Complementary the transmission and reflection spectra, it is originated that the interference amplitude of reflection is generously proportioned than that of transmission. For reflection, interference essentially comes about between the direct reflection light beam and various reflected light largely beam. In addition to the transmittance interference is caused largely by the direct transmitted light beam and multiple-transmitted light principally beam. On top, the reflection spectrum has a great deal larger interference amplitude and can also demonstrate the long period fluctuation resulted from GaN merely.

4. Results

It is appealing to observe if and how the built-in fields

influence the lateral transport of photo generated carriers. In this study, we present spectral photoconductivity (SPC) and transient photoconductivity (TPC) studies. Figure 1 shows the emission spectrum versus cumulative distribution function. We could easily find that the emission spectrum goes up after the cumulative distribution function of 600 and reaches at the full percent for 750.

For low energies nevertheless there is no suitable electronic transitions potential so transmission is incredibly high in that range. It is not 100% on the other hand, on account of reflection. There is a moderately pointed delimitation between the regions of high and low absorption. The energy at which absorption starts off gives the impression to be attributing for each material: For GaN it keeps up a correspondence to the direct band gap at 3.4 eV. For low energies we scrutinize thin film interference special effects that result from the superimposing of light that is reflected on in cooperation sides of the thin film. If this interference is productive or disparaging depends on the wavelength. Figure 2 points out the transmission pulse with respect to frequency offset.

In order to estimate the reflection, transmission and absorption of a thin film stack, index of refraction with complex value and thickness of the all film are compulsory inputs of the numerical analysis. Refractive index is material dependent and in performing on this parameter is not promising; the merely changeable input constraint is the thickness of the film. Nevertheless, ruling aspirant index of refraction may be acquired by choosing from the majority neighbouring materials. This is difficult for the reason that all index of refraction values are wavelength dependent and may have important dissimilarity spectrally. Absolutely not, thickness of the film is subjective restriction and it can be attuned from quite a lot of nanometer to micrometer. Figure 3 illustrates the linear absorption spectra.

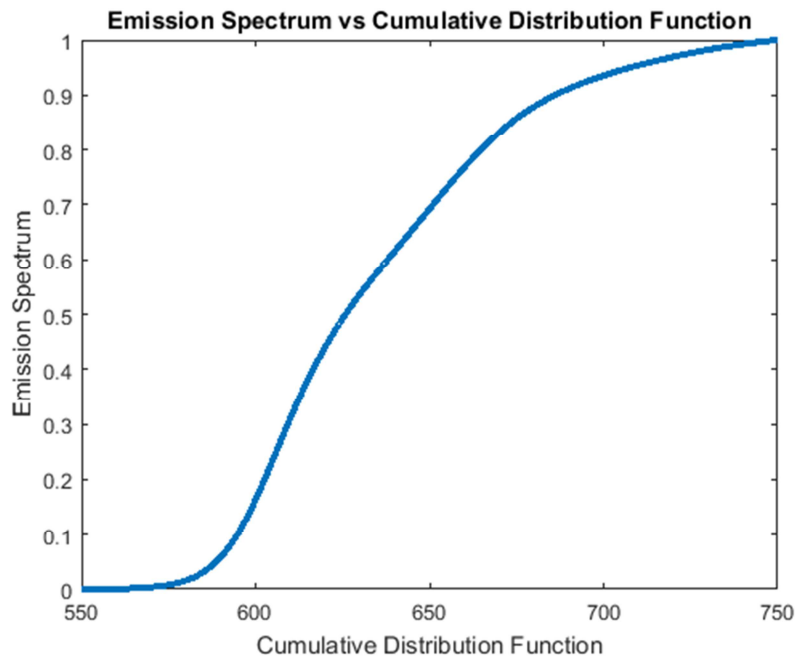


Figure 1. Emission Spectrum versus Cumulative Distribution Function.

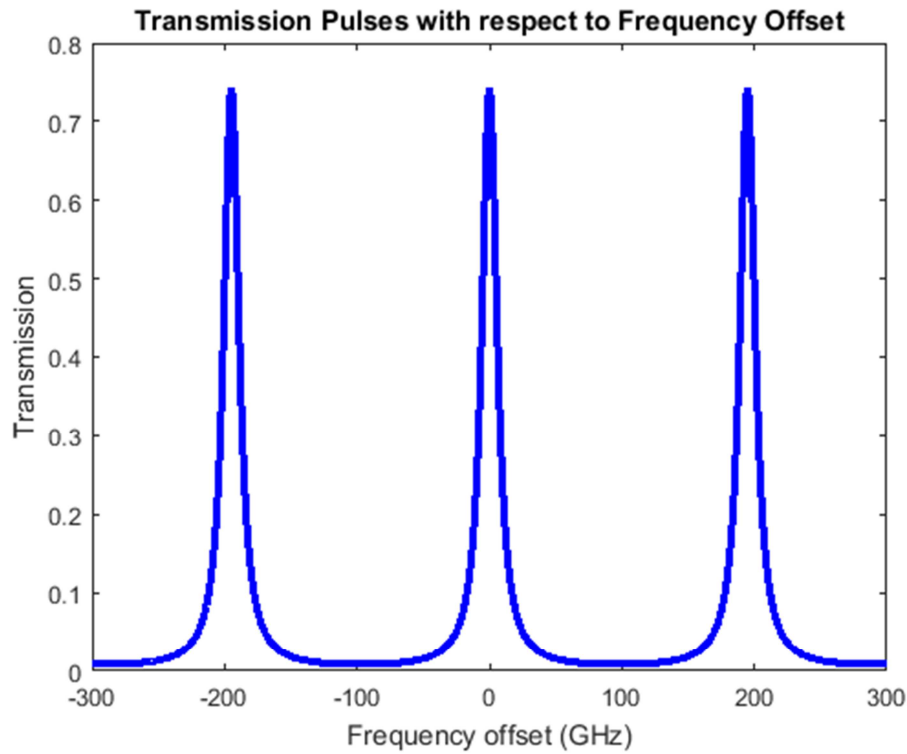


Figure 2. Transmission Pulse with respect to Frequency Offset.

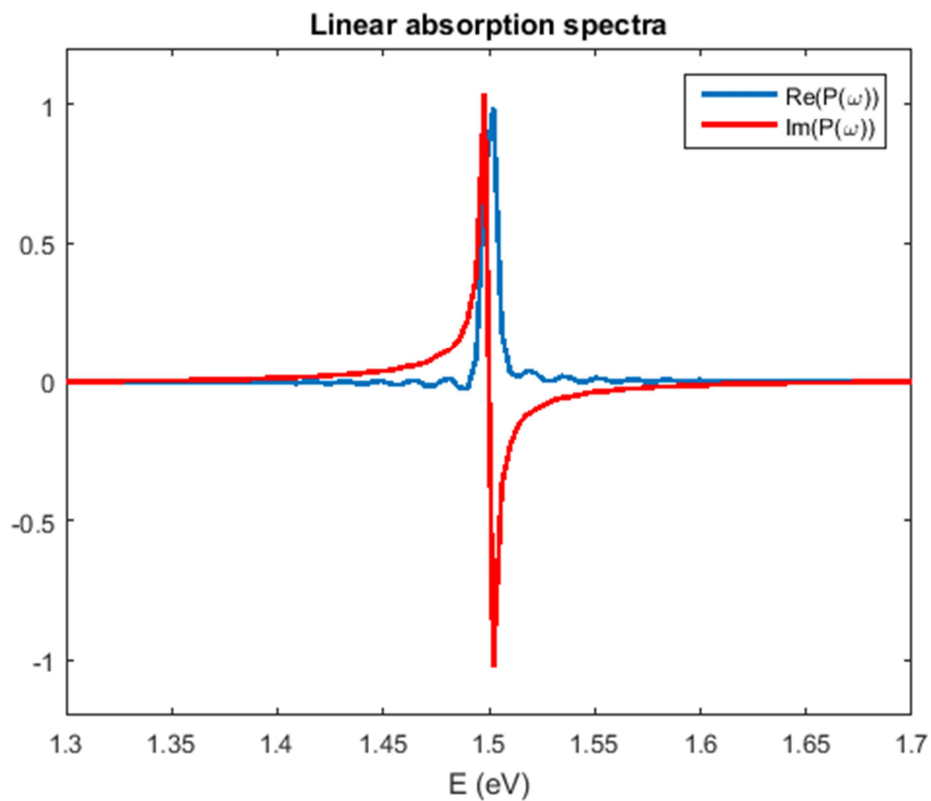


Figure 3. Linear Absorption Spectra.

The transmission spectra of the GaN nanostructure considered at high spectral resolution (0.06 meV) reveal oscillations attributable to the radiation interference under multiple reflections on the external features of the structure. In

the case of low sufficient resolution, when the radiation consistency length develops into not more than the structure thickness, those oscillations vanish shown in Figure 4. For this reason, the transmission spectra with completely smoothed

interference effects are supplementary suitable. Both spectral curves reveal a sharp reflection maximum at the photon energy of 47.5 meV which is a fingerprint of the low-frequency phonon resonance in sapphire [23]. At lower photon energies, the in cooperation spectra correspond to non-monotonic reliance with a lowest amount. Enlarge of the reflectivity at the lowest photon energies is affected by multiple reflections in the interior the sample which come up when the sample is converted into incompletely transparent. It should be accentuated that an arbitrary augment of the reflectivity at the long-wavelength edge of the spectrum for the nanostructure is appreciably larger than for the sapphire substrate. This characteristic points out a significant involvement of 2D electrons to the reflectivity of the nanostructure.

The understanding of the reflection spectra in Figure 4 is not as uncomplicated as that for the transmission. For high

energies, where absorption is high in keeping with the transmission illustration, reflection increases as well. This can merely be described by a hypothetical behaviour of the interaction between light and matter. The rationalization for in cooperation clarifications is almost certainly a deficient calibration of the spectrometer in the reflection measurements. When recording the baseline by which the device calibrated the point of 100% of reflection, a mirror was placed in the position of the sample. Even though it was made of a special material that demonstrates approximately total reflection in the required wavelength range, it is not perfect and absorbs or transmits a small portion of the light. This results confirm in the 100% point to be attuned a modest too squat, so that all reflection data that is accurate with this baseline would be to some extent too high. Figure 4 presents the transmission and reflection spectrum.

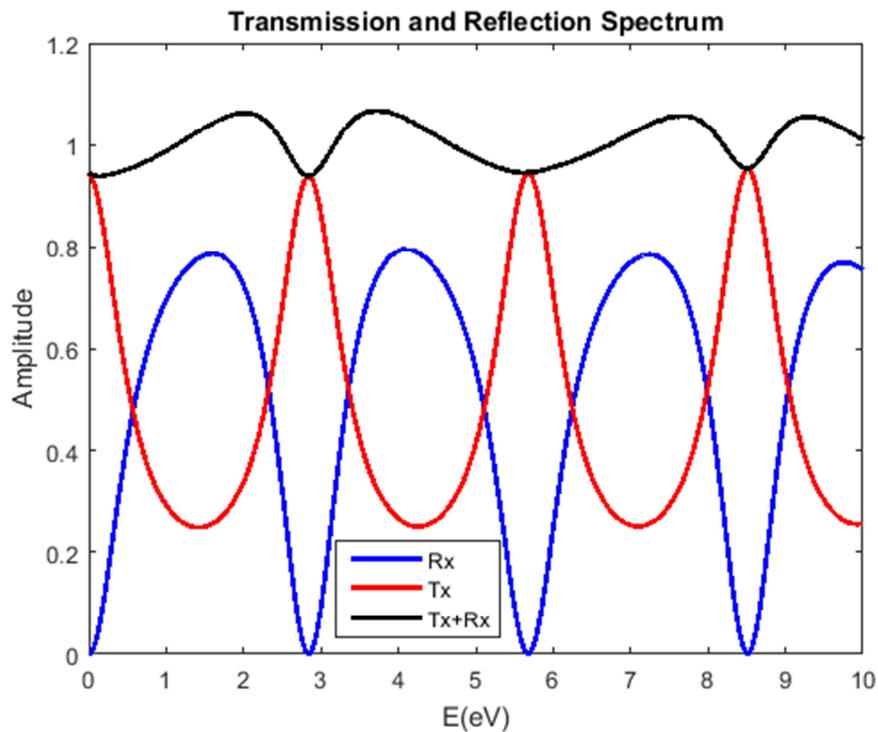


Figure 4. Transmission and Reflection Spectrum.

5. Conclusion

To end with, the hypothetical have evaluated the photo emission and reflection spectrum by using the FDTD model for GaN sample. It should be found out that the metallic structure could be light-transparent, and the photo emission and reflection spectrum would be excited when the geometry of the structure matches the resonance enhancement environment. Furthermore, the dielectric substrate has noteworthy influence on the transmission properties by upsetting the field distribution on the semiconductor materials, improves the transmission efficiency and reduces the scattering by the phase shift at resonance wavelengths of the structure. These extraordinary properties put forward

promising relevance to light-transparent metal contacts, stealth materials, etc. The index of refraction below the band gap was got hold of by correcting the transmission spectra, and the optical band gap was attained by fitting the transmission data with Elliott's theory of absorption. The absorption coefficient and index of refraction prove reasonable agreement with those considered by other researches. These results afford additional in sequence of significance toward the design optimization of optoelectronic devices employing the III-nitrides.

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